SUSTAINABILITY OF CONSTRUCTION MATERIALS

Dayalan J
Dr. Madhavi T

BOOKS ARCADE

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Dr. Madhavi T

BOOKS ARCADE
KRISHNA NAGAR, DELHI

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BOOKS ARCADE

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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CHAPTER - 1

INTRODUCTION TO BUILDING AND CONSTRUCTION MATERIALS

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

The engineering discipline known as construction material science deals with the use of building materials to construct structures in a way that maximizes strength, economy, safety, and durability. This science also looks for new, appropriate building materials to use [1]. In today's technologically advanced world, building materials play a significant role. No area of engineering is plausible without their use, despite the fact that construction activities represent their most significant application [2]. Additionally, the building materials sector plays a significant role in the economy of our country because the output it produces determines the quantity and caliber of construction work. The selection of materials for a particular scheme is influenced by a few general factors [3].

The climatic context is perhaps the most crucial of these climatic differences have led to the development of various building materials and construction methods in various parts of the world. The cost of the materials is another important consideration [4]. The choice of materials may be significantly influenced by the rapid development of construction techniques, the increasing use of mechanical equipment and plants, but rather changes in the way the building industry is structured. Geomaterials, also referred to as building materials, are extracted from a variety of quarries and mines. As the demand for housing the worlds expanding population rises, so does the pressure to find new resources. Since antiquity, stone and clay for adobe bricks have been the primary building materials used in the world, and concrete has a long and illustrious past. Quarrying for these materials still has a need, and it has similar environmental effects to other extractive industries [2] .

Economic costs

The purchase price of building materials represents their initial economic cost. This is frequently the factor that determines the choice of materials. Sometimes people see the value of paying a higher initial cost in exchange for a lower lifetime cost and take into account the energy savings as well as durability of the materials. For instance, installing an asphalt shingle roof is less expensive than installing a metal roof, but the lifetime cost of the metal roof is lower each year. The final choice may be influenced by the different maintenance requirements and costs for various materials [5].

Ecological costs

Costs of pollution can be both large and small. Building materials rely on extraction industries, such as mining, logging, and petroleum, to create environmental damage at the source as well as during the transportation of raw materials, production, product transportation, retailing, and installation. The off-gassing of building materials or indoor air pollution are two examples of the precision aspect of pollution. Materials found to really be harmful are listed on the Red List for construction. The total amount of greenhouse gases generated throughout the material's life is known as the carbon footprint.

Energy costs

The energy used to produce, deliver, and install the material is included in the initial energy costs. The ongoing production and delivery of energy toward the building for its use, upkeep, and eventual removal entails financial, ecological, and social costs. The energy used to extract, manufacture, deliver, and install the materials is referred to as the initial embodied energy of a structure. With use, maintenance, and duplicate of the building materials own as well as how the materials and design help minimize the lifetime energy consumption of the structure, the lifetime embodied energy keeps increasing.

Social costs

Social costs include harm to the workers who produce and transport the materials as well as potential health issues for building occupants if there are issues with the biology of the structure. People have been significantly impacted by globalization in terms of lost jobs, skills, and personality due to the closure of manufacturing facilities as well as the cultural aspects of the locations of new facilities. Global manufacturing of building materials has social costs related to fair trade and lab our rights.

Building material significance

The most significant and frequently used combination of building materials is steel and concrete, which is used in multi-story factories, commercial buildings, and bridges. These components can be utilized in hybrid structural systems, such as Examples of composite structures where members made of steel and concrete work together compositely include concrete cores ringed by steel tubes. Steel and concrete are the most common and important construction material combinations, with applications in multi-story commercial buildings, factories, and bridges. These substances can be used in mixed structural components, for example, Concrete cores surrounded by steel tubes, for example, as well as composite structures where steel and concrete members act together compositely [1].

Steel concrete composite systems have a number of advantages over traditional reinforced concrete or steel structures, including max strength ratios, structural integrity, long-lasting finishes, dimensional stability, and sound absorption. These benefits have resulted in a significant increase in the utilization of composite construction around the world in recent years. In multi-story buildings, structural steelwork is commonly used in conjunction with concrete, such as steel beams with floor slabs in concrete.

The same is true for highway bridges, where concrete decks are typically preferred. The extent to which the elements or components of a building structure should be all steel construction, all reinforced concrete construction, or all composite construction is determined by the circumstance, Because of its significant potential for improving overall performance through relatively minor changes in the production and construction technologies, hybrid materials are of particular interest. In composite construction, shear studs at the interface of two dissimilar metals are used to connect them. It significantly reduces material costs. The material used to construct a structure denotes its structural existence. It demonstrates the presence of sensibility in a design and thus defines the structure's practicability. In the field of architectural visualization, the use of building material(s) while construction is underway is symbolic of its existence. It contributes to the establishment of a link between visual quality and high integrity in architecture. An architect's choice of building material generalizes the type of architecture used in the construction. The concept of architects symbolism is not isolated solely to represent changing architectural trends. Rather, it is defined in the absence of any instinct or control [6].

Building materials are an essential component of the architectural field. The type of building and the materials used are determined by the site chosen as well as the nature of the surroundings. The material used determines the type and form of the structure. The concept of 'building materials' extols the durability and aesthetics of design. It not only provides meaning, but it also improves the artistic value of a building venustas (beauty) and firmitas (firmness).

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CHAPTER - 2

ENGINEERING MATERIALS

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

Engineering materials are a category of materials used to build components and structures that were created by people. The main purpose of an engineering material is to sustain applied loads with splitting or exhibiting significant deflection [1]. The four primary categories of engineering materials are metals, polymers, ceramics, and composites. Modern architects and builders employ the natural building materials clay and mud to construct a variety of sorts and styles of structures while offering flexibility and innovation [2]. In Malaysia, such building supplies are usually used with other important building supplies to increase the construction's overall quality [3] . Today, clay is processed to improve soil quality using a mechanical pneumatic compressor. In buildings, clay also functions as a natural Ac unit. Because of this, dirt and clay are enjoying a resurgence in favour in the present [4]. By nature, aluminium is brittle and weak, but it may be made ductile and malleable to strengthen it. Pure aluminium has strong resistance to corrosion due to an oxide covering that forms over it and stops oxidation. Aluminum loses some of its corrosion resistance when alloyed.

Aluminum is a common material, particularly in the aircraft sector, because of its low weight and resistance to corrosion. Aluminum alloys offer a high intensity ratio while not being as dense as steel. A four-digit number is used to identify aluminum alloys, with the first digit designating the main alloying component. Cast iron most often comes in grey. Graphite flakes are one type of carbon that may be discovered. The concrete strength of ferrite, a brittle substance, is greater than its tensile strength. Gray cast iron gets its name from the grey brittle failure that it experiences. [5].

Aluminum Alloys

Although aluminium in its pure form is fragile and weak, it may be alloyed to become more robust. Pure aluminium has high corrosion resistance due to a oxide covering that develops over the substance and stops oxidation. Aluminum loses some of its corrosion resistance when alloyed. Aluminum is a common material, especially in the aircraft sector, because of its low weight and resistance to corrosion. Aluminum alloys have a high potency ratio while not having the same strength as steel. Four-digit numbers are used to identify aluminium alloys, with the initial number designating the primary alloying component. [6].

Nickel Alloys

Alloys made of nickel are resistant to corrosion and high temperatures. Iron, chromium, and copper are often used alloying elements. Common nickel alloys include negative binomial nickel, K-Monel, Inconel, and Hastelloy.

Copper Alloys

Commonly known properties of copper alloys include their ability to transmit electricity, resistance to corrosion, and ease of forming and casting. Copper alloys are valuable materials for engineering, but they're also highly beautiful and commonly utilised in ornamental applications. The two most prevalent types of copper alloys are brass and bronze. Zinc is the principal alloying component of brass. The majority of bronzes include a sizable amount of tin. Bronzes may contain aluminium, nickel, zinc, silicone, or other elements. Despite being corrosion resistant, bronzes are often stronger than brasses.

Titanium Alloys

Titanium alloys are lightweight, strong, and resistant to corrosion. Their density is much lower than steel's, and they have an excellent strength-to-weight ratio. As a result, titanium alloys are widely used, particularly in the aerospace sector. One major disadvantage of metallic materials is their high cost. Titanium alloys are classified into three types: alpha alloying elements, beta alloys, and apex predator alloys. Alpha alloys are not heat treatable and must be strengthened through solid-solution bolstering processes. Heat treatment, primarily precipitation hardening, can be used to strengthen beta and alpha-beta alloys. Titanium alloys are distinguished by the proportions of alloying elements, such as Ti-6Al-4V.

Polymers

Polymers are substances comprised of molecules connected by extensive chains of monomer units. They may be synthetic or natural. Numerous practical and potent substances, including plastics, rubbers, fibres, adhesives, and coatings, are made of polymers. The three different kinds of polymers are thermoplastics, thermosets, and elastomers.

Thermoplastic Polymers

Thermoplastics and thermosets are categorised based on how they react to heat. A thermoplastic softens and melts when heated. Once cooled, it will return to its solid state. Repeated chilling and heating of thermoplastics results in no chemical change (unless the temperature is high enough to break the overall molecular bonds). They are therefore perfect for injection moulding.

Thermosetting Polymers

During the first procedure, thermosets are heated until they set into a permanent hard state. Thermosets won't melt when heated. The thermoset will deteriorate, though, if the heat supplied is too great since the molecular bonds would dissolve. Generally speaking, thermosets are tougher and more durable than thermoplastics. They also maintain their original dimensions more effectively than thermoplastics when exposed to variations in humidity and air temperature.

Elastomers

Elastomers are completely elastic polymers having mechanical characteristics akin to rubber. Elastomers are frequently used in seals, sealants, pipes, connectors, and other flexible components. Vulcanization, which includes adding sulphur and perhaps subjecting the substance to high pressures and temperatures can strengthen and stiffen rubber. The outcome of this process is the formation of cross-links between polymer chains.

Ceramics

Solid compositions known as ceramics can contain metallic or nonmetallic components. The main divisions of ceramics include glasses, concretes, clay market segments, refractories, and abrasives. Ceramics have a high melting point, high rigidity, strong wear resistance and corrosion resistance, and low temperature and electrical transmission. Additionally, ceramics are quite fragile.

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CHAPTER - 3

CONCRETE AS BUILDING MATERIAL

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

Concrete is the most commonly used building material. It is also one of the most commonly used building materials. This used concrete to build the foundation, regardless of whether the building is made of structural steel [1]. Unless the structure's foundation is made of steel or wood, the foundations of all other structures are made of concrete or reinforced. Cement, aggregate, and water combine to form concrete. In addition, we use admixtures to improve the concrete's various properties [2]. The grade of concrete is chosen based on the endurance and strength requirements of the concrete. The grade of concrete represents the typical strength of concrete. The cement and aggregate mix proportion (fine aggregate; sand for manufactured sand and coarse aggregates. Concrete additives such as retarders, moisture reducers, superplasticizers with high range water reducers, and so on are used to shape the behavior of the concrete. The admixtures change the setting time, workability, and other properties of concrete [3].

Fresh concrete is poured into the area where structure will be built. Before pouring concrete, check the setting out, scaffoldings, reinforcement, cleaning, and so on. When constructing a larger structure, special care must be taken. The heat created as a result of the heat of condensation increases significantly as the thickness of the concrete increases. As a result, necessary precautions must be taken to prevent concrete cracking caused by the heat generated during the hydrolysis reaction and service [4].

When pouring concrete, rapid drying should be avoided. It has a direct impact on the structure's durability. Concrete curing is done to create a strong cover zone and to prevent concrete cracking.

- Concrete testing is performed both before and after the pouring of concrete to ensure that the expected flow ability and strength of the finished product are available.
- The concrete pond before pouring, a test is performed to determine the workability of the concrete.

Concrete cube tests or engine tests are performed to determine whether the concrete has the specified characteristic strength in the mix design. It is a composite material, and its strength increases as more materials are added [5].

Steel as Building Materials

Steel, like concrete, is one of the most commonly used building materials in construction. Steel used in construction can be classified according to its intended use.

- Steel Reinforcements
- Rebar Structural Steel

Reinforcement Steel as Building Materials

Ceramics are solid compounds that can be made up of either metallic or nonmetallic elements. Glasses, cementitious materials, clay product lines, refractories, and abrasives are the primary classification systems of ceramics. Ceramics have good wear and corrosion resistance, a high melting temperature, a high stiffness, and low thermal and electrical conductivity. Ceramics are also extremely brittle. There are two types of reinforcement. They are made of mid and tor steel. Tor steel has now been devised to rib steel (TMT bars) with higher tensile and yield strength. Currently, reinforcements with yield strengths ranging from 500 to 650 N/mm2 are manufactured. Thermo Mechanical Treatment has improved the reinforcement in the modern era. As a result, these bars are known as TMT steel bars. As a result, rebar is one of the most critical building materials [6].

Structural Steel

Structural steels are used to construct structures other than buildings, such as bridges and towers. Typically, structural steels are used to construct a portion or the entire building. The roof of a reinforced concrete structure could be made of structural steel supports (trusses). Furthermore, the structure of the building could be made of structural steel. Universal beams (I beam), sections (H column), Rectangular Hollow Sections (RHS), Circular Hollow Portions (CHS), angle sections, and other structural steel components are available. Depending on the character of the structure, structural steel will be used as a building material.

Masonry Materials as Building Materials

Masonry is the most common partition material used in low-rise building construction. Due to the increase in structure load, low-weight partition materials are used as masonry wall replacements. There are essentially two kinds of masonry used in building construction.

- Brick
- Block masonry

Brick Masonry

Bricks are among the oldest building materials still in use today. Engineering brick is now widely used in construction. In addition, various types of bricks are used in the construction. In general, the strength of both the brick should be 10N/mm2. Brick masonry walls can be built in a variety of thicknesses, including 113.5mm, 225mm, and 300mm. Brick provides one of the best materials for protecting the structure while also maintaining comfort. The heating rate is also within the acceptable range.

Block Masonry

Brick masonry, block has become one of the most popular building materials used in moderate construction. Blocks come in a variety of widths, including 100, 125, 150, and 200mm. They can even be reduced. The thickness of plaster and mortar is greatly reduced when block walls are built.

Aluminum

With the increasing demand for construction and the inability to produce materials such as timber, aluminium is a widely used structural material in today's construction. It is made of eco-friendly materials, and the impact mostly on ecosystem is minimal in comparison the use of a timer. Aluminum is not particularly strong, so it has been strengthened by the addition of other alloys such as copper, magnesium, zinc, and so on. Aluminum products come in various grades with varying strengths. The material should be chosen based on the application. Furthermore, the various profiles created with aluminium increase its strength while also fulfilling the function of the profile section.

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CHAPTER - 4

STRUCTURES AND DESIGN GRANTED FOR BUILDING

Dr. Nakul Ramanna Sanjeevaiah, Professor and Head,
Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India
Email Id- nakul@presidencyuniversity.in

The foundation of the structural analysis, design, and detailing work that a structural engineer intends to deliver in delivering the structural scheme of the buildings that will be compatible with the architectural theme, satisfy the functional needs, while also conforming to the Indian Standards and other applicable building standards to achieve safe, stable, strong, and yet optimally economic structures [1].

RCC Structures

"Reinforced cement concrete" is what the term RCC stands for. Concrete performs better in compression than it does in tension. Steel reinforcing bars are used in conjunction with concrete to increase the ductile resistance capacity of the structure. Because of the good bonding properties of steel and concrete, this is the most common building construction concept and is widely used by engineers. RCC is considered the best material for low-rise buildings material for construction. In India, all process and operational for RCC structures are based on the IS:456 Codebook. The term "reinforced concrete structure" refers to members made of concrete and steel bars, such as beams, signage, columns, and roof trusses. The steel bars in these structures are enwrapped in concrete, and though their mechanical properties will still be lost if the structure is destroyed by fire [2]. Reinforcing schemes are typically designed to withstand tensile stresses in specific areas of the concrete that could result in unacceptable crack formation and/or structural failure. Modern reinforced concrete can include a variety of reinforcing materials such as steel, polymers, or alternate composite materials in addition to or instead of rebar. Reinforced concrete can also be permanently stressed (concrete in compression, reinforcement in tension) to improve the final structure's behavior under working loads. The most popular approaches in the United States are the pre-tensioning and post-tensioning [3].

Steel Structures

Steel structures are created when fabricated steel or Structural steel is used as a building material. Steel buildings in India use various types of steel shaped members such as I-sections, angle sections, and channel sections. Steel structures are metal structures made of structural steel* components that connect to carry loads and provide comprehensive rigidity. Because of the high strength hardened steel, this building is dependable and uses fewer raw materials than other types of structures such as concrete and timber. Steel structures are used in almost every type of structure in modern construction, including heavy industrial buildings, high-rise buildings, equipment support systems, infrastructure, bridges, towers, airport terminals, heavy industrial plants, pipe racks, and so on [4]. Because it is a lightweight material, it is extremely useful in earthquake-prone areas. The members are pre-fabricated in factories in various shapes and sizes based on site requirements. This also leads to faster construction. Steel structures are primarily used to build industrial roofs and sheds. However, there are several drawbacks to using structural steel as a building material for posts and beams in buildings [5].

Composite Structures

Composite structures are load-bearing elements (e.g., stiffeners, panels, shells, etc.) made of materials that are typically non-metallic non-homogeneous fiber-resin combinations. Composite materials have increasingly replaced metals in many functional applications aircraft, aerospace, combat equipment, automobiles, civil infrastructure, healthcare products, and sporting equipment over the last several decades. A composite material is essentially a mixture of two or more different materials, each with its own distinct properties. On a micro scale, multiphase metals are composite materials, but the term composite is generally applied to materials formed by mechanically bonding a number of distinct materials together. The resulting material has properties that are not shared by the constituents in isolation [6].

Adding straw to silt to make stronger mud walls is one example. Most composite materials have a continuous bulk phase called the matrix and a dispersed, non-continuous phase called the reinforcement. Concrete (cement mingled with sand and aggregate), prestressed concrete (steel rebar in concrete), and fiberglass are some other examples of basic composites (glass strands in a resin matrix). The high stiffness is provided by the fibres, while the surrounding polymer resin matrix keeps the structure together. The bulk phase accepts the load over a large surface area and transfers it to the reinforcement material, which can carry a greater load, according to the fundamental design concept of composites. The significance here is that there are countless matrix materials and fibre types that can be combined in an infinite number of ways to produce the desired properties. These materials were initially developed for use within the aerospace industry because they have a higher hardness to weight or intensity ratio than metals in certain applications.

On a micro scale, composites that meet the mechanical bonding criteria can be produced. For example, tungsten carbide powder retains its identity when mixed with cobalt powder and then squeezed and sintered together. The resulting material has a smooth cobalt matrix surrounded by tough tungsten carbide particles. This material, known as a metal-matrix composite, is used to make carbide drill bits. A metal matrix composite is a metal that has been reaffirmed with another substance to enhance strength, wear, or other properties. When a concrete member and a steel component, such as a steel plate or an I-section, are used together in a way that forces and stresses are transferred, the member is said to be composite moments in them in order to fully benefit from steel in strain and concrete in tension. Compression is used in tandem to maximize the capabilities of both.

Composite Slabs

The composite slab's final stage consists of a profiled steel sheet and an upper concrete topping that are interconnected in such a way that horizontal shear forces can be rebuffed at the steel-concrete interface. Steel beams support the composite slabs, which normally act in tandem with the concrete slab. The use of profiled steel sheeting unquestionably expedites construction. It is also frequently used in conjunction with concrete mixtures to reduce dead load caused by floor construction. Composite slabs are made up of profiled steel decking and an in-place reinforced concrete topping. The decking not only serves as a permanent formwork for the concrete, but it also provides a produce the goods concrete surface so that, once the concrete has gained force, the two materials act compositely. It is a combination of load bearing but also framed structure that allows the benefits of both types to be enjoyed. Outer walls are load bearing in this type, and internal supports take the form of a column. Load-bearing walls and internal columns support the roofs and floors. This type of structure's design and construction may become difficult and complex. A composite structure is one that contains steel and concrete elements that resist loads through a joint action (that is, by pooling about their respective strengths). The composite structure is commonly used for industrial shelter or warehouses with very long spans.

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CHAPTER - 5

STRUCTURAL PERFORMANCES OF THE BUILDING

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

Any structure must have the fundamental structural capabilities in order to sustain its performance for the protection of property as well as to safeguard health welfare, latent construct, and comfort from outside influences. According to this standard, safety, reparability, and maintainability are fundamental structural requirements that, in that order, preserve people's lives, property, functions, and comfort [1]. To ensure the safety of everyone within and outside the building, safe functioning is required. The safety verification process assesses whether or not the land, equipment, furniture, and constructed assets can be used without jeopardizing human safety or inflicting damage. To make it simple to repair any damage to the structure brought on by outside forces, durability requirements were created (protection of property) [2]. Reparability verification assesses whether deterioration or destroy to steel beams, building components, equipment, furniture, as well as the soil is appropriately managed within a fixed range in terms of ease of fix, including the restoration of institutional performances, challenges of repair works, repair costs, and economic loss.The purpose of mandating serviceability is to provide comfort and safety while residing in the structure. The serviceability verification determines whether the structural frames, building elements, equipment, furniture, and ground are sufficiently protected against malfunctions and sensory disorders [3]. These three performances are inextricably linked.

The five criteria listed above were chosen since there are so many fundamental structural performance products to analyse. Although institutions frames and components have traditionally been the main assessment items, this standard also considers the ground, equipment, and furniture in light of the extent of the 1995 Tohoku Nanbu Earthquake's devastation. The structural frames are the foundation and superstructures. Although foundations and superstructures have typically been considered independently, this guideline combines underpinnings into structures to assess a building's overall performance [4]. Foundations are considered to be structural components. Other than equipment and furniture, building elements comprise structural parts along with interior and external non-structural components that compose the building structure. These five assessment artefacts do not stand alone entirely. The locations of concrete elements and the ground must be considered while assessing structural frameworks. The structural frame are a collection of structural parts, and each component is thoroughly evaluated as a whole [5].

Limit states

The limit phases of quality measurement items for the important structural capabilities of safety, reparability, & serviceability, respectively, are the protection limit state, generally limit state, and efficiency state. Each performance assessment item's state is expressed by a general notion known as a limit state, which is also known as a constructing state for conveying systemic risk. a list of each evaluation item's limit states. For instance, the rejection of destruction that blatantly endangers human life is characterized as the safety limit condition of a frame structure. Additionally, it is stated in the building item's safe level that construction material spills or fallout that endangers human life should be avoided at all costs. The likelihood of an evident risk to humans determines the safety limit [6].

Frames must maintain their ability to support vertical loads and must not tumble or collapse. Elements must not detach and spread out. Equipment and furniture must not tumble, fall out, or continue to move. The foundation cannot decay, degrade, or distort to the extent that it compromises the structural framework. The level of structural damage and how simple it would be to repair and reconstruct the structure both affect how much damage can be repaired. Allowable ranges for each examination object are specified. The comfort and features of the building define its serviceability limit. It is established and maintained that certain distances must not result in malfunctions or sensory problems.

Loads and external forces

It is necessary to take into account the loading, live load, wind loads, wind, seismic motion (tremor load), other piles, external pressures or disruptions from the ground, heat, etc. The load and external force levels utilized in calculations must be higher than those allowed by code, acceptable for the building's performance, and consistent with the expected loads and environmental stimulus frequencies over the course of the building's service life. It is important to consider the load wavelengths brought on by geographical as well as environmental factors. The majority of the time, extremely unusual large volumes and outside occurrences are employed to confirm safety. Rare loads and external forces are used to confirm reparability, and common load and forces are used to judge serviceability. As mentioned in the section above, the owner and mechanical designer should decide on the bitrates from both forces and pressures concurrently depending on the use and significance of the building. The code's minimum frequency requirements must be adhered to. By directly assessing the frequency of loads and forces throughout the simulation, it is possible to determine the intensity of loads with external factors in relation to the structural and functional levels a structure's usefulness. Basic burden and applied external levels may be estimated for the assumed frequency.

Structural performance levels

Building owners and structural engineers should decide on the levels of the social performance at the same time. If there are any levels that are suggested by code, they should never be lower. Structural performance levels for each measuring function item are given as a combination of limit states, loads, and/or external pressure strengths. The landlord and the structural designer should decide on the levels of the social performances concurrently while taking into account societal pressures, cultural and financial conditions, and the owner's preferences. These levels reflect the degrees of safety, reliability, and ease of maintenance. The Japanese Building Quality Law establishes minimal standards for structural performance that must be reached while taking into account societal restraints and technical advancements. When determining performance levels, it is important to take into account the building's use, significance, and lifespan as well as any changes in load brought on by ageing, the technical and financial ease with which performance can be improved, the risk to human life, and the financial, social, and environmental repercussions that result when measuring performance items fall below the minimum standard.

The structural designer may be able to identify the levels of the structure's performance in partnership with the owner by carefully taking into account these assessment variables and criteria. The expanded capacity should take the lead in choosing performance levels since it is better knowledgeable about structural technologies and function than the owner, who should theoretically set the levels of structural performance. The structural designer must provide the owner enough details so that they may decide on the suggested levels in a well-informed manner.

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CHAPTER - 6

STRUCTURAL PERFORMANCE LEVELS

Ms. Anju Mathew, Assistant Professor,
Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India
Email Id- anjumathew@presidencyuniversity.in

The load-deflection property of a frame structure can be controlled to set its performance at any level. Structural designers will determine the properties of structural frames based on the performance requirements of the owners and design structures accordingly. Control of structural frame properties is critical in developing constructions to meet performance levels. More technological advancement is expected [1].

Seismic and Wind Loads

Response spectrum analysis is used to determine a structure's maximum response in the event of displacements, story shears, and story drifts. Seismic motion is made up of horizontal and vertical ground acceleration, with the inclination angle typically providing resistance to gravity loads. In practice, however, all structures are adaptable to some extent. Wind loading on a tall building acts not only over a larger surface area, but also with greater intensity as height increases and with a larger moment shoulder about the base than on a low rise building. Wind loading on a low-rise building has no effect on the structure's design; however, wind loading on a tall place can have a significant impact on its structural arrangement and design [2].

A wind load is the most common lateral load. The Eiffel Tower is one illustration of a structure that was made to withstand high wind loads. When wind blows against a building, it creates positive pressure on the windward side and negative pressure (or suction) on the leeward side. It may also cause negative tension on the side walls or even on the roof, depending on the shape of the structure. The pressure on the walls and roof varies across the surface rather than being uniform. Winds can cause loads to be applied to structures from new directions. As a result, a designer must be acutely conscious of the risks that this lateral load implies [3].

a designer can be well aware of the dangers that this lateral load implies. The magnitude of the pressure acting on the areas of skin is proportional to the wind speed squared. Wind loads vary from place to place. National weather services' meteorological data is one of the most trustworthy sources of wind speed. Geographic location, elevation, degree of exposure, correlation to nearby structures, building height and size, direction of wind direction, velocity of prevailing winds, and positive or negative stressors due to architectural design details are all factors that influence wind load (atriums, entrances, or other openings). All of these factors are considered when calculating the lateral forces on the facades [4].

For the purposes of this course, wind loads and the pressures they exert on wall and roof factors will be assumed to be static and uniform. They not only pound a structure with only a constantly vibrating force, but they also increase as a building's height increases. An equally distributed load can be used to approximate the loading of something like a tower. It's called a vertical cantilever. You can investigate the variables that influence the structural behaviour of a tall, thin tower using the applet below. It does not represent real-world methods for calculating total air flow on a tall building. Its purpose is to demonstrate this same interaction of the variables in the equations that govern structural behavior. Compression waves and rotational waves are two types of waves. These waves generate a large shear force or longitudinal stress at the ground level, but this load is scattered towards the upper floors due to the buildings' inertia. But even so, no earthquake load straightforwardly acts on the upper floor, but the occupants feel jolted. As a result, earthquake load is just an induced load. According to Newton's first law, every object prefers to remain in the same country until and if it is forced to submit to external loads. Can be define earthquake load as inertial load [5].

A passenger in the back seat of a car feels pushed backward. However, directly pushed back by any external influence. This can be compared to the force felt on the upper floor, but no clear load is responding on that floor. Both the backward push felt by a person sitting in a car when it starts moving forward and the jolting felt by a person in a building during an earthquake are inertial forces. Despite the fact that both forces are dynamic within nature. In the event of a cyclone, people such as fishermen and those working on the water's edge are warned ahead of time. People living in any building can also be relocated to a safer location if their buildings are unable to resist the strong wind. However, earthquake prediction is impossible. Its precise phenomenon in terms of date, time, and location is still being investigated by geologists and scientists. Nobody can predict only the exact date and time of fault dislocation and tectonic plate relative moment. As a result, if an earthquake coincides with a tsunami, many people are killed on the seashore. If it is feasible to predict, people on the beach can be saved [6].

Although geologists can predict its occurrence based on previous seismic activity and the existence of slip planes or tectonic plate boundaries. Any of the two might be more severe and life threatening based on their intensity, but because earthquakes cannot be expected with exact date and timing, we can say earthquakes are more dangerous. Whichever is scarier, individuals are encouraged to build structures that can withstand earthquakes and strong winds that have been specified according to the earthquake zone and wind zone for a specific area.

Project Cost Estimation

One of the most essential stages in project management is cost estimation. A cost estimate affirms the baseline cost of the project at various stages of development. A cost estimate at a specific stage of project development is a prediction made by the cost technologist or estimator based on available data. Cost engineering, according to the American Association of Cost Engineers, is defined as the area of engineering practice in which engineering judgement and experience are used in the implementation of science principles and methods to the problem of cost estimation, cost control, and profitability.

Production function

The production function is the relationship between output of a process and the necessary resources in microeconomics. The friendship between the labor volume of construction and a sector of the economy such as labour or capital can be used to express the production function in construction. A production function connects the amount or number of units produced to the various labour, material, and equipment inputs. For example, using mathematical and/or statistical methods, the amount of output Q can be calculated as a function of different data factors X1, X2 to Xn. Thus, for a given level of income, we can try to find a set of input factor values that minimizes the production cost.

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CHAPTER - 7

SCRAP VALUE ESTIMATION

Dr. Shrishail B Anadinni, Professor and Associate Dean (Core Branches),
Department of Civil Engineering, Presidency University, Bangalore, Karnataka, India
Email Id- shrishail@presidencyuniversity.in

The projected price at which a fixed asset may be sold after accounting for all depreciation is known as scrap value [1]. The commodity that is sold is commonly separated into several pieces, each of which is appraised and sold individually. A physical asset's scrap value is established when scrap value of a physical asset is established when any of its component parts are no longer functional. Scrap, or component pieces, have value if they've been put to other uses. While certain scrap materials can be utilized without processing, this is not always the case [2]. The scrap value is determined by the demand and deliver of scrap materials. It is the estimated price at which a plant or machinery can be marketed after depreciation. The asset is typically disassembled into its constituent parts, with each component prized and sold separately.

Types of Building Materials Used in Construction

There are several types of construction material which are used in the construction which are illustrated below:

Natural Construction Materials

The two main types of construction materials are natural and synthetic materials. Building fibres are materials that have had minimum or no industrial processing, such as sawn wood or glass. Examples of artificial material produced in industrial settings following intensive human modification include plastics and paints made from petroleum [3]. They both have their uses. Mud, boulders, and fibrous plants are the most basic materials, except from tents constructed of flexible raw materials like fabric or skins. These three have been combined by people all around the world to construct dwellings that are suitable for the local climate. In these constructions, stone and/or wood are typically utilised as the fundamental technical structures, with mud covering in the spaces as a sort of concrete and insulation. For instance, ancient northern peoples frequently employed wattle and daub as season frames or as permanent houses in tropical areas [4].

Fabric

In the past, nomadic groups all across the world favoured the tent as their primary residence. Two popular designs are the yurt and the conical teepee. It has been brought back to life as a significant building technology with the invention of tension design and synthetic textiles. A steel cable or an inside support system (air pressure) can support structures made of flexible materials like cloth cellular membrane.

Mud and clay

Depending on how much of each particle is utilised, different construction styles are produced. Usually, the soil's quality is what makes the difference. Cob/adobe building is often linked with soils with high clay content, while sod construction is usually associated with soils with low clay content. Numerous quantities of straw and grasses and sand/gravel are further important components [5]. Building walls with rammed earth is both an old and new technique. Clay soils were formerly manually compacted between boards, but today forms and mechanically pressurised compressors are employed instead. Clay-rich soil in particular has a large thermal weight and is very good at preserving steady temperatures. Earthen houses are naturally warm during the winter and cool in the summer like stone, clay also absorbs heat or cold but slowly releases it. Because clay walls change temperature more gradually than, instance, a wood-framed building, it takes more energy to artificially raise or reduce the climate, but even the heat/coolness lasts a long time. Homes have been constructed for millennia throughout northern and southern Europe as well as in remainder of the globe using materials mostly made of earth and cement, such as corn, sod, or adobe, and they continue to be constructed on a lesser scale. Some of these buildings have been occupied for countless years [6].

Rock

As far back as history goes, there have always been rock formations. It is the strongest material for construction and is often accessible. Around the world, there are several distinct varieties of rock, and each has certain qualities that make them more or less suitable for particular uses. Rock is a solid substance that offers a lot of protection, but its biggest drawbacks as a material are its bulk and jitteriness. Its high energy level is also seen as a major drawback because stone is difficult to keep warm sans spending a lot on reheating. As long as people have stacked stones one upon another, dry-stone structures have been constructed. The stones were eventually held together by various types of mortar, with cement being the most used nowadays. For instance, the marble uplands of Moorland National Forest in the United Kingdom offered plenty of resources for the first inhabitants. During the Neolithic and later Bronze Age, loose granite boulders were used to build round cottages; the ruins of an approximately 5,000 of these structures may still be visible today. Throughout the mediaeval era (Dart moor Dilapidated shack) and into the current day, granite remained popular. Another form of stone is slate, which is frequently used for roofing in the UK and other places where it is available. Most big towns have structures made mostly of stone, while other civilizations, like the Incas and the builders of the Egyptian and Aztec pyramids, constructed their whole civilisation out of stone.

Thatch

Among the first materials that have been discovered is thatch; grass is a great insulator and is simple to gather. Many African tribes maintain year-round habitation in buildings built completely of grass. In Europe, thatch roofs were previously popular, but they lost favour as alternative roofing materials became more accessible due to mechanisation and advancements in transportation. However, there is presently a rebirth of the practise. For instance, many new residences in the Netherlands feature distinctive ridge slabs that are covered with green roofs.

Brush

A typical sight in tropical and tropical regions, such as the tropics, where very huge leaves may be utilised in the building, are brush constructions, which are totally built of plant components. Native Americans often built brush structures for living and sleeping. These are similar to a badger's lodge and are mostly constructed out of branches, twig, leaves, and bark. These constructions were known by various names, such as wickiups and lean-tos.

Wood

When it is chopped or pressed to timber and timber such as board, planks, and similar materials, wood, a byproduct of pines and other fibrous plants, is utilised in building. It is a universal material that could be utilised to build practically any form of structure for the majority of climates. When crushed vertically, wood is incredibly strong. It may also be extraordinarily flexible under pressures, maintaining strength while bending. A variety of wood types have a broad range of characteristics, even within a single tree species. This implies that certain species are more suitable than others to particular purposes. Growing circumstances have an impact on quality as well.

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CHAPTER - 8

EFFECT OF COPPER SLAG ON STRENGTH PROPERTIES OF EXPANSIVE SOIL

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

It is crucial to understand the engineering qualities of the soil or rock since they will ultimately bear the burden of any construction on Earth. Because they lack engineering qualities, weak soils including loose sand, soft clays, expansive soil, or organic deposits are not appropriate for the building [1],[2].

Black cotton soil covers a large area of India. In the presence and absence of moisture, it has extreme swelling and high shrinking qualities. As a result, it is very unstable in all climatic zones. Black cotton soil is considered one of the troublesome soils for many civil engineering constructions because of this. Montmorillonite, a clay mineral, is in charge of the expanding properties. While illites and vermiculites may be expansive, they often do not cause significant issues. Kaolinite is typically not expansive.

Before beginning any work, the construction engineer must consider the soil's strength, permeability, and volume change. Therefore, if the current soil has all of these desirable qualities, one may proceed; otherwise, one must either replace the current soil with a better one or modify its characteristics. Stabilization of the soil is the process of changing its qualities of the soil [3], [4].

Stabilization of Soil

Before building, the physical characteristics of the soil are changed via a procedure called soil stabilization. When materials, design, or construction are correctly taken into consideration, stabilized soils perform better than nonstabilized soils. The succeeding layers might be thinner and there will be significant financial savings when the stabilized soil layer is included in the structural design of the pavement. Stabilized soil not only increases strength but also creates a solid monolith, reducing permeability, shrink/swell potential, and the negative consequences of freeze/thaw cycles.

In situ or in their natural form, soils may be improved via soil stabilization, which eliminates the need for expensive remove-and-replace procedures. Naturally moist, weak soils are often present on construction sites where roadways, building pads, parking lots, runways, or other surface structures need to be developed. These soils may be chemically modified to increase their engineering qualities, such as moisture content and flexibility, and to enhance strength via stabilization. Ex situ, or even off-site, soil stabilizing procedures are technically feasible but are often designated for environmental initiatives as opposed to regular building work [5], [6].

Adhesives Used To Stabilize Soil

There are additions like Baggage Ash, Fly Ash, GGBS, Lime, etc. that change the black cotton soil's current qualities. A by-product of coal-fired power plants, fly ash is a thin, grey powder made mostly of spherical, glassy particles. Pozzolanic characteristics of fly ash allow it to interact with lime to produce cementitious compounds. It is often referred to as an additional cementitious substance. Concrete, flowable fill, dams, mines, landfills, mines, or geopolymer concrete are just a few of the many uses and applications for fly ash. Flue ash and "ash" are other names for fly ash.

Ash from bagasse, a waste product of the sugar industry. It is a substance that comes in powder form and is comparable to fly ash, although the two materials' particle shapes are different. Due to the burning process and the existence of unburned carbon particles, it is often black. Comparatively speaking, ground bagasse ash has a low specific gravity of 2.31 to 2.68. It has a density range of 1.85 to 2.65 g/cm3. The specific gravity of bagasse ash decreases with an increase in LOI value. Bagasse ash is made up of erratic, abrasive particles. Bagasse ash particle size and surface roughness both rise with an increase in LOI value. Bagasse ash had a comparable particle size distribution to regular Portland cement. Bagasse ash has a particle size range of 0 to 100 mm.

A by-product of the blast furnaces used to create iron, GGBS ("Ground Granulated Blast-furnace Slag") is a cementitious material that is mostly utilized in concrete. About 1,500 °C is the operating temperature of blast furnaces, which are supplied with a precisely regulated combination of limestone, coke, or iron ore. The leftover components create a slag that floats on top of the iron once the iron ore is converted to iron. A by-product of blast furnaces, which are used to produce iron. This slag is regularly tapped out as a molten liquid and must be quickly cooled in a lot of water if it is to be employed in the production of GGBS. Quenching generates granules resembling coarse sand and optimizes cementitious characteristics. After drying, the granulated slag is crushed into a fine powder.

The main components of lime, an inorganic mineral that contains calcium, are oxides and hydroxides, often calcium oxide and/or calcium hydroxide. As a byproduct of coal seam fires and in altered limestone xenoliths in volcanic ejecta, calcium oxide is also known by this term. Lime is a mineral having the chemical formula CaO, according to the International Mineralogical Association. The meaning of the term lime derives from its early usage as mortar in construction. These materials continue to be utilized extensively as chemical feedstocks, construction, and engineering materials (including concrete, cement, limestone products, and mortar), as well as for the refinement of sugar and other things.

This research evaluated the behavior of copper slag- and lime-treated extremely expansive clay in a laboratory setting under static and cyclic loading. In this investigation, the copper slag, a by-product of the smelting and refining of copper, was utilized as a stabilizing agent. The hydrated lime powder was employed as an additional ingredient to increase the copper slag's pozzolanic activity. To explore the behavior of the clay treated with various ratios of copper slag and lime in the admixture content, extensive laboratory experiments including Atterberg limits, California bearing ratio (CBR), free swell, or unconfined compressive strength (UCS) tests were conducted. The X-ray diffraction test was used to examine the morphological change in the soil after stabilization. The findings of the CBR and UCS tests were used to determine the ideal amount of admixture. The strength requirement led to the discovery of the optimal stabilizer content, which was discovered to be copper (Cu) slag and lime at a 1:1 ratio, producing 12.5% admixture content by weight. The findings of the X-ray diffraction (XRD) examination showed that the soil structure underwent significant modifications throughout the curing process. To ascertain their dynamic qualities, the stabilized soil samples were also exposed to dynamic loading. According to the research, stabilizing expansive soil with copper slag and lime enhances both its static and dynamic qualities by decreasing swelling and boosting shear strength. Additionally, by measuring the robust modulus, the behavior of the stabilized soil under fatigue stress was examined. The findings demonstrate that stabilizing clay soil with 12.5% admixture increased the soil's dynamic shear modulus by approximately 30%, damping ratio by about 56%, and resilient modulus by about 104%, demonstrating the soil's improved dynamic behavior.

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CHAPTER - 9

TYPES OF SOIL STABILIZATION

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

In order to stabilize soil, changes must be made to the soil's physical composition. Unstabilized soil often has larger particle sizes [1],[2]. A road building project cannot utilize such soil because it would sink as a result of its incapacity to support the weight of the vehicles. Additionally, the craftsmanship is removeable with running water [3],[4]. Therefore, stabilization aids in increasing the soil's strength. Because the soil's particles have been reduced in size, compacting the soil is also made simpler. Soil may be stabilized using a variety of techniques and substances. Geotextiles, electricity, lime, cement, chemicals, and bitumen are among them [5],[6].

Using Cement to Stabilize Soils

Cement may be added to soil to stabilize it. The cement has active components that facilitate the breakdown of soil particles. In addition, the cement aids in hiding the dirt. Fly ash, sodium carbonate, calcium chloride, lime, sodium sulphate, and calcium chloride are additional ingredients added to the combination. The kind of soil that is being stabilized determines how much cement is added to the mixture. 10% is suggested for gravel, 12% for sand, 15% for silt, or 20% for clay soil. This is due to the distinctive composition and structure of each kind of soil.

Lime Stabilization of Soils

Clay soils may be stabilized by lime. In fact, you may use it alone and still get flawless results. Lime aids in reducing soil plasticity when used with any kind of soil. This implies that it cannot expand or contract. Because there is no room between the particles, such soil absorbs extremely little ground water. On such a surface, driving a vehicle is possible without running the danger of being stuck. This is because unlike other forms of unstabilized soils, the soil cannot extend as you would anticipate.

Using Bitumen to Stabilize Soils

Bitumen compounds may be added to the soil while building roadways and parking lots. Because bitumen is naturally sticky, it aids in binding the soil particles together. Because of the way bitumen is structured, a sturdy layer is formed above the soil that prevents ground water from being absorbed.

Chemical Stabilization of Soils

This process includes introducing chemicals into the soil, as the name would imply. These chemicals interact with the soil, altering its structure in the process. Chemicals fill in the gaps between particles, preventing water from penetrating them. Sodium chloride, calcium chloride, and sodium silicate are some of the most popular compounds used to stabilize soil. Polymers, chrome lignin, alkyl chlorosilanes, siliconites, amines, and quarternary ammonium salts are a few more compounds that are introduced to the soil.

Cement Soil Stabilization

Soil cement is the name given to stabilized soil. The chemical interactions between cement and siliceous soil during the hydration process are thought to be the cause of the cementing activity. The kind of soil included in the cement, the circumstances of mixing, compaction, curing, and admixtures utilized are the key influencing elements. Following are examples of recommended cement dosages for various soil types:

- Gravels: 5–10%
- Sands: 7–12%.
- 12 to 15% for silts and 12 to 20% for clays.

For the stability of soil in tropical climates, the amount of cement needed should typically be adequate for a compressive strength of 25 to 30 kg/cm2. If p percent of weight of cement on the basis of dry soil is needed to stabilize a layer of soil with surface area A (m2), thickness H (cm), and dry density rd (tonnes/m3), the cement mixture will be

Chemical Soil Stabilization

As a water-retentive ingredient in mechanically stabilized soil bases and surface, calcium chloride, which is hygroscopic and deliquescent, is utilized. Surface tension rises, the vapor pressure drops, and the rate of evaporation reduces. Frost heave is prevented or reduced as a consequence of the decrease in the freezing point of pure water. By lowering the electric double layer and reducing water uptake, salt prevents fine-grained soils from losing strength. Compaction is aided by calcium chloride's role as a flocculant for the soil. Calcium chloride may need to be applied often to make up for the chemical loss caused by leaching activity. The atmosphere's relative humidity has to be more than 30% for the salt to work. The second chemical that may be utilized for this is sodium chloride, which has a stabilizing effect comparable to that of calcium chloride. In addition to other compounds including polymers, chrome lignin, amines, calcium chloride, alkyl chlorosilanes, siliconites, or sodium hexametaphosphate, quarternary ammonium salts, and phosphoric acid mixed with a wetting agent, sodium silicate is also employed for this purpose.

Other Techniques

You may also use electricity to stabilize your soil. For clay soils, the procedure, known as electro-osmosis, is strongly advised. The strategy will, however, make you work for your money since it is so expensive. You may also enclose dirt in bags made of linen or plastic. This method, however laborious, aids in compacting the soil and splitting it up into tiny pieces. The technique is perfect for unpaved roads.

There are many techniques for soil stabilization. The approach you use will depend on the kind of soil present at the project location. You need look no farther than Hasten Chemical for the best soil stabilizing partner. Humans are experts in soil, and our track record speaks for itself. Humans are without a doubt Texas' top soil stabilization business. In fact, we are the world's top provider of soil stabilization supplies. When you give us your project, we'll do it within your specified budget without sacrificing quality. Calcium chloride, soil stabilizers, oil and gas, adhesives and sealants, alcohols, rubbers, or carbon are just a few of the numerous things we provide.

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CHAPTER - 10

COMPONENTS OF STABILIZATION

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

To increase the geotechnical attributes of poor soils, including compressibility, permeability, strength, and durability, stabilizing agents (binder materials), are used. Soils, soil minerals, or stabilizing agents or binders are among the elements of stabilization technology (cementitious materials) [1],[2].

Soils

To attain desired engineering qualities, stabilization must be done mostly in soft soils (clayey peat, silty, or organic soils). Due to their vast surface area in comparison to their small particle diameter, fine-grained granular materials are the simplest to most stable. Due to its flat and elongated particle morphologies, clay soil has a larger surface area than other types of soil. On the other hand, silty materials may be challenging to stabilize since they might be sensitive to even modest changes in moisture [3],[4]. Peat and organic soils have significant levels of porosity and organic matter, as well as water contents that may reach over 2000%. In most circumstances, the deposit is superficial, but in the worst cases, it may extend to several meters below the surface. Peat soil can range in consistency from muddy to fibrous. Due to their high exchange capacity, organic soils may impede the hydration process by holding onto the calcium ions released during the hydration of calcium silicate and calcium aluminate in cement. The right kind of binder and the quantity of binder supplied are essential for effective stabilization in such soils [5],[6].

Stabilizing Substances

These substances, either hydraulic (primary binders) or non-hydraulic (secondary binders), combine with water when they come into contact with it or when pozzolanic minerals are present to create cementitious composite materials. Cement, lime, and fly ash are the most often used binders.

Cement

The use of cement as a binding agent dates back to the 1960s when soil stabilization technology was first developed. Because it may be employed by itself to provide the necessary stabilizing effect, it may be regarded as the principal stabilizing agent or hydraulic binder. The main factor in cement reaction, which may occur in any soil and is not reliant on soil minerals, is its interaction with water. This may be the cause of cement's widespread usage in soil stabilization. There are several different varieties of cement available on the market, including regular Portland cement, cement from blast furnaces, sulfate-resistant cement, and high alumina cement. Typically, the ultimate strength sought and the kind of soil to be treated determine the cement to be used. The cement reaction takes place during the hydration process. The process begins when cement is combined with water and other ingredients for a specific application, which causes a phenomenon known as hardening. Cement will encapsulate soil like glue after it has hardened (set), but soil structure won't be altered. The cement granules' centers may not get hydrated because the hydration process moves slowly from the cement grains' surfaces. A complicated set of unidentified chemical reactions take place throughout the intricate process of cement hydration. On the other hand, this procedure may be impacted by

- The proportion of water to cement,
- A mixture's particular surface,
- The presence of foreign substances or contaminants,
- The water-to-cement ratio,
- The curing temperature,
- The presence of additives

The final impact on the setting and increase in strength of cement-stabilized soil may differ depending on the factor(s) involved. To reach the necessary strength, this should be considered while designing the mix. The two primary cementitious components of regular Portland cement, calcium silicates (C3S & C2S), are in charge of developing strength. Another hydration byproduct of Portland cement is calcium hydroxide, which interacts with pozzolanic components in stabilized soil to form more cementitious material. In most cases, a tiny quantity of cement is applied, but it is enough to enhance the soil's engineering qualities and the cation exchange of the clay. Enhanced characteristics of cement-stabilized soils include the following.

- Reduced volume expansion or compressibility.
- Decreased cohesion (Plasticity).
- Enhanced strength (PCA-IS 411, 2003).

Lime

Lime is an affordable soil stabilization technique. In contrast to a cementing effect brought on by the pozzolanic reaction, a strengthening influence brought on by cation exchange capacity is referred to as "lime modification." Natural clay particles with a plate-like shape that naturally flocculate into metalline formations with needle-like connections are used to modify soil. Clay soils acidify and become less susceptible to changes in water content. A pozzolanic reaction in which cementitious chemicals are produced when lime and pozzolana minerals interact in the presence of water is known as "lime stabilization." The intended outcome may be achieved with either hydrated lime ($Ca(OH)_2$) or quicklime (CaO). Slurry lime may also be used in dry soil settings when water may be required to generate proper compaction. The most prevalent kind of lime is quicklime, which is superior to hydrated lime in the following ways. A greater amount of free lime is accessible per unit mass; denser than hydrated lime (needs less storage space) and has less dust.

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CHAPTER - 11

CLAYEY SOIL ELECTRICAL STABILIZATION

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

The electro-osmosis technique is used to electrically stabilize clayey soils [1],[2]. This labor-intensive technique for stabilizing soil is primarily used to allow cohesive soils to drain. An earlier study on asphalt-based grouting material found that although the component's concrete is at room temperature during the grouting stage, the posttensioned concrete structure utilizing that material has a comparatively high slurry temperature [3],[4]. When the temperature stress surpasses the concrete's tensile strength and causes cracks to form on the inside or outside of concrete components, the durability of concrete structures is compromised. In order to measure temperature stress in the test beam under different circumstances, sensors were installed in the test beam before concrete was poured. The sensors were used to monitor the temperature and temperature stress near the duct at various slurry temperatures. Each scenario's test lasted 30 minutes, and data was read once every 1 minutes [5], [6].

Stabilizing Soil with Grout

Stabilizers are injected into the soil using this technique. Due of their limited permeability, clayey soils are not suitable for this approach. This technique of stabilizing soil is expensive. This technique works well for stabilizing underground zones with a relatively small footprint. The following categories apply to grouting techniques:

- Using clay grout
- Using chemical grout
- Grouting with chrome lignin
- Bituminous grouting and polymer grouting

Using Fabrics and Geotextiles to Stabilize Soil

Geotextiles are synthetic porous textiles composed of nylon, polyvinyl chloride, polyethylene, and other synthetic fibers. Geotextiles come in woven, non-woven, and grid shape variations. Geotextiles are very strong. It increases the stability of the structure when appropriately buried in the ground. It is used while building unpaved roads over softer soils. Incorporating metallic strips into the soil to stabilize it and giving a facing skin element a tie back or anchor. Information on Soil Stabilization. High strength geotextile fabrics are used for stability and reinforcing purposes, often to strengthen retaining walls or stabilize steep slopes. High strength geotextiles provide designers the option of creating steeper slopes, which results in a smaller base for the embankment but more usable space. It is resistant to chemical and biological conditions often found in soils, as well as UV deterioration. High-strength geotextiles aid in reducing the amount of differential settling brought on by various subsurface conditions.

- Roof grout serves as a representative of bitumen-polymer grouts since it may be utilized either as a standalone roofing material or as part of a seamless roofing system. Typically, grout is put in liquid form to a surface that has been previously prepared, and it then dries into a damp-proof coating that has no cracks or seams.
- The following ingredients make up bitumen-polymer grout: thermoplastic polymer (polymeric petroleum resin, synthetic rubber, etc.); binding agent (bitumen); filler; solvent; and additional additives.
- The material's flexibility, high strength, corrosion resistance, resistance to hostile media, resistance to oxidation or UV rays, lightness, and durability are all due to these precise components.
- Bituminous grout has the additional benefit of being able to be used on any surface, including concrete, steel, and ruberoid. To ensure a uniform thickness of grout coat, the surface of any layout should be completely flat.

Given the wide variety of roofing materials now on the market, it seems logical that the customer would be confused about which product to choose. Making a choice is made even more challenging by the fact that most characteristics, including waterproofing, flexibility, cold endurance, and heat endurance, are quite equivalent. Because of this, we suggest taking ageing resistance into account. The lifespan of bituminous grout is 20 years.

Before a project can begin, a site feasibility assessment is by far the most advantageous. Before the design phase starts, a site survey is often conducted to better understand the subsoil features so that the project's location may be chosen. When choosing a site, the following geotechnical design requirements must be taken into account.

- Design load and the structure's purpose.
- Foundation kind to be applied.
- Subsoil bearing capacity.

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This state of the art review focuses on soil stabilization method which is one of the several methods of soil improvement. Soil stabilization aims at improving soil strength and increasing resistance to softening by water through bonding the soil particles together, water proofing the particles or combination of the two. Usually, the technology provides an alternative provision structural solution to a practical problem. The simplest stabilization processes are compaction and drainage if water drains out of wet soil it becomes stronger.

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CHAPTER -12

EXPANSIVE SOIL STABILIZATION METHODS

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

Mechanical and chemical stabilizations are two approaches that are often used to stabilize soil. In an effort to maximize each advantage, one or both of the two techniques may be applied [1],[2]. Engineers advocate physicochemical alteration of the soil for expansive soils like clay to achieve durability [3],[4]. It follows that the swell-shrink consolidation volume fluctuations are calibrated by either preserving or enhancing the strength-related qualities for a prolonged duration, which is often accomplished by chemical stabilization [5],[6]. As a result, the usage of different additives was primarily covered in this study, however short descriptions of alternative strategies for stabilizing expansive soils were also included. In this situation, it is important to take into account how different soil stabilization strategies interact with one another.

Mechanical or physical method

Compaction

A common technique for treating expansive soil is compaction. In contrast to those started by long-term consolidation of soft clays, it employs mechanical techniques to expel air gaps from the soil mass so that the soil may sustain load later on without additional immediate compression. The optimal moisture content (OMC), which is acquired at a matching maximum dry density, is thus crucial for getting the moisture density relationship of soils (MDD). Nevertheless, in certain circumstances, depending on the site-specific circumstances and the objectives of the compaction process, it could be preferable to compress the soil close to OMC. Grain size distribution, grain shape, soil specific gravity, as well as the quantity and type of clay minerals in the soil are among the soil-dependent parameters that have a substantial impact on the OMC or MDD. Recent research has looked at how expansive soils respond to changes in density and moisture content.

Yan and Wu's (2009) experimental investigations on expansive soils revealed the effects of moisture or density on expansive force. Dry density but also expansive force were shown to have a positive exponential connection, but moisture content or expansive force had a negative exponential association. This conclusion is consistent with prior research showing that swelling potential often rises when dry density and water content both decrease. On a macroscopic scale as opposed to the microstructure, the impact of the compaction process on expanding soil mass is more noticeable. Mercury intrusion porosimetry microstructural studies on compacted bentonite-sand mixtures revealed that while the inter-aggregate pores varied at different dry densities (10 mm at 1.67 Mg/cm3 but also 50 mm at 1.97 Mg/cm3), the intra-aggregate pores with mean size diameter less than 0.2 mm were not affected by the soil dry density.

Pre-Wetting

Pre-wetting is an age-old technique that was often used in the past to reduce swelling in expansive soils. By establishing a wet atmosphere, which causes the soil to absorb water and expand, this approach floods expansive soils, resulting in a preconstruction heave. The basic idea behind this procedure is that soil saturating it leads it to expand, preventing repeated soaking from causing detrimental heaving and keeping consistent volume at such high moisture content. However, in field circumstances, maintaining the soil at high moisture levels continuously is far from possible, the pre-wetting results are not trustworthy, and it is not often advised.

However, this strategy has been successful when the pre-wetted soils have a high hydraulic conductivity, allowing the soaking process to be finished rapidly. Low values of hydraulic conductivity for expansive soils raise concerns about the efficacy of the pre-wetting technique, despite the conventional practice of using substances like organic compounds with a hydrophilic head and a hydrophobic tail, commonly known as surfactants, to speed up the water seepage process through the expansive soil layer. Pre-wetting has thus been utilized effectively in the Yazoo clay formation in Mississippi and the Hawthorne clay formation in Gainesville, Florida, in the United States.

Drying-Wetting Cycles

Wetting-drying cycles of the soil are often utilized for exploration of equilibrium conditions in fields due to the expansive soil volume change behavior. In a nutshell, a wetting-drying cycle entails saturating expansive soil with water until complete swelling is achieved, then drying the soil in a matching manner to restore its starting water content. Until an equilibrium condition is established, the cycle is continued until plastic deformation progressively stops occurring. Studies on the impact of wetting-drying cycles on expansive soils have produced contradictory findings. The effect of the wetting-drying cycle on the swelling behavior of an expansive soil was recently studied.

Reinforcement

By using fibrous materials, such as geosynthetics (such as geogrid, geotextile, geocomposite, geonet, and geocell) or randomly placed fibers of natural or synthetic origin, weak soils may be mechanically stabilized. For the purpose of weaving the soil grains into a unit mass with increased mechanical performance, it often necessitates the introduction of the aforementioned randomly or specially created components in the soil regime. Natural and synthetic fibers of various kinds and combinations are used to strengthen soil. A thorough analysis of synthetic and natural fibers for soil reinforcement has been conducted, and the impacts of several randomly dispersed fibers on soil engineering parameters are described.

Solid Wastes

Municipal locations can create significant amounts of solid trash. These wastes mostly consist of organic material and other materials such as wood, paper, glass, rubber scraps, plastics, reusable items, plant detritus, metals, and others. There are environmental issues associated with the management and disposal of such wastes generated in significant amounts, such as landfills. However, several of these compounds have been shown to be effective in applications for soil stabilization. When rubber crumb particles were added at a 25% concentration, the swelling potential of the soil was reduced from 3.71% to 1.37%, according to research on argillaceous marlstone. Studying the impact of recycled basanite, a solid waste made from waste plasterboard containing gypsum, on the resilience of soft clay treated with cement.

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CHAPTER -13

BLACK COTTON SOIL USING COPPER SLAG IN THE BUILDING OF PAVEMENT

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

One of the most often used materials in applied research is soil. All buildings, with the exception of a few that are built on solid rock, rely mostly on the land. Everywhere in the earth, geotechnical engineers have significant challenges when building on expansive soil. The swelling soils expand while wet owing to the clay minerals, as well as the area unit is susceptible to shrinking when it dries. Normally, these soil area units are unsaturated [1],[2]. Black cotton soil is mostly clay, ranging from clay to loam, and is often light to dark gray in color. In this decent soil, cotton flourishes. In the southern and central regions of India, the soil predominates [3],[4]. The most important property of the soil is that it has an extremely high bearing capacity, shrinks and becomes hard like stone when dry. Black cotton soils are inorganic clays that range in sponginess from mild to high and make up a significant soil cluster in Bharat. They stand out because to their superior swelling and shrinking characteristics. About 20% of India's entire land area is covered by this black cotton soil, which is mostly found in the western and central regions [5],[6].

Black cotton soils are created from a variety of minerals, including hummus or montmorinolite, as well as chemicals, including iron chemical compound or carbonate. Black cotton soils may be mostly mineralized with montmorinolite. The major cause of the swelling or shrinkage characteristic of black cotton soils is this mineral. Hydra salt Al or metallic element are clay minerals. They are made from sheets of silicon oxide and aluminum that have been piled on top of one another to create a sheet-like structure with a growing lattice. Some minerals are bio geochemically active because to the metallic element ions that make up their structure in some Al. They cause the soil to grow more food by drawing water molecules as well as other hydrous captions to the surface. Another characteristic of the teeming metal in black cotton soils is that it may be given as CaCo3 molecules or saturating ions. The soils are treated with the atomic number 11 in relation to Base Exchange, making them softer and more pliable. These soils have a high level of plasticity and compressibility due to the organic matter found in the humus type. It is thought that either hummus or titanic oxide is responsible for the dark hue of the black cotton soils.

The qualities of soil, which vary greatly from place to place as well as at different depths, are complex, heterogeneous, uncontrolled, and enormously variable. It cannot be moved as readily as other building materials like steel or concrete, and its technical qualities are also dependent on the environment in which it is present. The main factor at play on a building site is soil. Some of the primary features that have an impact on how a structure is constructed include its shrinkage limit, bearing capacity, bulk density, porosity, level of saturation, plastic limit, water content, plastic limit, etc. The current period of soil stabilization in India began in the middle of the 1970s, when there was a shortage of petroleum and its derivatives. It was primarily done to increase soil stability, but since adequate methods and tools were lacking, it did not succeed. The practice of soil stabilization has been brought back to life in current technologies due to the increased need for infrastructure everywhere in the globe. The stabilization of soil also uses GGBS and copper slag (CS) material. With more equipment readily available for research and development, it has become more cost-effective while also producing superior outcomes. The following design parameters for construction, including such design load, type of foundation, and load-bearing capability of the subsoil, are required for soil feasibility conditions for geotechnical projects. The building process heavily depends on the subsoil's capacity to support loads, leaving us with just three options: modify the design, modify the soil, or permanently vacate the site. Due to inadequate load-bearing capability, there are a growing number of abandoned sites. Here, in situ or ex-situ stabilization of the soil takes place. Draining and compaction are the two easiest methods for stabilizing soil.

One of the most significant regional soil deposits in Bharat is black cotton soil. It is very troublesome and covers an area of three lakh square meter linear units. An in-depth investigation is conducted to find a solution. It has become popular to use waste materials in construction. This is required because of the disposal problems it raises. Otherwise, such materials would harm the environment. Copper dross is a possible byproduct of the copper smelting process. Copper dross is often used in a wide range of industries. The amount of copper trash produced by companies and people is excessive. Due to the fact that there aren't many disposal sites available and they will soon run out, it is widely advised to do research on the use of copper in building and geotechnical materials. Several attempts at using geotechnical materials have also been made. Waste materials include poisons and dangerous compounds and must be treated before use in order to preserve the environment and minimize harm. This possible environmental risk must be avoided.

When discussing the strength, setting time, or sturdiness of concrete mixes made with copper dross, copper dross is often utilized as a fine combination. Additionally, up to 1.5% of calcium hydrate was employed as an associate material to pozzolanic processes together with up to 1 to 15 percent by weight of copper dross as a substitute for cement. The findings show an increase in compressive strength for up to 90 days after the connection. In particular, copper dross is utilized for surface blast-cleaning. Metal, stone, concrete, and other materials' surfaces may be scrubbed and formed by abrasive blasting. This technique propels a stream of grit, or abrasive grains, in the direction of the job. One of the many different materials that would be utilized as abrasive grit is copper dross. A few of the factors taken into account while choosing the grit material are the pace at which grit is used, the amount of mud produced, and the quality of the finished surface. Sand does more harm to people than copper dross-based blasting media does to both people and the environment. The product complies with the strictest environmental and health standards.

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