USE OF METAKAOLIN AND VETIVER FIBER AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE

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USE OF METAKAOLIN AND VETIVER FIBER AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE

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by

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Lucknow

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CERTIFICATE

This is to certify that the thesis Entitled **"USE OF METAKAOLIN AND VETIVER FIBER AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE"** by **Shailesh Kumar** under the guidance of Assistant Professor **Bilal Siddiqui**, is submitted to the Babu Banarasi Das University, Lucknow for the award of the degree of master of technology (Structural Engineering). It is a bona fide record of research work carried out by him under my supervision. The contents of this thesis, in full or in parts, have not been submitted to any other institute or i=university for the award of any degree or diploma.

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This thesis is based on original contribution based on M. Tech. Research work at Babu Banarasi Das University, Lucknow and has not been previously submitted to meet requirements for an award at any higher education institute under my name or that of any other individuals. To the best of my knowledge and belief, the thesis contains no materials previously published or written by any other person except where due reference is made.

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SHAILESH KUMAR

ABSTRACT

Concrete is a very sturdy and multipurpose mouldable construction material. It is composed of cement, sand and aggregate (e.g., gravel or crushed rock) mixed with water. The cement and water together form a mixture which covers the sand and aggregate. The cement sector is that the third largest industrial source of pollution emitting over 500,000 tons per annum of CO2 , sulphur dioxide , oxide and carbon monoxide gas Researchers all over the world have started giving their best effort on the extension of partial supplementation of ordinary Port-land cement with minerals or raw materials by naturally occurring, manufactured, or manmade waste. Various types of pozzolanic materials fly ash, silica fume, metakaolin, blast furnace slag etc. are at hand which has cementeous properties. Mixing these materials with ordinary Portland cement can enhance the cementing and mechanical properties of cement. These days use of metakaolin is developing high popularity in partial replacement of cement due to its fineness in improving various strengths and parameters of mortars and concrete. Well in several research it has been seen that further addition of fibers (natural or man-made) increase concretes structural integrity. Fibers are small pieces providing reinforcement and certain other properties They can be roundabout or level. The fiber is oftentimes depicted by a fit boundary called "viewpoint proportion". The angle proportion of the fiber is the proportion of the length of the fiber to the diameter.so in the accompanying exploration supplanting of concrete with vetiver fiber and metakaolin is completed.

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CHAPTER 1

1.1 General Description

Generally, dehydroxylated form of the clay mineral kaolinite is known as metakaolin. Rocks that have high measure of kaolinite in them are alluded to as china stone or kaolin, generally used in the assembling of porcelain. The metakaolin molecule size is littler than concrete particles, yet not as fine as silica. Smoke. The quality and reactivity of metakaolin unequivocally rely upon the part of the crude material utilized Metakaolin can be made from various sorts of essential and auxiliary sources containing kaolinite. Metakaolin is refined calcined kaolin clay under carefully controlled conditions to form an amorphous aluminosilicate which is reactive in concrete. Some natural pozzolans material like fly ash and silica fumes, metakaolin react with the calcium hydroxide that is also known as lime is a by-product produced during cement hydration. Between 100-200°C, clay minerals lose most of the water present in them. Between 500-800°C kaolinite becomes calcined by losing water through de-hydroxylation. The de-hydroxylation of kaolin to metakaolin is an endo-thermic process because of the massive amount of energy required to get rid of the chemically bonded hydroxyl ions. Further increase in temperature range, kaolin becomes metakaolin, with a two-dimensional order in crystal structure. To achieve fines of 700-900 m2/kg this material is grounded. So as to frame a pozzolan (beneficial establishing material) almost complete dihydroxylation must be reached without overheating, i.e., altogether broiled however not consumed. This procedure of simmering produces a shapeless, exceptionally pozzolanic state, where as overheating can cause sintering, to frame the dead consumed, nonreactive stubborn, called mullite.

Table 1: Chemical composition of Metakaolin

Chemical	Composition
SiO	50% - 55%
Al_2O_3	38% - 42%
CaO	1%-3%
TiO_2	0.8-1.2
Na_2O	<1%
Fe_2O_3	0.2-0.5
K_2O	<1%

MnO	<0.5%
MgO	<0.1%
Loss on Ignition	Max 1.5%
Physical	Properties
Bulk Density (g/cc)	0.5461 (When packed)
Color	White
Specific Gravity	2.30

Natural fibers are a natural resource and have several advantages related to them, like that they convey the composite high specific stiffness and strength, have a desirable fiber aspect ratio, are biodegradable, are readily available from natural sources. Vetiver is the base component in the Vetiver Grass System , a very effective soil, water conservation, and land rehabilitation system. Vetiver is closely associated with sugar cane and sorghum plants. Many developing countries try to develop substitutes for cement from locally available raw materials like agricultural and industrial wastes. Fly ash, rice hush ash, and rice straw ash (here in after referred to as FA, RHA, and RSA, respectively) have been proven to be economical partial substitutes for cement.

Table 2: Natural Fiber

Natural fiber	Types of fiber	Example
Plant fiber	Bast Fiber	Flex, Hemp Kenaf and Jute
Plant fiber	Straw Fiber	Corn, Rice, Straw, Wheat
Plant fiber	Seed Fiber	Cotton, Coir
Plant fiber	Leaf Fiber	Sisal, Pineapple
Planr fiber	Grass Fiber	Bamboo, switch grass, vetiver

1.2 Cement as construction Material

Cement, which is generally used as a binding material in construction and engineering works is, typically made by heating a mix of limestone and clay until it almost fuses then grinding it to a fine powder. When mixed with water, the silicates and aluminates in to it undergo a chemical reaction; the resulting hardened mass is then impervious to water. It may even be mixed with water and aggregates (crushed stone, sand, and gravel) to make concrete Modern hydraulic cement is formed by mixing substances containing lime, silica, alumina, and iron oxide then heating the mixture until it almost fuses. During the heating process dicalcium and tricalcium silicate, tricalcium aluminate, and a primary solid solution containing iron are formed. Gypsum is later added to those products during a grinding process. Cement witch have content of high aluminate in them is employed for fireproofing, because it's quick-setting and immune to high temperatures; this along with a high sulfate content is employed in complex castings, because it expands upon hardening, filling small spaces.

1.3 Concrete

Cement might be a development material made out of concrete, fine totals (sand) and coarse totals

blended in with water which solidifies with time. Portland concrete is that the ordinarily utilized kind of concrete for creation of cement. Solid innovation allude to the investigation of solid properties and its useful applications in development. In a structure development, concrete is utilized for the advancement of establishments, segments, bars, pieces and other burden bearing components. There are varying kinds of restricting material is utilized beside concrete like lime for lime cement and bitumen for black-top solid which is utilized for development. Various sorts of cements are used for concrete works which have different properties and applications. Some of the sort of cement are Portland Pozzolana Cement (PPC), rapid hardening cement, Sulphate resistant cement etc. Materials are mixed in specific proportions to get the specified strength. Mixing strength is specified as M 5, M 10, M 15, M 20, M 25, M 30 etc, where M signifies Mix and 5, 10, 15 etc. as their strength in kN/m^2. In us , concrete strength is laid out in PSI which is Pounds per sq in . Water cement ratio plays a crucial role which influences various properties like workability, strength and sturdiness . Adequate water and cement ratio is needed for production of workable concrete for construction. When water is mixed along with other materials, cement reacts with water and hydration reaction starts. This reaction helps ingredients to make a tough matrix that binds the materials together into a durable stone-like material. Concrete can be casted in any shape. Since it's a plastic material in fresh state, various shapes and sizes of forms or formworks are wont to provide different shapes like rectangular, circular etc. Various structural members like beams, slabs, footings, columns, lintels etc. are constructed with concrete. There are differing types of admixtures which are wont to provide certain properties. Admixtures or additives like pozzolans or superplasticizers are included within the mixture to enhance the physical properties of the wet mix or the finished material. Various sorts of concrete are manufactured lately for construction of buildings and structures. These types of concrete have special properties and features which improve quality of construction as per requirement.

1.3.1 Components of Concrete

Element of cement will be concrete, sand, totals and water. Blend of pressure driven concrete and water is named as glue. Thus, concrete are frequently called as a blend of glue, sand and totals. Some of the time rocks are utilized as opposed to totals. The concrete glue covers the outside of the fine and coarse totals when blended completely and ties them. Not long after blending the fixings, hydration response begins occurring which gives quality and an unshakable cement is obtained solid which is utilized for development.

1.4 What is Grade of Concrete?

Grade of concrete signals towards its strength required for construction. For example, M30 grade signifies that compressive strength required for construction is 30MPa. The first letter in grade “M” is that the mix and 30 is that the required strength in MPa.Based on various lab tests, grade of concrete is presented in Mix Proportions. For example, for M30 grade, the combination proportion are often 1:1:2, where 1 is that the ratio of cement, 1 is that the ratio of sand and a couple of is that the ratio of coarse aggregate supported volume or weight of materials. The strength of the concrete is measured with concrete cube or cylinders depends upon the type of test by civil engineers at construction site. Cube or cylinders are made during casting of support and after hardening it's cured for 28 days. Then compressive strength test is conducted to seek out the strength. Grades which are most often use in construction of concrete are M15, M20, M25 etc. For plain cement concrete works, generally M15 is employed. For ferroconcrete construction minimum M20 grade of concrete are used.

1.5.1 The following are the advantages of concrete :

- Availability of concrete ingredients easily.
- Easy handling and moulding of concrete into any shape.
- Easy transportation from the place of blending to put of casting before initial set takes place.
- Ability to pump/spray to fill into cracks and lining of tunnels.
- When reinforced, all kinds of the structures are made possible from a standard lintel to massive fly overs
- Monolithic character gives better appearance and far i rigidity to the structure.
- The property of concrete to possess high compressive strength, makes a concrete structure more economical than that of steel structure.

1.5.2 The following are the disadvantages of concrete :

- Due to low lastingness , concrete is required to be reinforced to avoid cracks.
- In long structures expansion joints are required to be provided if there's large temperature variance within the area.
- Construction joints are provided to avoid cracks thanks to drying shrinkage and moisture-expansion.
- Soluble salts in concrete cause efflorescence if moisture reacts with them.
- Concrete made with ordinary hydraulic cement , gets integrated within the presence of alkalies, sulfates etc.
- Loads which are sustained develop creep in structures.

1.6 Fiber Reinforced Concrete

As often as possible fiber ferroconcrete is deciphered as a material comprising of blends of concrete, mortar or concrete and intermittent, discrete, consistently scattered appropriate strands. Fiber ferroconcrete are of different sorts and properties with numerous points of interest. Nonstop networks, woven textures and long wires or bars aren't viewed as discrete filaments. Fiber might be a little bit of fortifying material having certain qualities properties. They can be roundabout or level. The fiber is generally portrayed by an advantageous boundary called "angle proportion". The proportion of the fiber is that the proportion of its length to its measurement. Commonplace viewpoint proportion ranges from 30 to 150. Fiber ferroconcrete (FRC) is concrete oblige sinewy material which extends its auxiliary trustworthiness. It holds short discrete filaments that are consistently designated and haphazardly situated. Filaments incorporate glass strands, steel filaments, engineered filaments and regular filaments. Inside these dissimilar to sorts of filaments that character of fiber ferroconcrete contrasts with shifting cements, fiber materials, geometries, dispersion, direction and densities. Concrete strengthened with strands (which are generally steel, glass or "plastic" filaments) is a littler sum costly than hand-tied rebar, while as yet expanding the lastingness over and again. Shape, measurement and length of fiber is significant. A slender and short fiber, for example short hair-formed optical fiber , might be compelling the essential hours in the wake of pouring the solid (decreases breaking while the solid is getting tight) yet won't increment the solid elasticity.

1.7 Effect of Fibers in Concrete

Strands of fibers are generally used in cement to direct plastic shrinkage splitting and drying shrinkage breaking. Strands let down the penetrability of cement and along these lines reduces seeping of water. A few kinds of strands produce more prominent effect, scraped area and break obstruction in concrete. By and large filaments don't expand the flexural quality of cement, so it can't supplant second opposing or

steel fortification. A few strands lessen the quality of concrete.The measure of filaments added to a solid blend is estimated as a level of the whole volume of the composite (cement and filaments) named volume division (Vf). Vf regularly runs from 0.1 to 3%. Viewpoint proportion that is length/breadth is determined by partitioning fiber length by its width . Filaments with a non-round cross area utilize a similar distance across for the computation of proportion . f the modulus of versatility of the fiber is over the framework (cement or mortar cover), they help to hold the heap by expanding the lastingness of the texture . Increment inside the proportion of the fiber typically portions the flexural quality and strength of the network. In any case, strands which are excessively long tend to "ball" inside the blend and make usefulness problems.Some late examination showed that utilizing filaments in concrete has restricted impact on the effect opposition of cement materials.This finding is critical since generally individuals think the pliability increments when cement strengthened with filaments. The outcomes additionally called attention to that the miniaturized scale filaments is better in sway obstruction contrasted and the more drawn out strands.

1.8 Necessity of Fiber Reinforced Concretes

- It increases the tensile strength of the concrete.
- It reduce the air voids and water voids the inherent porosity of gel.
- It increases the durability of the concrete.
- Fibres like graphite and glass have amazing protection from creep, while a proportionate isn't valid for some gums. In this manner, the direction and volume of filaments impact the wet blanket presentation of rebars/ligaments.
- Ferroconcrete itself might be a material , where the support demonstrations on the grounds that the fortifying fiber and along these lines the solid on the grounds that the grid. It is in this way basic that the conduct under warm worries for the 2 materials be comparable all together that the differential distortions of cement and subsequently the support are limited.
- It's been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static and dynamic properties.

1.9 Types of Fiber –

Fibers can be classified as-

- Man-made fibers
- Natural fibers

1.9.1 Man-made fiber

Polypropylene Fiber- The Polypropylene filaments are close by a monofilament form type and fit in thermoplastic polypropylene gathering. The Polypropylene filaments are warmth soft or more common administration temperature their properties might be misshaped. Polypropylene strands are genuinely hydrophobic. Polypropylene filaments have been employed at minimal inside to oversee plastic shrinkage splitting of concrete. Polypropylene filaments are manufactured strands which obtained as a side product from material industry. These are accessible in various viewpoint proportions and are less in expense. The utilization of the substitution materials provide downfall in cost, vitality investment funds and less hazardous in the earth.

Basalt fiber- Basalt rock is generated with rapid cooling of molten lava on the earth crust. Basically this rock is normally available on the earth surface, beneath of the oceans. Basalt rock is also one type of igneous rock containing 45-60% of Sio2 [silica] content to its volume. This basalt rock is naturally very hard and dense material having dark brown in colour similar to thenormal ballast rock. Sometimes due to oxidation process its changes to rust-red colour. Normally the Basalt rock and Ballast rocks looks similar, but the difference between them can be judged depending up on their mineral admixtures and their Textures.The Basalt rock is melted at 15000 C to 16500C for manufacturing the BASALT FIBERS. From this Basalt rock various types of secondary materials like Basalt fibers, Basalt Rebars, Basalt fiber pins, Basalt fiber geo girds, Basalt Fabric can be produced. First these basalt fibers are produced as continuous Basalt fibers then after they are chopped in to various sizes based on the use of purpose. The main advantage of the basalt fibers is it doesnt commit any toxic reaction with air and water. Rigidity or stiffness of a cloth is measured by its Young Modulus and measures what proportion a cloth deflects under stress. Carbon fiber reinforced plastic is over 4 times stiffer than Glass reinforced plastic, almost 20 times quite pine, 2.5 times greater than aluminum.

Carbon fiber-Carbon fibers in recent have shown good-performance and there fibers are readily available for civil engineering application. It is also called carbon graphite fiber or graphite fiber; carbon fiber consists of very thin strands of the element carbon. Carbon fibers have high tensile strength and are very strong for his or her size. In fact, carbon fiber could be the strongest material. Carbon fibers have high coefficient of elasticity and fatigue strength than those of glass fibers. Considering servicesble life, studies suggests that polymer reinforced with carbon fiber have more potential than agamid and glass fibers. They have high resistance to chemicals and and can tolerate high temperature with low thermal expansion. and corrosion resistance. Tensile strength or ultimate strength is that the maximum stress that a cloth can withstand while being stretched or pulled before necking, or failing.

Steel fiber- Steel fiber is a metal reinforcement. Steel fiber for reinforcing concrete is defined as short, discrete lengths of steel fibers with an aspect ratio (ratio of length to diameter) from about 20 to 100, with different cross-sections, which are sufficiently small to be randomly dispersed in an unhardened concrete mixture using the standard mixing procedures. Even certain amount of steel fiber mixed in concrete can bring qualitative changes in concrete's physical property, greatly increasing resistance to cracking, impact, fatigue, and bending, tenacity, durability, and other properties Steel fibers are added to concrete to improve the structural properties, particularly tensile and flexural strength. The extent of improvement in the mechanical properties achieved with steel fiber reinforce concrete over those of plain concrete depends on several factors, such as shape, size, volume, percentage and distribution of fibers. Round, straight and plain fibers have been analyzed and were brought to knowledge that it develop very weak bond and hence low flexural strength. For a given shape of fibers, flexural strength of SFRC was found to extend with ratio (ratio of length to equivalent diameter).

Glass fiber- Glass fiber also called fiberglass. It is material comprised of amazingly fine filaments of glass Fiberglass might be a lightweight, very solid, and powerful material. In spite of the fact that properties with respect to quality are to some degree not as much as carbon fiber and it's less firm, the texture is for the most part far less fragile, and hence the crude materials are considerably less exorbitant. Its mass quality and weight properties additionally are entirely great in contrast with metals, and it are frequently effectively shaped utilizing forming forms. Glass is that the most seasoned, and generally recognizable, execution fiber. The fibers which are freshly brought and are thin in size are the strongest

because the thinner fibers are more ductile. Whenever the surface me more scratched, the resulting tenacity is less. Because glass has an amorphous structure, its properties are an equivalent along the fiber and across the fiber. Humidity is a crucial think about the lastingness. Moisture is definitely adsorbed, and may worsen microscopic cracks and surface defects, and lessen tenacity.

1.9.2 Natural fiber-

Sisal Fiber- Sisal fiber (Agave sisal fiberingS) is an agave that yields a stiff fiber traditionally used in making twine rope and also dartboards. The term may refer either to the plant or the fiber, counting on context. It is sometimes incorrectly mentioned as sisal fiber hemp because hemp was for hundreds of years a serious source for fiber, so other fibers were sometimes named after it.The length of Sisal 1.5 to 2 meters tall. The sisal fiber plant has a life span of about 710 year and typically produces 200250 commercially usable leaves. Each leaf contains a mean of around 1000 fibers.Fiber is extracted by a process referred to as Decortication, where leaves are crushed and beaten by a rotating wheel set with blunt knives, so that only fibers remain. In India, where production is usually on large estates, the leaves are transported to a central decortication plant, where water is employed to scrub away the waste parts of the leaf. The fiber is then efeectively dried in sun , brushed and baled for export. Superior quality sisal fiber is found in East Africa. Proper drying is vital as fiber quality depends largely on moisture content.

Coir fiber- Coir fiber is that the natural fibre extracted from the husk of the coconut. The coir fiber is that the thickest and most resistant of all commercial natural fibers. Low decomposition rate is that the key advantage for creating durable products. Early century ropes made up of coir fiber are discovered. The coir fiber's high strength is that the main reason for the rope production for hundreds of years . There are generally two sorts of coir fiber the brown fiber from mature coconuts and therefore the finer white fiber from immature green coconuts after absorbing to 10 months. Coir fiber is one among the foremost lignin-rich natural fibers Coconut coir fiber cement mortar has been made in Thailand and used as a roof sheet to scale back the heat transfer and energy conservation. that natural fibre based composite building materials are more suitable for decent and humid weather regions like Thailand. Coir fiber which is treated with approx. 2% of alkali to reinforce polyester composites; the results have shown better lastingness and reduction of the strength beyond 2% of caustic soda (NaOH) concentration

Jute fiber- Jute might be a bast utilized for terminating, burlap, and line as a sponsorship material for tufted floor coverings. It is an all-inclusive , delicate, sparkly fiber which will be spun into coarse, solid strings. It is one among the most financially savvy normal filaments, and is second just to cotton in sum created and kind of employments. Jute strands are made fundamentally out of the plant materials cellulose, lignin, and gelatin. Both the fiber and thusly the plant from which it comes are ordinarily called jute. It has a place with the Corchorus inside the basswood family, Tiliaceae.It is the second most imperative vegetable fiber after cotton, as far as use, worldwide utilization, creation, and accessibility. It has high lastingness , low extensibility, and guarantees better breathability of materials . Along these

lines, jute is very reasonable in agrarian product mass bundling. It assists with shaping most excellent modern yarn, texture, net, and sacks. It is one among the premier adaptable characteristic strands that has been used in crude materials for bundling, materials, non-material, development, and horticultural segments. Building of yarn prompts a diminished breaking steadiness and an expanded breaking extensibility when mixed as a ternary mix. Not at all like the fiber alluded to as hemp, jute isn't such a (Cannabis). In this way it are frequently undeniably more effortlessly recognized from kinds of Cannabis that produce an opiate

Banana fiber- Banana plant or plantain plant not only provide us with delicious fruit but it also provides fibers for textile and other use , the banana fiber. Banana fiber is natural fiber. Natural fibers present important advantages like rarity , appropriate stiffness and mechanical properties and high disposability and renewability. Moreover, they are recyclable and biodegradable. Lot of research have been carried out on use of natural fibers in reinforcements. Banana fiber, a lingo-cellulosic fiber,which is obtained from the pseudo-stem of banana plant (Musa sepientum), which consist of relatively good mechanical properties. Banana plant may be a large perennial herb with leaf sheaths that form pseudo stem. Its height are often 10-40 feet (3.0-12.2 meters) surrounding with 8-12 large leaves. The leaves are up to 9 feet long and 2 feet wide (2.7 meters and 0.61 meter). Banana plant is out there throughout Thailand and Southeast Asian, India, Bangladesh, Indonesia, Malaysia, Philippines, Hawaii, and a few Pacific islands.

2.1 Objective of my research-

- To study the performance of concrete containing different percentages of metakaolin and vetiver fibre to identify the optimum replacement percentage.
- To study the comparative effect of metakaolin and vetiver fibre on compressive strength and tensile strength of concrete.

2.2 Types of Tests on Cement to Check the Quality

The following tests are conducted on cement in the laboratory are as follows:

- Fineness Test
- Consistency Test
- Setting Time Test
- Strength Test
- Soundness Test
- Heat of Hydration Test
- Tensile Strength Test
- Chemical Composition Test

Fineness test on cement

The fineness of cement is liable for the speed of hydration, rate of evolution of warmth and therefore the rate of gain of strength. Finer the grains more is that the area and faster the event of strength. The fineness of cement are often determined by Sieve Test or Air Permeability test.
Sieve Test: Air-set lumps are broken, and therefore the cement is sieved continuously during a circular and vertical motion for a period of quarter-hour . The residue left on the sieve is weighed, and it shouldn't exceed 10% for ordinary cement. This test is rarely used for fineness.

Air Permeability Test: Blaine's Air Permeability Test is employed to seek out the precise surface, which is expressed because the total area in sq.cm/g. of cement. The surface area is more for finer particles.

Consistency test on cement

This test is conducted to seek out the setting times of cement employing a standard consistency test apparatus, Vicat's apparatus.Standard consistency of cement paste is defined as that water content which will permit a Vicat plunger of 10 mm diameter and 50 mm length to penetrate depths of 33-35 mm within 3-5 minutes of blending . The test has got to undergo 3 times , whenever the cement is mixed with water varying from 24 to 27% of the load of cement.This test should be conducted at a constant temperature of 25°C or 29°C and at a constant humidity of 20%

Setting Time of cement

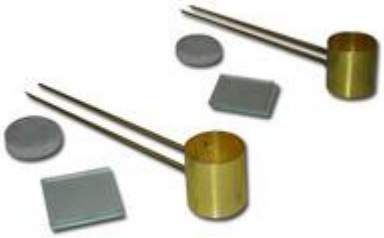
Vicat's apparatus is employed to seek out the setting times of cement i.e., starting setting time and last setting time.
Initial Setting Time: For this test, a needle of 1 mm square size is employed . Into the paste the needle is allowed to penetrate (a mixture of water and cement as per the consistency test). The time taken to penetrate 33-35 mm depth is recorded the initial setting time.
Final Setting Time: After the paste has attained hardness, the needle doesn't penetrate the paste quite 0.5 mm. The time at which the needle doesn't penetrate quite 0.5 mm is taken because the final setting time

Strength test of cement

The strength of cement can't be defined directly on the cement. Alternatively the strength of cement is indirectly defined on cement-mortar of 1:3. The compressive strength of this mortar is that the strength of cement at a selected period.

Soundness test of cement

This test is conducted in Le Chatelier's apparatus to detect the presence of uncombined lime and magnesia in cement.



Heat of Hydration Test

During the hydration of cement, heat is produced thanks to chemical reactions. This heat may raise the temperature of concrete to a heat of 50°C. To avoid these, in large scale constructions low-heat cement has got to be used. This test is carried out using a calorimeter adopting the principle of determining heat gain. It is concluded that Low-heat cement shouldn't generate 65 calories per gram of cement in 7 days and 75 calories per gram of cement in 28 days.

Tensile Strength of Cement

This test is administered employing a cement-mortar briquette during a tensile testing machine. A 1:3 cement-sand mortar with the water content of 8% is mixed and moulded into a briquette within the mould. This mixture is cured for 24 hours at a temperature of 25°C or 29°C and in an atmosphere at 90% relative humidity.The average strength for six briquettes tested after 3 and 7 days is recorded.

Chemical Composition Test

Different tests are conducted to work out the quantity of varied constituents of cement. The requirements are based on IS: 269-1998, is as follows:

• The ratio of the percentage of alumina to that of iron oxide should not be less than 0.66.
• Lime Saturation Factor (LSF), i.e., the ratio of the percentage to that of alumina, iron oxide and silica should not be less than 0.66 and not be greater than 1.02.
• Not more than 4% there should be loss of total ignition.
• Total sulphur content should not be greater than 2.75%.
• Weight of insoluble residue should not be greater than 1.50%.
• Weight of magnesia should not be greater than 5%.

2.3 Field Tests of Cement

The following tests should undergo before mixing the cement at construction sites:

Colour Test of Cement

The colour of the cement should not be uneven. It should be a uniform grey color with a light greenish shade.

Presence of Lumps

The cement should not contain any hard lumps. These lumps are formed by the absorption of moisture content from the atmosphere. The cement bags with lumps should be avoided in construction.

Cement Adulteration Test

The cement should feel smooth when it is rubbed it between fingers. If not, then it is because of adulteration with sand.

Float Test

The particles of cement placed in water should flow freely in water for some time before it sinks down..

Date of Manufacturing

It is vital to see the manufacturing date because the strength of cement decreases with time. It's better to

use cement before 3 months from the date of producing.

2.4 What are Different Tests for Concrete Quality Check?

Quality tests on concrete are performed as a neighborhood of internal control of concrete structures. Different quality tests on concrete like compressive strength tests, slump tests, permeability tests etc. Are wont to assure the standard of the concrete that's supplied for a given specification. These quality tests on concrete give a thought about the properties of concrete like strength, durability, air content, permeability etc.Each quality test conducted on concrete determines their respective quality results of concrete. Hence, it's impossible to conduct all the test to work out the standard of concrete. We have to settle on the simplest tests which will give logic of the concrete quality.The primary quality test determines the variation of the concrete specification from the specified and standard concrete specification. The quality tests make sure that the simplest quality concrete is placed at the location in order that concrete structural members of desired strength are obtained.

2.4.1 Quality Tests on Fresh Concrete

Most Common Quality Tests on Fresh concrete are:

1. **Workability Tests**-Workability of concrete mixture is measured by, Vee-bee consistometer test, Compaction factor Test, and Slump test.

Compaction Factor Test for Concrete Workability
Compaction factor test is that the workability test for concrete conducted in laboratory. The compaction factor is that the ratio of weights of partially compacted to completely compacted concrete. It was developed by Road lab in uk and is employed to work out the workability of concrete.
The compaction factor test is employed for concrete which have low workability that slump test isn't suitable.
Apparatus
Compaction factor contraption comprises of trowels, hand scoop (15.2 cm long), a pole of steel or other appropriate material (1.6 cm width, 61 cm since a long time ago adjusted toward one side) and an equalization.
Sampling
Concrete mix is ready as per mix design within the laboratory.
Compaction Factor Test on Concrete
Procedure of Compaction Factor Test on Concrete

- Place the concrete sample gently within the upper hopper to its brim using the hand scoop and level it.
- Cover the cylinder.
- Open the trapdoor at rock bottom of the upper hopper in order that concrete fall under the lower hopper. Push the concrete which is sticking on its sides gently with the rod.
- Open the trapdoor of the lower hopper and permit the concrete to fall under the cylinder below.
- Cut of the surplus of concrete above the highest level of cylinder using trowels and level it.
- Clean the outside of the cylinder.
- Weight the cylinder with concrete to the closest 10 g. This weight is understood because the weight of partially compacted concrete (W1).
- Empty the cylinder then refill it with an equivalent concrete mix in layers approximately 5 cm deep, each layer being heavily rammed to get full compaction.
- Level the top surface.

- Weigh the cylinder with fully compacted. This weight is understood because the weight of fully compacted concrete (W2).
- Find the weight of empty cylinder (W).

Calculation of Compaction Factor Value

The compaction factor is characterized on the grounds that the proportion of the heap of mostly compacted cement to the heap of completely compacted concrete. It shall normally to be stated to the closest second decimal place.
Compaction Factor Value= (W1-W) / (W2-W)

Concrete slump test

Solid droop test or slump test is completed to make sense of the functionality or consistency of solid blend arranged at the research facility or occasion at the site during the constructio of the work. Solid droop test is run from clump to cluster to discover the uniform nature of cement during construction.The droop test is that the most clear usefulness test for concrete, includes minimal effort and gives quick outcomes. Because of this reality, it's been broadly utilized for usefulness tests since 1922. The droop is regulated according to methodology referenced in ASTM C143 inside the us , IS: 1199 – 1959 in India.Generally solid droop esteem is utilized to chase out the functionality, which shows water-concrete proportion, however there are different elements including properties of materials, blending strategies, dose, admixtures and so forth likewise influence the solid droop esteem.

Factors which influence the concrete slump test:

- Equipment's Required for Concrete Slump Test
- Sampling of Materials for Slump Test
- Procedure for Concrete Slump Cone Test
- Slump Value Observation:
- Results of Slump Test on Concrete
- Material properties like chemical composition, fineness of particles, particle size distribution, moisture content.
- Material properties like concoction piece, fineness of particles, molecule size conveyance, dampness content.
- Temperature of cementitious materials. Size, surface, joined evaluating, tidiness and dampness substance of the totals,
- Chemical admixtures sum, type, cooperation, blend, succession of expansion and its adequacy,
- Air substance of cement,
- Concrete grouping, blending and shipping techniques and hardware,
- Temperature of the solid,
- Sampling of solid, droop testing strategy and in this way the state of hardware ,
- The measure of free water inside the solid, and
- Time since blending of cement at the hour of testing.

Equipments Required for Concrete Slump Test

Shape for droop test or slump for example droop cone, non-permeable base plate, estimating scale, temping pole. The shape for the test is inside such a the frustum of a cone having stature 30 cm, base distance across 20 cm and top width 10 cm. The packing pole is comprised of steel with 16 mm breadth and 60cm long and adjusted toward one side.

Sampling of Materials for Slump Test

A concrete mix (M15 or other) by weight with suitable water/ cement ratio is prepaid within the laboratory almost like that explained in 5.9 and required for casting 6 cubes after conducting Slump test.

Procedure for Concrete Slump Cone Test

- Clean the inside surface of the shape and apply oil.
- Place the form on non-permeable , smooth level base plate.
- Fill the readied solid blend in 4 roughly equivalent layers in the mould.carefully.
- Tamp each layer with 25 strokes of the adjusted finish of the packing pole during a uniform way over the cross segment of the shape. For the following layers, the packing ought to infiltrate into the hidden layer.
- Remove the overflow concrete and level the surface with a trowel.
- Clean away the mortar or water spilled out between the form and subsequently the base plate.
- Raise the form from the solid promptly and gradually vertical upward way.
- Measure the droop in light of the fact that the distinction between the pinnacle of the shape which of stature purpose of the example being tried

.**Slump Value Observation:**

Make sure to measure the slump it (Vertical settlement) will be recorded as far as millimeters of subsidence of the example during the test.
Results of Slump Test on Concrete
Slump for the given sample= _____mm

Concrete Slump Test Results - Slump Shapes

- Clean the inside surface of the shape and apply oil.
- Place the form on non-permeable , smooth level base plate.
- Fill the readied solid blend in 4 roughly equivalent layers in the mould.carefully.
- Tamp each layer with 25 strokes of the adjusted finish of the packing pole during a uniform way over the cross segment of the shape. For the following layers, the packing ought to infiltrate into the hidden layer.
- Remove the overflow concrete and level the surface with a trowel.
- Clean away the mortar or water spilled out between the form and subsequently the base plate.
- Raise the form from the solid promptly and gradually vertical upward way.
- Measure the droop in light of the fact that the distinction between the pinnacle of the shape which of stature purpose of the example being tried.

True Slump – True slump is that the only slump which will be measured within the test. The measurement is taken between the highest of the cone and therefore the top of the concrete after the cone has been removed .
Zero Slump – Zero slump is that the indication of very low water-cement ratio, which ends up in dry mixes. These sort of concrete is usually used for construction .
Collapsed Slump – this is often a sign that the water-cement ratio is just too high, i.e. concrete mix is just too wet or it's a high workability mix, that a slump test isn't appropriate.
Shear Slump – The shear slump indicates that the result's incomplete, and concrete to be retested.

Air content

Air content measures the entire air content during a sample of fresh concrete but doesn't indicate what the ultimate in-place air content is, because a particular amount of air is lost in transportation Consolidating, placement, and finishing

Measurement of Air Content in Concrete

Air content of concrete is measured by the pressure air measurement method which is predicated on the principles of The Boyle's law. The Boyle's law states that the volume of the gas is inversely proportional to the pressure.By the appliance of pressure on a concrete of known volume (that contains air voids), compression takes place which ends up within the reduction of the quantity . This volume change is measured and associated with the first initial volume.The difference between original and reduced volume of concrete provides the air content in concrete. Menzel was the one that refined the apparatus and made it as a typical test.One of the most advantages of this method is that no knowledge of the weights and specific gravities are necessary.

ASTM Method of Air Content Measurement in Concrete

The ASTM test method for pressure air measurement specifies two meters to live the air content. Type A meter helps within the direct measurement of the change in volume within the concrete. This is administered by means of a column of water over the known volume of concrete.With the appliance of the pressure, the quantity reduction are often determined by employing a calibrated sight tube. The Type a way have a simple procedure. One of the restrictions of this method is that it requires recalibration of the elevation or the atmospheric pressure changes to a worth exceeding 183m.. The Type B air meter involves the utilization of a known volume of air at a known higher pressure. This can equilibrate with the known volume of the concrete during a sealed container.The pressure drop observed within the high-pressure chamber is said to the quantity of air within the concrete. As compared with A air meter, there's no need for recalibration. But it's its own limitation of leakage from the valves.Hence the operator must be prepared anytime ready with the tools to correct the leakage and therefore the variation within the dial readings. Ignorance can provide an incorrect result. The pressure measurement technique requires the concrete sample to undergo complete consolidation during a bowl. This is because the air voids formed thanks to lack of concrete are going to be measured because the air content of the concrete. Proper rodding above a slump of 75mm, internal vibration below 25mm is important to undergo proper consolidation. Until the surface is free from aggregate and shows a glistening appearance, the vibration must be continued. Over vibration may result in removal of air voids that are intentionally entrained. For concrete with aggregates size greater than 50mm must be screened through 3.75 mm sieve before the test, as for larger aggregates the stratified sampling becomes difficult. A strike of the plate or a bar is employed to cross off the concrete. The pressure method is employed less with concrete having dense aggregates. The air within the porosity within the aggregates are going to be compressed even as air within the cement paste. This will provides a higher air content value than the first . This is corrected by means of an aggregate correction factor. But this is often not suitable for concrete that uses lightweight aggregate with the correction factor greater than 0.5%.

Setting Time

The action of adjusting mixed cement from a fluid state to a solid state is named "Setting of Cement".Initial Setting Time is defined because the period elapsing between the time when water is added to the cement and therefore the time at which the needle of 1 mm square section fails to pierce the test block to a depth of about 5 mm from the bottom of the mold. Final Setting Time is characterized on the grounds that the period slipping by between when water is added to solidify and in this manner the time at which the needle of 1 mm square area with 5 mm distance across connection has an effect on the test square..

Initial Setting time

Initial setting time of concrete is that the period of time between addition of water to cement till the time at 1 mm square section needle fails to penetrate the cement paste, placed within the Vicat's mould 5mm to 7mm from rock bottom of the mould. This test is required to know the time cement takes for initial setting between mixing and transporting and placing of concrete.

Procedure to Find Setting Time of Cement

Apparatus Required

- Vicat's apparatus
- Balance
- Measuring cylinder
- Stop watch
- Glass plate
- Enamel tray
- Trowel

Test Procedure

- Consistency test to be done before starting the test procedure to seek out out the water required to offer the paste normal consistency (P).
- Take 400 g of cement and prepare a neat cement paste with 0.85P of water by weight of cement.
- Gauge time is kept between 3 to five minutes. Start the stop watch at the moment when the water is added to the cement. Record this time (T1).
- Fill the Vicat mould, resting on a glass plate, with the cement paste gauged as above. Fill the shape totally and smooth off the outside of the glue making it level with the most elevated of the form. The concrete square accordingly arranged in named test square.
- Place the test square limited to the shape and laying on the non-permeable plate, under the bar bearing the needle.
- Lower the needle tenderly until it comes in contact with the outside of test square and brisk discharge, permitting it to enter into the test square.
- In the starting the bloch is totally punctured by needle. Rehash this method for example rapidly discharging the needle after like clockwork till the needle neglects to penetrate the square for around 5 mm estimated from absolute bottom of the form. Note this time (T2).

Final Setting time

Final setting time is that point period between the time water is added to cement and consequently the time at which 1 mm needle has an effect on the glue (cement) in the form however 5 mm connection doesn't establish any connection. This is test is required to know the speed of gain of strength of cement with reference to time.

Procedure to Find Final Setting Time of Cement

Apparatus Required

- Vicat's apparatus
- Balance
- Measuring cylinder
- Stop watch
- Glass plate
- Enamel tray
- Trowel

Test Procedure

- Consistency test to be done before starting the test procedure to seek out out the water required to offer the paste normal consistency (P).
- Take atleat 400 g of cement and now prepare a neat cement paste with 0.85P of water by weight of cement.
- Gauge time is kept between 3 to five minutes. Start the stop watch at the moment when the water is added to the cement. Record this time (T1).
- Fill up the Vicat mould,which is resting on a glass plate, with the cement paste gauged as above. Fill the shape totally and smooth off the outside of the glue making it level with the most elevated of the form. The concrete square in this manner arranged is named test square.
- For determining the ultimate setting time, replace the needle of the Vicat's apparatus by the needle with an annular attachment.
- The cement is taken into account finally set when upon applying the ultimate setting needle tenderly to the outside of the test obstruct; the needle has an effect consequently, while the connection neglects to do as such. Record this time (T2).

The tensile strength of concrete is one of the vital and key properties which greatly affect the extent and size of cracking in structures. Moreover, the concrete is extremely weak in tension thanks to its brittle nature. Hence. it is not anticipated to resist the direct tension. So, concrete develops cracks when tensile forces exceed its lastingness. Therefore, it's necessary to work out the lastingness of cement to work out the heap at which the solid individuals may break. Furthermore, splitting lastingness test on concrete cylinder may be a method to work out the lastingness of concrete. The procedure supported the ASTM C496 (Standard Test Method of Cylindrical Concrete Specimen) which almost like other codes lik IS 5816 1999.Finally, different aspects split cylinder test of concrete specimen are going to be discussed within the following sections.

Apparatus for Splitting Tensile Test of Concrete

Testing Machine
Testing machine shall meet the following requirements:
Firstly, it shall conform to the wants of Test Method C 39/C 39M.
Secondly, testing machine should be ready to apply the load continuously and without shock.
Thirdly, it should be ready to apply loads at a continuing rate within the range 0.7 to 1.4 MPa/min (1.2 to 2.4 MPa/min supported IS 5816 1999) splitting tensile stress until the specimen fails.
Plate or Supplementary Bearing Bar

- It is employed when the diameter or the most important dimension of the upper bearing face or the lower bearing block is a smaller amount than the length of the cylinder to be tested.
- Plate width is 50mm
- it shall be used in such manner that the load will be applied over the entire length of the specimen.

Bearing Strips

- Two bearing strips are used.
- bearing strip size is 3.2 mm thick, 25 mm wide, and of a length adequate to , or slightly longer than, that of the specimen
- The bearing strips placed between the specimen and both the upper and lower bearing blocks of the testing machine or between the specimen and supplemental bars or plates if needed.

Sampling of Concrete Cylinders
Concrete specimen moulds

- It shall be made of steel, and 3 mm thick.
- The mould shall be capable of being opened longitudinally to facilitate the removal of the specimen and is provided with a means of keeping it closed while in use.
- The mean internal diameter of the mould is 15 cm ± 0.2 mm and the height is 30 0.1 cm.
- Metal base plate is provided for the mould.
- Moulds need to be coated with a thin film of oil before use, in order to prevent sticking of concrete with mould.

Tamping Rod

- Used for manual compaction of concrete specimen
- It shall be a round, straight steel rod with a minimum of the tamping end rounded to a hemispherical tip of an equivalent diameter because the rod.
- Both ends rounded, if preferred.
- Diameter of the Tamping rod is 16 mm and its length is 600 mm.

Tamping rod

Concrete pouring and compaction

- After the mixture is ready , it's poured into the oiled mould in layers approximately 5 cm deep.
- Then, each layer is compacted either with the help of hand or by vibration.
- For manual compaction, use tamping bar.

- Distributed bar stroke uniformly so as to compact it properly.
- Minimum tamp stroke for every layer is 30.
- Penetrate strikes in to the underlying layer
- Apply the rode for the entire depth of bottom layer
- complete top layer compaction
- Lastly the outside of the solid ought to be done level with the most noteworthy of the mould,using a trowel and secured with a glass or metal plate to stop dissipation.

Curing of Specimen

- Casted specimen ought to be put away in a spot at a temperature of 27° 2°C for 24 0.5 hrs from the time extension of water to the dry fixings. After that, the example ought to be checked and faraway from the shape and promptly lowered in clean water or soaked lime arrangement and kept there until taken out only before the test.
- The water or solution in witch the specimens are kept should be renewed every seven days and should be maintained at a temperature of 27° 2°c.
- For design purpose, the specimen cured for 28 days.
- At last, for every reading, three specimens shall be casted and tested. Then, the average tensile strength will be taken.

Procedure of Splitting Tensile Test

- Initially, take the wet specimen from water after 7, 28 of curing; or any desired age at which lastingness to be estimated.
- Then with a dry cloth wipe out water from the surface of specimen
- After that, draw polar lines on the two closures of the example to guarantee that they are on the equivalent hub place.
- Next, record the heap and measurement of the example.
- Set the pressure testing machine for the predefined run.
- Place compressed wood strip on the lower plate and spot the example.
- Align the example all together that the lines set apart on the closures are vertical and focused over absolute bottom plate.
- Place the other compressed wood strip over the example.
  Bring down the upper plate all together that it simply contacts the compressed wood strip.
- Apply the heap ceaselessly without stun at a rate within the range 0.7 to 1.4 MPa/min (1.2 to 2.4 MPa/min supported IS 5816 1999)
- Finally, note down the breaking load(P)

Calculations

Calculate the splitting lastingness of the specimen as follows:
T= 2P/ pi LD

Modulus of elasticity

Modulus of elasticity of concrete is the ratio of stress to the strain of the concrete under the application of loads.

Determine modulus of elasticity

Modulus of elasticity of concrete is defined because the ratio of stress applied on the concrete to the respective strain caused. The accurate value of modulus of elasticity of concrete are often determined by conducting a laboratory test called compression test on a cylindrical concrete specimen. In the test, the deformation of the specimen with reference to different load variation is analyzed. These observations produce Stress-Strain graph (load-deflection graph) from which the modulus of elasticity of concrete is decided . The slope of a line that is drawn in the stress-strain curve from a stress value of zero to the compressive stress value of 0.45f'c(working stress) gives the modulus of elasticity of concrete. The laboratory test to work out the modulus of elasticity of concrete is explained below.

Procedure

The test procedure involves two stages. Initially, the compressometer is set-up, followed by the appliance of load and testing.

Setting Up Compressometer

A compressometer may be a device utilized in the compression test of the concrete cylinder to work out its strain and deformation characteristics. The set up involves the following procedures.

- The compress meter comprises of two frames(top and bottom), The frames are initially assembled by the help of spacers. The spacers are held in position during the assembling.
- The pivot rod which is placed on the screws are then locked in position. The tightening screws of the top and bottom frames are kept in loose condition.
- Once the compressometer is arranged, it's placed on the concrete specimen kept on A level surface. The compressometer is centrally placed on the specimen.
- Once the position is about , the screws are tightened and therefore the compressometer is persisted the specimen.
- Once the set up is done, the spacers can be unscrewed and removed.

Testing the Specimen

The test procedure involves the following steps:

- The specimen with the compressometer found out is placed over the compression testing machine platform. It is centered properly.
- The load application is performed continuously at a rate of 140 kg/cm²/minute with none obstruction.
- The load application is sustained until a stress value adequate to (c+5)kg/cm² is attained. Here c is the 1/3rd of average compressive strength of the cube (The strength value of cube calculated to the nearest of 5kg /cm²) which is a load of 12.4T.
- Once this stress value is reached, it is maintained for a period of 60 seconds and then reduced to the stress of 1.5 kg/cm² which is a load value of 0.3T.
- Again, the load is further increased until the strain of (c+1.5) kg/cm² is reached which may be a load of 11.8T. At this point, compressometer reading is recorded.
- Now, the load is gradually reduced and the readings are recorded at 1T intervals i.e.11.8T,10.8T,9.8T,8.8T,7.8T,……,1.8T,0.3T.

- Repeat the test by applying the load for the third time and record the compressometer's readings at an interval of 1T i.e 1.8T,10.8T,9.8T,8.8T,7.8T,……,1.8T,0.3T is determined.

Load-Deflection Graph

From the observations, the load deflection graph is plotted for the loading conditions. Tangents are drawn at the initial portion of the graph and at the point of value equal to the working stress of the concrete mix. A line is drawn joining both points.

Calculation and Results

Calculation
Slope of Initial Tangent gives:
Initial tangent modulus = stress/strain
Slope of tangent at working stress gives:
Tangent modulus at working stress= stress/strain
Slope of Line joining initial tangent point and point of working stress gives:
Secant modulus = stress/strain

Permeability Tests on Concrete

When permeable concrete it can cause corrosion in reinforcement in presence of oxygen, moisture, CO_2, SO_3- and Cl– etc. This formation of rust due to corrosion becomes nearly 6 times the volume of steel oxide layer, due to which cracking develops in reinforced concrete and spalling of concrete starts.The durability of concrete structures depends on the permeability of reinforcement cover by concrete. It is this thin layer of concrete over reinforcement on which lifetime of a structure depends.The permeability tester for concrete cover may be a non-destructive instrument for the determination of air permeability of canopy concrete.The permeability of concrete cover depends on the condition of concreting at site like segregation and bleeding, finishing and curing, the formulation of micro-cracks, etc.The composition and properties of the duvet concrete may differ very considerably from those of the great quality of canopy concrete. Moreover, the concrete test specimens used for quality control can never represent the standard and properties of the duvet concrete since they're produced and stored during a completely different manner. Durability of concrete structure under aggressive environmental influences depends essentially on the standard of a comparatively thin surface layer (20 – 50 mm). This layer is provided to protect the reinforcement from corrosion which may occur as a result of carbonation or other chemical effects. The influence mentioned is enhanced by damage thanks to frost/thaw or frost/thaw/salt.There is no generally accepted method to characterize the pore structure of concrete and to relate it to its durability. However, several investigations have indicated that concrete permeability both with reference to air and to water is a superb measure for the resistance of concrete against the ingress of hostile medium in the gaseous or in the liquid state and thus is a measure of the potential durability of a particular concrete. The Permeability Tester permits a rapid and non-destructive measurement of the standard of the duvet concrete with respect its durability.

Principle of Concrete Permeability Tester:

The rate at which the air from the concrete cover may extracted, may be a measure of permeability of concrete. This method is used to evaluate the resistance of concrete to carbonation, penetration of aggressive ions and quality of grout in post tensioned ducts.

Description of Concrete Permeability Tester:

The technical details of the instrument are given below:

Display Unit

- Non volatile memory for upto 200 measured objects
- Display on 128 X 128 graphic LCD
- RS 232 C interface
- Integrated software for printout of measured objects and transmission to PC
- Operation with 6 batteries LR6 1.5 v for about 60 hrs. or commercial power unit 9 VDC/0.2 A.
- Temperature range –100C to +600C
- Carrying case 320 / 285 / 105 mm, total weight 2.1 Kg

Control Unit and vacuum cell

- The volume of inner chamber and hose and therefore the cross sectional area of the inner chamber are terms within the formula for calculating kT and L. They must therefore not be changed.
- Vacuum connection –small flange 16 KF
- Carrying case 520 / 370 / 125 mm , total weight 6.3 kg

Resistance probe WENNER –PROCEQ

- Electrode spacing 50 mm

Vacuum pump:

- The instrument is operated with a billboard air pump .
- Technical data as per DIN 28400
- Suction capacity :1.5 m3/h
- Final total pressure :approx 10 bar
- Suction side connection : small flange 10 KF / 16KF
- High water vapour toleration

Methodology of Concrete Permeability Tester:s

It operates under vacuum and can be used at the site and also in the laboratory. The essential features of the tactic of measurement are a two chamber vacuum cell and a pressure regulator which ensures an air flow at right angles to the surface and into the inner chamber. Dry surface which do not have cracks should be selected for test. It should be insured that inner chambers should not be located above the reinforcement bar.Pressure loss is calibrated from time to time and after an outsized change in temperature and pressure. 3 to six measurements of electric resistance of the concrete and its mean is taken for the measurement of coefficient of permeability.This permits the calculation of the permeability coefficient kT on the basis of theoretical model. In case of dry concrete, the results are in good agreement with laboratory methods, like oxygen permeability, capillary suction, chloride penetration et al. . The quality class of the duvet concrete is decided from kT employing a table as shown below.

Table 3 The quality class of the duvet concrete

Quality of cover concrete	Index	kT (10^{-16} m^2)
Very Bad	5	> 10
Bad	4	1.0 - 10
Normal	3	0.1 – 1.0
Good	2	0.01 – 0.1
Very Good	1	< 0.01

The humidity, a main influence on the permeability, is compensated by additionally measuring the electric resistance ? of the concrete. With kT and ? the quality class is obtained from a monogram shown in fig below:

Limitations of Concrete Permeability Test

- The determination of kT and p shouldn't be administered on wet surfaces (the moisture entering the unit could damage the membrane within the pressure regulator).
- The most precise values are acquire for dry concrete (p measurement is superfluous).
- In order to obtained a particular idea of the standard of the duvet concrete of a structure or of a finished component, several measurements should be administered.
- The quality classification of canopy concrete from table and therefore the monogram from figure associated with young concrete i.e. concrete age about 1-3 months. Some measurements on concrete a few years old have shown that the classification in Table and the monogram cannot be directly applied.
- The moisture content of the concrete shows a close effect on the gas permeability. The rectification of this effect id done by the measurement of the electric resistance generally leads to satisfactory results in the case of young concrete. For old concrete, further investigations must be administered .
- The investigations were performed using a vacuum pump with a suction capacity of 1.5 m3/h and a motor power of 0.13 kW, this pump makes it possible to achieve a vacuum of a few mbar. Pumps of lower power don't reach an equivalent vacuum and it's therefore advisable to use only pumps of comparable power.
- There could also be three further reasons why the specified vacuum (10-50 mbar) isn't reached.

The concrete cover is just too permeable (normal function of the unit). The concrete surface is too uneven: the rubber seals can compensate only a certain degree of unevenness (abnormal function). The unit has a leak (abnormal function).

In situ test on concrete

There are various in-situ test carried on hardened concrete, both destructive and non-destructive. Some of them are concrete pull out tests, Break off tests, Schmidt Hammer test.

Rebound Hammer Test

Rebound Hammer test could also be a Non-destructive testing method of concrete which provides a convenient and rapid indication of the compressive strength of the concrete. The rebound hammer is additionally called as Schmidt hammer that contains a spring controlled mass that slides on a plunger within a tubular housing.The operation of rebound hammer is shown within the fig.1. When the plunger of rebound hammer is pressed against the surface of concrete, a spring controlled mass with a continuing energy is formed to hit concrete surface to rebound back. The extent of rebound, which may be a measure of surface hardness, is measured on a graduated scale. This measured value is designated as Rebound Number (rebound index). A concrete with low strength and low stiffness will absorb more energy to yield during a lower rebound value.

Objective of Rebound Hammer Test

As per the Indian code IS: 13311(2)-1992, the rebound hammer test have the next objectives:

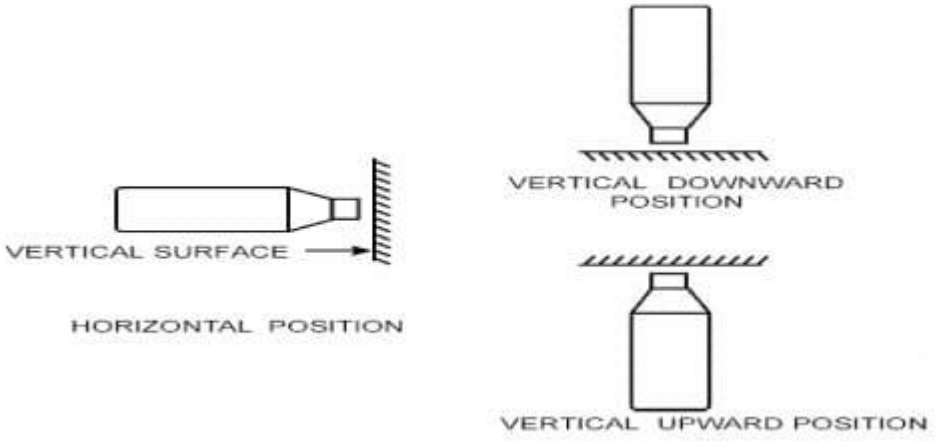
• To determine the compressive strength of the concrete by relating the rebound index and thus the compressive strength
• To assess the uniformity of the concrete
• To assess the quality of the concrete supported the standard
• In terms of quality one concrete element must be associated with other
Rebound hammer test method are often used to differentiate the acceptable and questionable parts of the structure or to match two different structures supported strength.

Principle of Rebound Hammer Test

The principle on which Rebound hammer test method is predicated is that the rebound of an elastic mass depends on the hardness of the concrete surface against which the mass strikes. When the plunger of rebound hammer is pressed against the concrete surface, the spring-controlled mass within the hammer rebounds. the quantity of rebound of the mass depends on the hardness of concrete surface. Thus, the hardness of concrete and rebound hammer reading are often correlated with compressive strength of concrete. The rebound value is read off along a graduated scale and is designated because the rebound number or rebound index. The compressive strength is usually read right from the graph provided on the body of the hammer.

Procedure for Rebound Hammer Test

The rebound hammer test procedure on concrete structure will starts with calibration of the rebound hammer. For this, the rebound hammer is tested against the test anvil made up of steel having Brinell hardness number of about 5000 N/mm2. Afterword's the rebound hammer is tested for accuracy on the test anvil, at right angles the rebound hammer is held to the surface of the concrete structure for taking the readings. The test thus are often conducted horizontally on surface and vertically upwards or downwards on horizontal surfaces as shown in figure below.If the rebound hammer is held at intermediate angle, the rebound number are getting to vary for the same concrete.



The impact energy required for the rebound hammer is different for various applications. below for different applications.

Points to Remember in Rebound Hammer Test

- With the help of the cloth the concrete surface should cleaned and it should be smooth and dry.
- Ant loose particles should be rubbed faraway from the concrete surface with a emery wheel or stone, before hammer testing.

- Rebound hammer test shouldn't be conducted on rough surfaces as a results of incomplete compaction, loss of grout, spalled or tooled concrete surface.
- The point of impact of rebound hammer on concrete surface should be a minimum of 20mm faraway from edge or shape discontinuity.
- Six readings of rebound number is taken at each point of testing and a mean useful of the readings is taken as rebound index for the corresponding point of observation on concrete surface.

Correlation between compressive strength of concrete and rebound number

The most suitable method of obtaining the correlation between compressive strength of concrete and rebound number is to check the concrete cubes using compression testing machine also as using rebound hammer simultaneously. First the rebound number of concrete cube is taken then the compressive strength is tested on compression testing machine. The fixed load required is of the order of seven N/ mm2 when the impact energy of the hammer is about 2.2 Nm.The load should be increased for calibrating rebound hammers of greater impact energy and decreased for calibrating rebound hammers of lesser impact energy. The test specimens should be as large a mass as possible so as to attenuate the dimensions effect on the test results of a full scale structure. 150mm cube specimens are favored for calibrating rebound hammers of lower impact energy (2.2Nm), whereas for rebound hammers of upper impact energy, as an example 30 Nm, the testing cubes should any further smaller than 300mm.The concrete cube specimens should be kept at temperature for about 24 hours after taking it out from the curing pond, before testing it with the rebound hammer. To obtain a connection between rebound numbers and strength of wet cured and wet tested cubes, it is important to work out a correlation between the strength of wet tested cubes and therefore the strength of dry tested cubes on which rebound readings are taken. A direct relation between rebound numbers on wet cubes and the strength of wet cubes is not recommended. Vertical faces of the cubes as cast only should be tested. At least nine readings should be taken on each of the 2 vertical faces accessible within the compression testing machine when using the rebound hammers. The points of impact on the specimen must not be nearer a foothold than 20mm and will be not but 20mm from one another. The same points must not be impacted quite once.

Interpretation of Rebound Hammer Test Results

After obtaining the correlation between compressive strength and rebound number, the strength of structure are often assessed. In general, the rebound number increases because the strength increases and is additionally suffering from variety of parameters i.e. type of cement, sort of aggregate, surface condition and moisture content of the concrete, curing and age of concrete, carbonation of concrete surface etc.
The rebound index is indicative of compressive strength of concrete up to a certain limited depth from the surface. The internal cracks, flaws etc. or heterogeneity across the cross section won't be indicated by rebound numbers.

Average Rebound Number	Quality of concrete
>40	Very good hard layer
30 to 40	Good layer
20 to 30	Fair
< 20	Poor concrete
0	Delaminated

Table 4- *Quality of Concrete for various values of rebound number*

If the connection between rebound index and compressive strength are often found by tests on core samples obtained from the structure or standard specimens made with an equivalent concrete materials

and blend proportion, then the accuracy of results and confidence thereon gets greatly increased.

Advantages and Disadvantages of Rebound Hammer Test

- The advantages of Rebound hammer tests are:
- Apparatus is easy to use
- Determines uniformity properties of the surface
- The equipment used is inexpensive
- Used for the rehabilitation of old monuments

The disadvantages of Rebound Hammer Test

- The results obtained is based on a local point
- The test results are not directly related to the strength and the deformation property of the surface
- The probe and spring arrangement would require regular cleaning and maintenance
- Flaws cannot be detected with accuracy

Factors Influencing Rebound Hammer Test

Type of Aggregate
Type of Cement
Surface and moisture condition of the concrete
Curing and Age of concrete
Carbonation of concrete surface

Type of Aggregate

The correlation between compressive strength of concrete and the rebound number will vary with the use of different aggregates. Normal correlations in the results are obtained by the use of normal aggregates like gravels and crushed aggregates. The use of lightweight aggregates in concrete would require special calibration to undergo the test.

Type of Cement

The concrete made from high alumina cement need to have higher compressive strength compared to Ordinary hydraulic cement . The use of supersulphated cement in concrete decrease the compressive strength by 50% compared thereto of OPC.

Type of Surface and Moisture Condition

Concrete with high honeycombs and no-fines concrete isn't suitable to be tested by rebound hammer. The strength is overestimated by the test when testing floated or trowelled surfaces when compared with moulded surfaces.Wet concrete surface if tested will provides a lower strength value. This underestimation of strength can go lower to twenty that of dry concrete.

Type of curing and age of concrete

The relation between the strength and hardness of concrete will change as the time pass there relationship is also effected by the curing conditions of concrete and their moisture exposure conditions. For concrete with an age between 3days to 90 days is exempted from the effect of age. For greater aged concrete special calibrated curves is important .

Carbonation on Concrete Surface

A higher strength is estimated by the rebound hammer on a concrete that's subjected to carbonation. It is estimated to be 50% higher. So the test need to be conducted by removing the carbonated layer and testing by rebound hammer over non-carbonated layer of concrete.

Pullout Tests

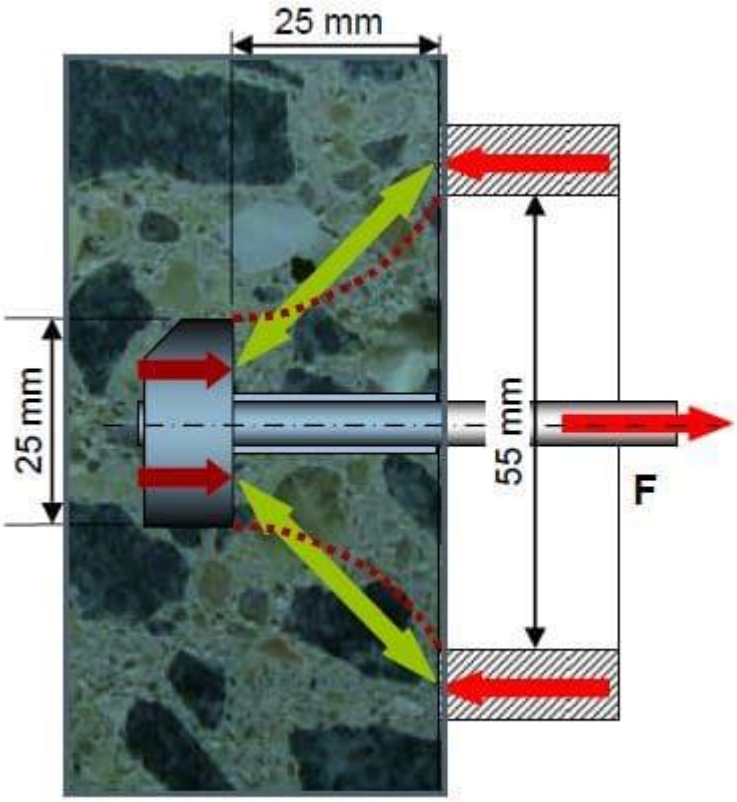
The main principle behind pull out testing is that the equipment designed to a selected geometry will produce results (pull-out forces) that closely correlate to the compressive strength of concrete.By measuring the force required to tug a steel disc or ring correlation is achieved, embedded in fresh concrete, against a circular counter pressure placed on the concrete surface concentric with the disc/ring.

Types of Pull Out Tests:

Depending upon the location of disc/ring in he fresh concrete, pull out test are often divided into 2 types,
LOK test
CAPO test (Cut and Pull out Test)

LOK Test:

This system is employed to get a reliable estimate of the in-place strength of concrete in newly cast structures in accordance with the pullout test method described in ASTM C900, BS 1881:207, or EN 12504-3.



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A steel disc, 25 mm in diameter at a depth of 25 mm, is pulled centrally against a 55 mm diameter counter pressure ring pertaining to the surface. To pullout the insert force F is required. The concrete within the strut between the disc and therefore the counter pressure ring is subjected to a compressive load. Therefore the pullout force F is said on to the compressive strength.

CAPO test (Cut and Pull out Test)

The CAPO-TEST allows to execute pullout tests on prevailing structures without the necessity of preinstalled inserts.. Procedures for executing post-installed pullout tests, like CAPO-TEST, are included in ASTM C900 and EN 12504-3. When selecting the situation for a CAPO-TEST, make sure that

reinforcing bars aren't within the failure region. The surface at the test location is ground employing a planing tool and a 18.4 mm hole is formed perpendicular to the surface employing a diamond-studded drilling bit . A recess (slot) is routed within the hole to a diameter of 25 mm and at a depth of 25 mm.A split ring is expanded within the recess and pulled out employing a pull machine reacting against a 55 mm diameter counter pressure ring. As within the LOKTEST, the concrete within the strut between the expanded ring and therefore the counter pressure ring is in compression. Hence, the last word pullout force F is said on to compressive strength.

Uses:

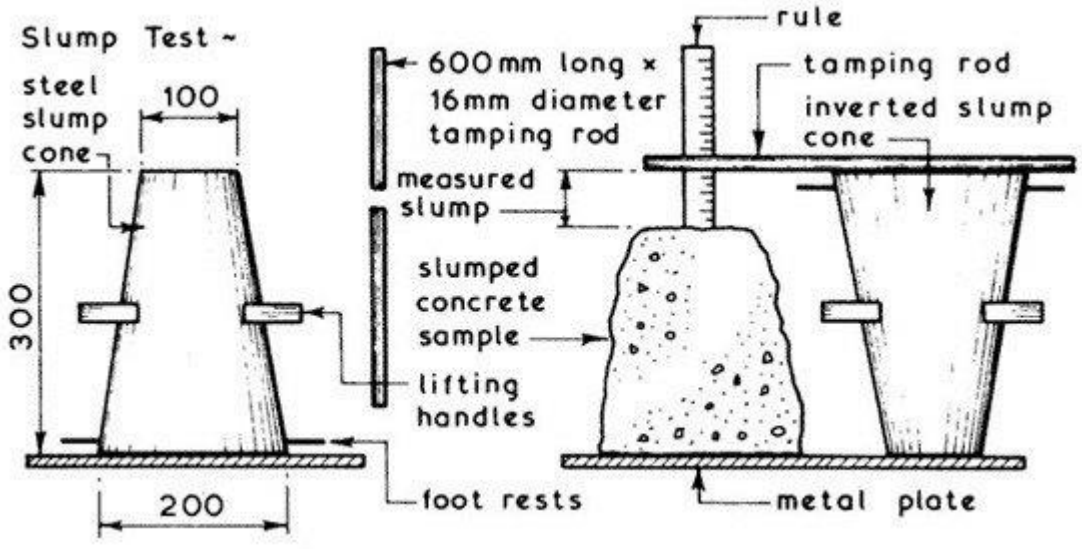
- Determine in-situ compressive strength of the concrete
- Ascertain the strength of concrete for completing post tensioning operations.
- Determine the time of removal of forms and shores supported actual in-situ strength of the structure.
- Terminate curing supported in-situ strength of the structure.
- It are often also used for testing repaired concrete sections.

Post Test Process:

After the concrete has fractured by this test, the holes left within the surface are first cleaned of the dust by a blower. It is then primed with epoxy and therefore the refore the hole is crammed with a polymer-modified mortar immediately thereafter and the surface is smoothened.

Compression Test and Slump Test for Quality Tests

All Among the tests mentioned above, the two important tests usually considered as quality tests are the compression tests and slump tests. If it is important , it is necessary to conduct fresh concrete temperature and hardened concrete density determination tests.



The purposes behind the decision of compressive quality test and droop test practically speaking for inside control testing of cement are:

- The compressive strength that's obtained by compressive strength test is where most of the concrete properties are associated with .
- Most economical or most accurately determinable test is compressive test and it easy to try to to also.
- The variableness of concrete is best studied with the assistance of compressive strength tests.

- The quality of the combination is judged by the slump test. This studies the variation of construction materials within the mix. These tests specialise in the water-cement ratio of the concrete mix.
- The slump test may be a sort of a test which is straightforward to conduct. It determines the standard of concrete very fastly before its placement. the location standards are as recommended by the respective concrete practice codes.
- Slump test are often conducted in situe which doesn't need any lab arrangement or expensive testing machines.
- We conduct the slump test before pouring into the formwork. Hence if there's a problem with the concrete quality, the tested batch are often rejected. this is able to help in mentioning a defective support and avoiding future dismantling and repair.

CHAPTER 3

3.1 Literature Review

J. Thivya, M.Arivukkarasi (2016) According to this investigation metakaolin and granite powder were use as partial replacement of cement with different percentage the best compressive strength of concrete increased with 15%MK and 20%GP re-placement in concrete. The compressive strength is increased around 8.5% compared to conventional concrete . The split tensile strength of concrete increased by 11.6% than conventional concrete. Further addition of Metakaolin and Granite powder de-crease the tensile strength of concrete.

- A.Kaur and V.P.S.Sran (2016) According to this research 3%,6%,9%,12% of me-takaolin was use as a partial replacement of cement in concrete (M30). The replacement of cement with MK up to 9%, give better results from strength prospective. There is increase in compressive strength of concrete with increase in partial replacement of MK with cement till 9%. Similarly, increase in split tensile strength of con-crete was observed till 9% addition of metakaolin at different interval of ages i.e. 7, 14 and 28 Days respectively.
- Dr. B. Krishna Rao and M. Anil Kumar (2016) The experiments were carried out at 10% replacement Of cement by metakaolin and 0, 10, 20, 30 and 40% replacements of fine aggregate by waste foundry sand. By doing the sieve analysis, it was found that waste foundry sand has finer material than fine aggregate. It was observed that as the percentage of foundry sand increases, the workability decreases due to the presence of finer particles the maximum replacement of foundry sand can be up to 30% in fine ag-aggregate by keeping metakaolin at constant rate of 10%.
- Morsy M. S.(2008) He investigated the properties of Portland cement mortar by using nano kaolin. The partial substitutions of ordinary Portland cement with nano metakaolin were carried out at 0%, 2%, 4%, 6%, 8% by weight of cement. It was clearly depicted by the results that there were increase in compressive as well as tensile strengths of concrete prepared with nano-metakaolin as compared with those of nor-mal concrete. About 49% increase in tensile strength was observed.
- Dinakar (2011) conducted study on behaviour of highly reactive metakaolin in con-rete and observed that if water cement ratio is kept similar for concrete containing silica fume and metakaolin, the concrete mix containing metakaolin had comparatively lesser water reducer requirement. This lesser demand has two benefits viz better finishing and lesser tendency of surface tearing during finishing. The super plasticizer requirement was adversely affected with increase in dosage of highly reactive metakaolin. For every 5%increase of metakaolin, the increase in super plasticizer was near about 0.6%. He also observed that the compressive as well as flexural strength of concrete using metakaolin was not only higher than that of ordinary concrete but also higher than that of silica fume concrete
- Chandrakant Mehetre et.al(2014) He conducted study on properties of concrete on adding metakaolin as one of the mineral admixture and reported that the addition of 10 % Metakaolin along with Cement Kiln Dust in self compacting concrete mixes en-hances various self-compact characteristics like flowing ability , segregation resistance etc.
- O. Pavithra, D. Gayathri, T. Naresh Kumar (2017) In this 10% of metakaolin is fixed and different percentage of quartz sand is used 25,50,75 as partial replacement of cement A combination of 10% metakaolin and 50% quartz sand in concrete is found to be optimum (41.97 N/mm2) for compressive strength at 28 days. A combi-nation of 10% metakaolin and 50% quartz sand in concrete is found to be optimum for split tensile strength at 28 days improved the tensile strength by 14.6% in contrast with the conventional mix . The mix having 10% metakaolin and 50% quartz sand which had highest compressive strength had shown lowest permeability which is a good indication for better concrete.
- K.Madhu , T.Divya Bhavana and Syed Eashan Adil (2016) In this metakaolin and rice husk with different percentage were use as replacement of cement it is observed that rice husk ash based concretes have achieved an increase in strength for 10% re-placement of cement and 5% replacement of cement by metakaolin and combine 10% RHA and 5% metakaolin at the age of 28 days when compared to

conventional con-crete in compressive test. it is observed that rice husk ash based concretes have achieved an increase in strength for 10% replacement of cement and 5% replacement of cement by metakaolin and combine 10% RHA and 5% metakaolin at the age of 28 days when compared to conventional concrete in split tensile test, combine effect of RHA and metakaolin are given result at 10%RHA and 5% metakaolin.

- Pichai Nimityongskul , Surak Panichnava (2013) Burning of dried vetiver grass was carried out in the ferrocement incinerator The burning of vetiver grass yields approximately 9% of whitish black ash which can easily be pulverized to powdered form (80kg). The initial setting time as well as the final setting time was higher than that of the control mix, which contained VGA as cement replacement. As anticipated the final setting time increased as the amount of VGA was increased. The results can be observed that the higher the content of VGA, the lower compressive strength of mortars. 20,40,60 percentage were used.
- Santhoshkumar.S, Kuralamuthan.S (2017) In this experiment the Vetiver fibre were added in percentages (0%, 0.2%, 0.4%, 0.6% and 0.8%) by Cement. Super plas-ticizer (SP) were added to increase the strength. On comparison, compressive strength of concrete with Vetiver fibre is better than conventional concrete with optimum re-placement percentage as 0.4%. It is increased by about 40.53 %. The split tensile strength and flexural strength of concrete increased with percentage of fibres showing an improvement of about 29.28 % and 75.22 % respectively at 0.4% vetiver fibre.
- Replacement of cement with metakaolin was done considering 0% 4% 6% 8% there ws a increase in the resiatance of the compressive to which rapid chloride permeability was found.it was observed that the high grade cement use in this research got an increase in compressive strength by by 10.13%, 14.24% and 22.90% by adding metakaolin content of 4%, 6% and eight respectively and that rapid chloride permeability was found to be decreased with increase in metakaolin content.

3.2 By reading all research paper on metakaolin-

- By reading all research paper we can say mk gives best result between 10 to 15 percent replacement of cement.
- Dosage of further 15% of metakaolin causes decrease of workability and compressive strength .
- Thus in my research I will use 4% 8% and 12% mk for replacement of cement.

3.3 Base Research Paper -

Experimental Investigation on Vetiver Fibre in Conventional Concrete by-

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3.4 General description about Metakaolin

Metakaolin may be a pozzolan, probably the foremost effective pozzolanic material to be used in concrete. It is a product that's manufactured to be used instead of a by-product and is made when china stone, the mineral kaolin, is warmed to a temperature somewhere in the range of 600 and 800ºC. Its quality is controlled during fabricate, prompting a way less factor material than modern pozzolans that are results. First utilized in the 1960s for the development of variety of huge dams in Brazil, metakaolin was successfully incorporated into the concrete with the first intention of suppressing any damage due to alkali-silica reaction.

When want to replace cement at levels of 5 to 10% by weight, the concrete produced is usually more cohesive and fewer likely to bleed. The compressive strength of hardened concrete is additionally increased at this level of replacement. Slightly higher replacement levels (up to 15%) produce a cement matrix that has low porosity and permeability. This leads to improvements to resistance of the hardened concrete to attack by sulfates, chloride ions and other aggressive substances, like mineral and organic acids. Freeze/ thaw resistance is improved and therefore the risk of injury resulting from the consequences of impact or abrasion is reduced for metakaolin concrete that has been finished and cured properly.

3.5 Metakaolin Concrete – Properties and Applications

The reactivity of metakaolin is predicated on chemical composition and reactive surface. This type of material is not like other admixtures for example fly ash, blast furnace slag, and silica fumes in terms of production because it is produced from high purity kaolin clay by calcinations at temperatures ranging from 700 to 800 °C.The average size of highly reactive metakaolin particle, which is smaller than cement particles, is starting from 1 to 2 and it's white in color which reciprocally influences the color of the final product. Specific gravity of highly reactive metakaolin is 2.5.

Fig.1: Highly Reactive Metakaolin

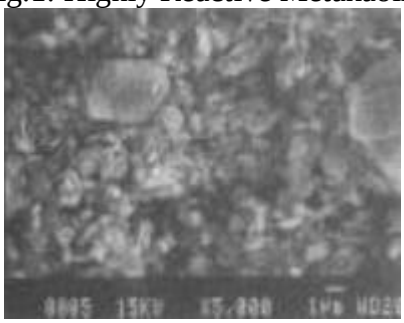


Fig.2: Micro Texture of Metakaolin

Properties of Fresh Concrete Containing Highly Reactive Metakaolin

It is claimed that, initial and final setting time of concrete incorporating about one-tenth highly reactive metakaolin is like controlled concrete. Bleeding of concrete containing metakaolin are often neglected thanks to its considerably high specific surface which is around 20m2/g.It is reported by Zhang and Malhotra that autogenous temperature rise of concrete incorporating metakaolin is quite that of concrete with zero metakaolin content.Introducing metakaolin into concrete cause increase water demand which suggests the mixture may have superplasticizer to realize necessary workability.

Mechanical Properties of Hardened Concrete Incorporating Highly Reactive Metakaolin

The properties of hardened concrete which have metakaolin in it are:

- There is the development in the Strength of concrete made with highly reactive metakaolin
- Drying shrinkage of metakaolin concrete.

Strength development of concrete made with highly reactive metakaolin

As it are often seen from which is taken from Zhang and Malhotra investigation, concrete containing metakaolin achieved greater strength compare to controlled concrete at any given time. The table provides flexural strength, lastingness , and modulus of elasticity of both controlled and metakaolin concrete.

mix	Compressive strength, MPa						Flexural strength, MPa	Tensile strength, MPa	Modulus of elasticity, Gpa
	1 day	3 days	7 days	28 days	90 days	180 days	28 days	28 days	28 days
Controlled concrete	20.9	25.5	28.9	36.4	42.5	44.2	6.3	2.7	29.6
Metakaolin concrete[1]	25	32.9	37.9	39.9	43	46.2	7.4	3.1	32

[1]metakaolin concrete incorporating 10% metakaolin

Note: both water/ cement ratio and water/ (cement+ metakaolin) ratios were 0.40. Additionally, the unit weight of both metakaolin concrete and controlled concrete were 2330 and 2350Kg/m^3 respectively.

Table 5- *Mechanical properties of both concrete incorporating metakaolin and controlled concrete*

Drying Shrinkage of Concrete Incorporating Highly Reactive Metakaolin

It is demonstrated that, after seven days of curing, drying shrinkage strain of concrete contained metakaolin is less than controlled concrete drying shrinkage.
After 112 days of curing in 50% ratio , the drying shrinkage of controlled concrete was above metakaolin concrete by approximately 20%.

Durability of Hardened Concrete Incorporating Highly Reactive Metakaolin

Air entrained concrete containing about one-tenth of metakaolin by mass supremely withstand ingression of chloride ions and has outstanding durability to repeated cycles of freezing and thawing. Metakaolin in concrete tend to scale back the dimensions of pores which consequently cause obtain more strength, higher density, and more resistance to acid. Furthermore, metakaolin improves concrete resistance to alkali silicate reactions and sulfate attack.

CHAPTER 4

4.1 Material Use in Research

Cement- M 20 cement is use in the given research work.

Fine Aggregate - Locally accessible sand affirming to zone II with explicit gravity 2.66 was utilized.

Coarse aggregate: Coarse aggregate utilized was 20 mm and less size and explicit gravity 2.70.

Vetiver fiber- In this experimentation Natural strands (Vetiver) with aspect ratio proportion 90 has been utilized. The length and width of vetiver fiber is 90mm and 1mm separately.

Metakaolin- In this experiments metakaolin having particle size less than 90 micron was used. Chemical composition of glass powder is as follows:

Chemical	**Composition**
SiO	43% - 52%
Al2O3	35% - 39%
CaO	2%-3%
TiO2	0.5-1.1
Na2O	<1%
Fe2O3	0.2-0.3
K2O	<1%
MnO	<0.3%
MgO	<0.2%
Loss on Ignition	Max 1.3%
Physical	**Properties**
Bulk Density (g/cc)	0.5452
Color	White
Specific Gravity	2.27

Table 6- *chemical and composition*

Mix proportion-

Two series of concrete mixtures with water-to-binder ratios of 0.45 were designed to produce metakaolin and metakaolin with vetiver fiber incorporated concretes. MK modified concretes were produced by 4%, 8%, 12% replacement of the cement with MK by the weight. For production of vetiver fiber (VF) reinforced concretes, vetiver fiber was added to the concrete by 0.3%,0.5% and 0.7% of concrete. Therefore, 24 different types of concrete mixtures were produced for examining the mechanical properties of the concretes**.** The details of the concrete mixtures are given below.

Table 7 -*Mix for Metakaolin*

Mix	Metakaolin	Water/Cement
Mk1	4%	0.45
Mk2	8%	0.45
Mk3	12%	0.45

Table *8 Nomenclature for Vetiver fiber and Metakaolin*

Mix	Metakaolin	Vetiver Fiber	Water/Cement ratio
Vmk1	4%	0.3%	0.45
Vmk2	4%	0.5%	0.45
Vmk3	4%	0.7%	0.45
Vmk4	8%	0.3%	0.45
Vmk5	8%	0.5%	0.45
Vmk6	8%	0.7%	0.45
Vmk7	12%	0.3%	0.45
Vmk8	12%	0.5%	0.45
Vmk9	12%	0.7%	0.45

For every test 24 cubes were made and 2 standard cube was made. Total being 26 cubes.

4.2 EXPERIMENTAL WORK

Casting of Specimen

The experimental Studies consist of testing of 24 specimen for each test (50 samples were total made) 3 sample with specimen of cement replaced mk with 4% 8% 12%, 3 specimen of vetiver fibre reinforced concrete along with mk , All specimen cubes having same M20 grade of concrete. The concrete cubes having size of (150*150*150) mm^3 and size of beam is (150*150*700)mm

Mixing of normal concrete.

Firstly mix the cement, dry course aggregates and fine aggregates in the proportion properly before mixing the water. Add the required water in the concrete mixing it for 2 minute to achieve uniformity of the concrete then casted in the mould of cubes and beam. Before poured the concrete the moulds are washed and oiled properly so that can remove easily after hardened of concrete.

Mixing of concrete with replacement of metakaolin.

Dry cement, course aggregates and fine aggregates are mixed manually in the pan for two minute. Mixing continuous for further two minutes while 80% of water was added and after proper mixing of concrete

remaining 20%water was added with the metakaolin. While mixing ensured that complete distribution of metakaolin in the concrete mix. Then casted the concrete cubes and beams containing metakaolin in the concrete.

Mixing of concrete with Vetiver fiber.

vetiver fiber have fairly high water absorption property so they are placed into the water for 30-60 mins before mixing into the concrete mix so that fiber don't effect the water cement ratio by absorbing the water. Dry cement, metakaolin (decided percentage), course aggregates and fine aggregates are mixed manually in the pan for two minute. Mixing continuous for further two minutes with water . The mixing was continued for another few minutes and the vetiver fibers were fed continuously to the concrete for a period of 2–3 min while stirring. and adding the fiber it should ensure that mixing should be uniformly distributed in the concrete mix. Then casted the concrete cubes and beam containing mk and vetiver fiber in the concrete.

Casting and curing.

The mould is arranged properly and placed at smooth surface. The side walls of the mould is oiled properly so prevent to absorbing water from concrete and easily remove after hardened of the concrete. While molded to ensure that cement, sand and course aggregates are mixed uniformally then the concrete cubes were compacted with the help of the vibrating machine. The specimen was remoulded after 24 hours of casting and placed the specimen in the water for curing of 7 days and 28 days. After 7 and 28 days the specimen was tested on the compression and flexural testing machine.

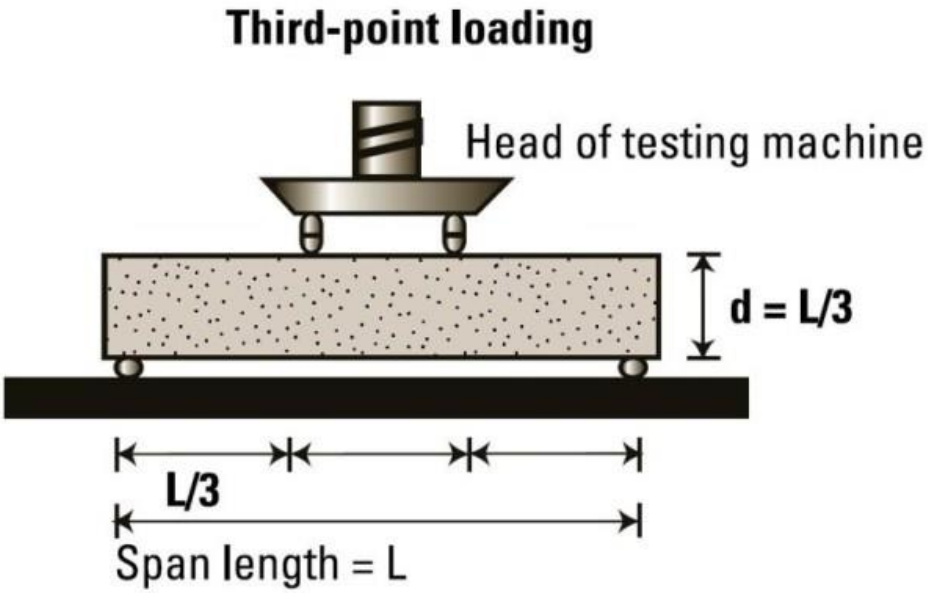
Testing of the concrete cubes and Beam.

Test procedure compressive strength-

After 7 days and 28 days specimen was tested by using compression testing machine having capacity of 1000 KN .Specimen placed on the bottom clamp plate of machine top surface of the specimen is slightly touched with the upper clamp plate then continuous loading was applied from both sides of the specimen till we might identify the small hair cracks further the loading is continued until we got the ultimate load. Finally compare the strength of the normal concrete and the specimen concrete. Cube specimens of size 150 mm x 150 mm x 150 mm were taken out form the curing tank at the ages of 7 days and 28 days furthermore, tried quickly on expulsion from the water .Surface water was cleared off, the examples were tried. The position of cube when tested was at right angle to that as cast. The load as applied gradually without shock till the failure of the specimen occurs and thus the compressive strength was found.The quantities of cement, coarse aggregate fine aggregate, metakaolin, vetiver fiber and water for each batch i.e. for different percentage of metakaolin and vetiver fiber replacement was weighed separately. The cement and metakaolin powder were mixed dry to a uniform colour separately. The coarse aggregates were mixed to get uniform distribution throughout the batch. Firstly, 50 to 70% of water was added to the mix and then mixed thoroughly for 3 to 4 minutes. Then the concrete was filled into the cube and beams moulds and then get vibrated to ensure proper compaction. The finished specimens were left to harden in air for 24 hours. The specimens were removed from the moulds after 24 hours of casting and were placed in the water tank, filled with potable water.

Test procedure flexural strength-

Size of the beam is (150*150*700)mm.after 7 and 28 day its taken out from the curing tank. The beam is wiped with a cloth and placed on the testing machine between the loading and supporting bar because flexural trial of sodden relieved examples will be made when functional after expulsion from wet stockpiling. Surface drying of the specimen results in a reduction in the measured flexural strength. Then the load is gradually increased with a rate of 400kg/min. the load at which it breaks is noted. Finally compare the strength of the normal concrete and the specimen concrete.



4.3 RESULT AND DISCUSSIONS

General

The experimental Studies consist of testing of 24 specimen for each test (50 samples were total made) 3 sample with specimen of cement replaced mk with 4% 8% 12%, 3 specimen of vetiver fibre reinforced concrete along with mk different percentage , The load failure of each cubes is discussed. The aimed of the experimental programmed to achieve many objectives through comparison between the strength with normal concrete. Testing of specimen discovered the compression strength and the split tensile strength on effect of different percentages of metakaolin and the vetiver fiber.

Compressive strength of concrete with partial replacement of cement with metakaolin.

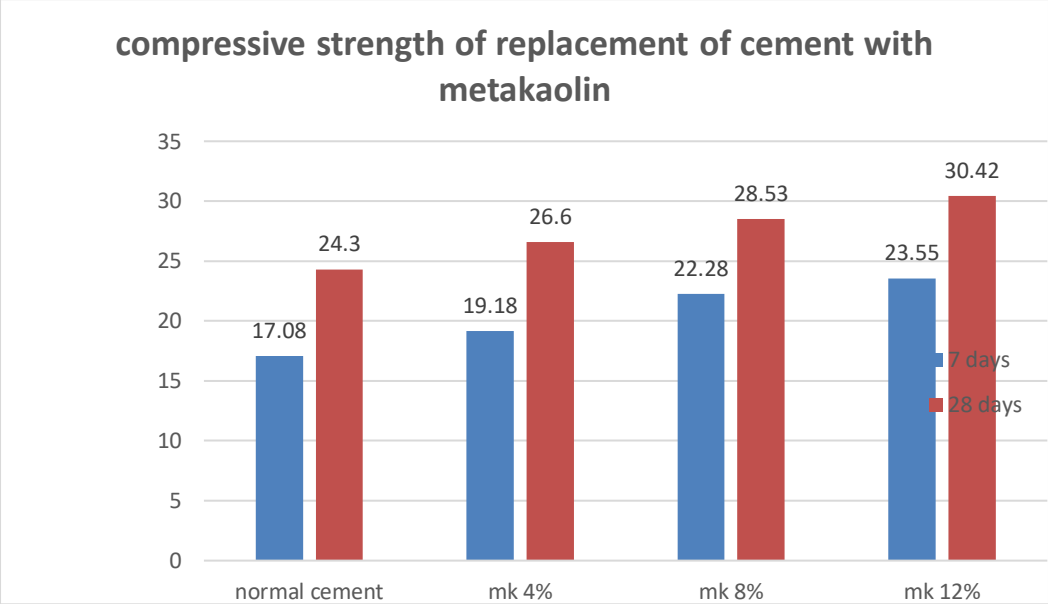
Concrete construction applications are particularly resistant to the most the compressive stresses. If the plain concrete is under pressure, cube diagonal falls on the vertical plane. Due to the lateral tension strain cracks occurs. Specimen size of (150*150*150) mm^3 cube are testing on compression strength of concrete after 7days and 28 days of curing. The sample was prepared by control Mix and with different percentages of metakaolin.

Table 9 - *Result of compressive strength test of replacement of cement with metakaolin*

mix	7^{th} days Compressive Strength	28^{th} day compressive strength
Conventional concrete	17.08 N/mm^2	24.3 N/mm^2
MK1	20.18 N/mm^2	27.6 N/mm^2
MK2	23.28 N/mm^2	29.53 N/mm^2
MK3	24.55 N/mm^2	31.42 N/mm^2

The compressive strength examined for different percentages of metakaolin is replacement of cement with weight for 4%, 8%, 12% metakaolin. As compared to the normal concrete mix strength is increased by 12.29% at 5% replacement of metakaolin after 7 days and for 28 days there was increase in strength by 9%. For 8% replacement strength is a increased by 30.44% for 7 days and for 28 days is increased by 17.40% as compared to the normal mix after 28 days testing.and for 12% replacement metakaolin compressive strength was increased by 37.88% for 7 days and for 28 days it is increased by

25%. So the optimum level of partial replacement of cement with metakaolin is 4-12% which gives the increase in strength after 28 days .



Flexural strength of concrete with partial replacement of cement with metakaolin.

The concrete beam of 150*150*700 was used for testing the flexural strength after 7 days and 28 days. The concrete specimen has been made for different percentages having metakaolin content of 4%, 8%, 12%, replacement. 1 sample has been casted for each percentage the results of flexural strength are reported in the table below, which shows the gain flexural strength for different percentages of metakaolin.

Table 10- *Result of Flexural strength test of replacement of cement with metakaolin*

Mix	7^{th} days Flexural Strength	28^{th} day Flexural strength
Conventional concrete	2.33 N/mm^2	3.50 N/mm^2
MK1	2.35 N/mm^2	3.73 N/mm^2
MK2	2.54 N/mm^2	4.06 N/mm^2
MK3	2.65 N/mm^2	4.21 N/mm^2

The Flexural strength result of separate concrete mix is shown graphically. Flexural . The variety of results for flexural quality of cement with concrete trade by metakaolin for 7 and 28 days. Unmistakably flexural quality of cement with 12% concrete substitution by metakaolin demonstrated a higher worth contrasted with control concrete for 7 days and 28 days separately.

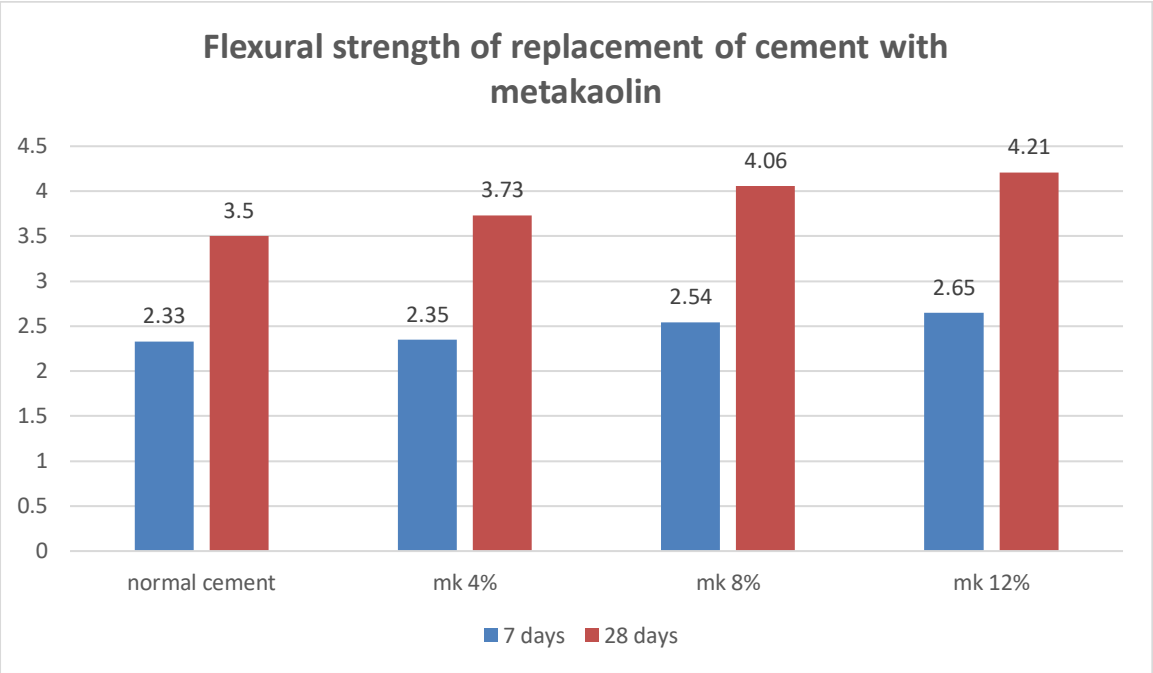


Table 11 - *Result of compressive strength with partial replacement of cement with metakaolin and vetiver fiber*

Mix	Metakaolin	Vetiver Fiber	7 days	28 days
Vmk1	4%	0.3%	25.23	34.81
Vmk2	4%	0.5%	22.20	29.97
Vmk3	4%	0.7%	19.76	26.27
Vmk4	8%	0.3%	23.85	32.17
Vmk5	8%	0.5%	21.06	28.82
Vmk6	8%	0.7%	18.43	24.68
Vmk7	12%	0.3%	19.11	25.79
Vmk8	12%	0.5%	17.22	23.41
Vmk9	12%	0.7%	16.75	22.94

Maximum compressive strength achieves with 4% and 0.3% vetiver fiber

Graph representation of compressive strength with partial replacement of cement with metakaolin and vetiver fiber

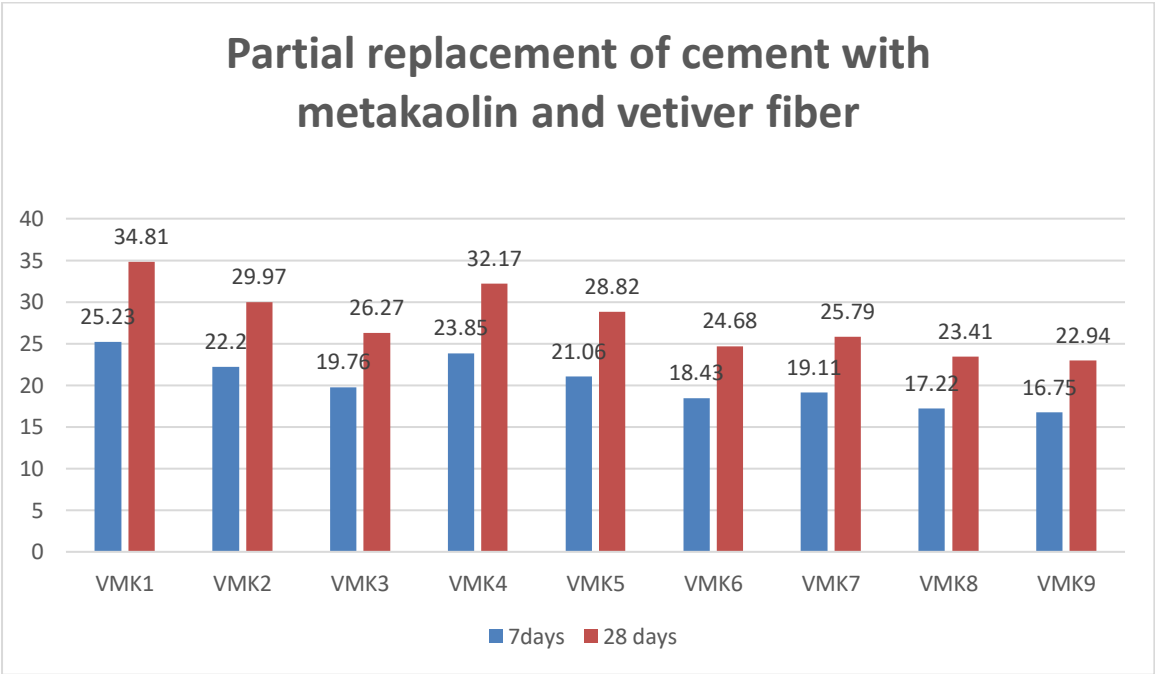
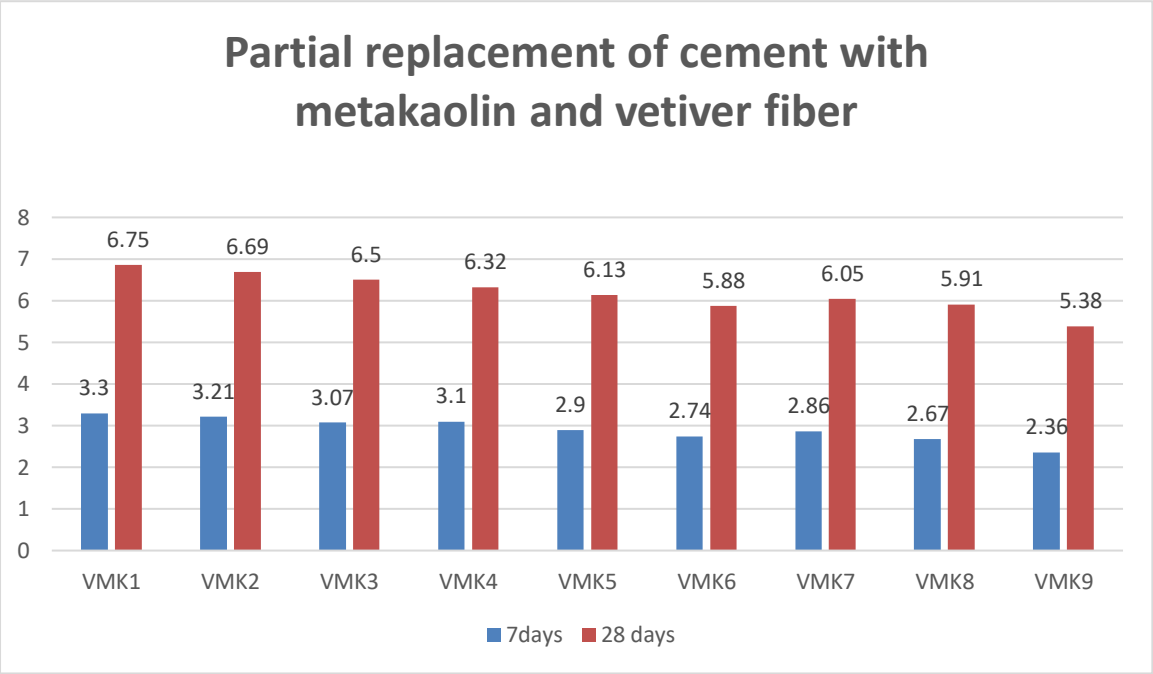


Table 12 -*Result of flexural strength with partial replacement of cement with metakaolin and vetiver fiber*

Mix	Metakaolin	Vetiver Fiber	7 days	28 days
Vmk1	4%	0.3%	3.30	6.75
Vmk2	4%	0.5%	3.21	6.69
Vmk3	4%	0.7%	3.07	6.50
Vmk4	8%	0.3%	3.10	6.32
Vmk5	8%	0.5%	2.90	6.13
Vmk6	8%	0.7%	2.74	5.88
Vmk7	12%	0.3%	2.86	6.05
Vmk8	12%	0.5%	2.67	5.91
Vmk9	12%	0.7%	2.36	5.38

(28 days)Maximum flexural strength achieves with 4% metakaolin and 0.3% vetiver fiber
P=38 kilo newton, minimum length of fracture from support(a)=21cm
l=60cm b=15cm, d=15cm formula used $fck=pl/bd^2$

Graph representation of flexural strength with partial replacement of cement with metakaolin and vetiver fiber



4.4 Ideal combination mix

After the entire experimental work it is concluded that mix M20+4% metakaolin+0.3% vetiver fiber is the best combination among all the mixes which gives the maximum compression strength and flexural tensile strength.

CHAPTER 5

5.1 CONCLUSION AND FUTURE SCOPE

5.1.1 Conclusion

- It is seen that when metakaolin used alone without vetiver fiber strength is increased.
- Metakaolin and vetiver fiber together give best result at low percentage
  4%mk and 0.3%vf.
- With the increases of percentage of metakaolin in concrete the workability decreases to some extend. As there is a decrease in fineness modulus of cementatious material, amount of concrete paste accessible for giving greasing up impact is less per unit surface territory of total along these lines expansion of vetiver fiber balance the effect and slightly increases the workability of concrete with even increasing the w/c ratio.

5.1.2 Future scope

Since it is widely available in india it can be obtained easily and many other test which are pending are need to be done specially split tensile test.

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