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AN EXPERIMENTAL STUDY TO INVESTIGATE WORKABILITY AND STRENGTH PROPERTIES OF CONCRETE BY PARTIALLY REPLACING CEMENT WITH PUMICE POWDER

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ABSTARCT

The construction industry is flourishing day by day; as a result, cement consumption also increases. Since cement production causes carbon footprint, partial replacement using waste materials from various industries is one of the solutions. Pumice powder, generated by the stone processing industry, is an inert by-product possessing excellent cementitious characteristics. Utilization of pumice powder in concrete can reduce the cost of construction and at the same time address the waste disposal problem. Mechanical strength characteristics were evaluated for normal and varying contents of pumice powder added mix after 7 and 28 days of curing. The primary objective of this investigation is to study the strength characteristics of pumice powdered concrete of M20 grade concrete & M30 grade concrete by conducting destructive tests like compressive, split tensile and flexural strength test. In the present study, an attempt has been made to investigate the strength parameters of concrete when cement is replaced with pumice powder by adding at various percentages like 0%, 5%, 10%, 15%, 20%, 25%, and 30%. Moreover, no such attempt has been made in replacing with the waste material i.e. pumice powder at highest percentages to prepare M20 and M30 grade of pumice powdered concrete. The strength characteristics are calculated at 7, 28 days and compared the test results with the nominal mix of concrete. The significance of this study is to promote the usage of by-product waste as a replacement for cement thereby reducing CO_2 emissions and thus resulting in the development of environmentally friendly concrete.

INTRODUCTION

Concrete is used extensively in various types of construction works as a construction material among civil engineers around the world for decades. The most commonly used construction material in the world is concrete. The art of arriving at proper mix through a suitable combination of cement, aggregates, water and admixtures is referred as mix proportioning. The mix proportions should satisfy all the requirements to use of minimum possible cement content so that maximum economy is achieved. The purpose of concrete mix proportioning is to combine the available cementations materials, water, fine and coarse aggregates, and admixture such that the resulting mix will meet the particle requirement of strength and durability. Concrete mix design is arrived at by using certain relationships established from experimental data which afford reasonably accurate guidance to select the best combination of ingredients in getting desired properties. The large scale production of cement involves environmental problems on one hand on the other hand the unrestricted depletion of natural source. So, in order to fulfill the requirement the cement can be replaced with cementitious material.

The primary objective of this investigation is to study the strength characteristics of pumice powdered concrete of M20 (low grade concrete) & M40 (high grade concrete) by conducting destructive tests like compressive, split tensile and flexural strength test. In the present study, an attempt has been made to investigate the strength parameters of concrete when cement is replaced with pumice powder by adding at various percentages like 0%, 5%, 10%, 15%, 20%, 25%, and 30%. Moreover, no such attempt has been made in replacing with the waste material i.e. pumice powder at highest percentages to prepare M20 and M30 grade of pumice powdered concrete. The strength characteristics are calculated at 7, 28 days and compared the test results with the nominal mix of concrete. The significance of this study is to promote the usage of by-product waste as a replacement for cement thereby reducing CO_2 emissions and thus resulting in the development of environmentally friendly concrete.

USE OF CEMENTATIOUS MATERIAL IN CONCRETE

The threat to the ecology has lead to lot of investigation to the utility of industrial by product as supplementary cementations material for making concrete. pumice powder, Hypo sludge, Fly ash, Rice husk ash and Silica fume are well known industrial by product that are being extensively used as supplementary cementations materials. The advancement in the cement technology has resulted in the development of high grade of cement which has enable engineers to use of lesser cement. This is possible by the use of the supplementary cementations materials. The use of RHA as a mineral admixture in the concrete has been increasing. It is known that concrete incorporating RHA restrain heat of hydration and has superior resistance to alkali-silica reaction, chloride ion penetration and sulphate attack. A well-proportioned mixture generally shows improved mobility, cohesiveness, strength and durability. The beneficial effects of these materials are well documented. Water cement ratio is an important factor in mix design. Primary requirement of good concrete is a satisfactory compressive strength in its hardened state. Many of the desirable properties like durability, impermeability and abrasion resistance is highly influenced by the strength of concrete. Strength can be considered to be solely dependent on water- cement ratio for low and medium strength concrete mix. For high strength mixes aggregate cement ratio workability and maximum size of aggregate influence the selection Of water/cement ratio. Workability of concrete varies with water/cement ratio and quantity of cementations material. Hence the use of plasticizers and super plasticizer is a must to get the desired workability when additional cementing materials are used.

NECESSITY OF THE PRESENT WORK

The world at the end of the 21st century that has just been left behind was very different to the world that its people inherited at the beginning of that century. The latter half of the last century saw unprecedented technological changes and innovations in science and engineering in the field of communications, medicine, transportation and information technology, and in the wide range and use of materials. The construction industry has been no exception to these changes when one looks at the exciting achievements in the design and construction of buildings, bridges, offshore structures, dams, and monuments, such as the Channel Tunnel and the Millennium Wheel. But this process of the evolution of the industrial and information technology era has also, however, been followed, particularly during the last four to five decades, by unprecedented social changes, unpredictable upheavals in world economy, uncompromising social attitudes, and unacceptable pollution and damage to our natural environment. In global terms, the social and societal transformations that have occurred can be categorized in terms of technological revolutions, population growth, worldwide urbanization, and uncontrolled pollution and creation of waste. But perhaps overriding all these factors is globalization- not merely in terms of economics, technologies and human and community lives - but also with respect to climatic changes and weather conditions of the world.

OBJECTIVES OF THE WORK

The objective of the present investigation is to investigate

- The workability for concrete mixes of grade M20, M30 by replacing mass of cement with pumice powder at different proportions.
- The strength characteristics are determined by using destructive tests like compressive strength test, split tensile strength test, flexural strength test on concrete mixes of grade M20, M30 by replacing mass of cement with pumice powder at percentages like 0%, 5%, 10%, 15%, 20%, 25%, and 30%.

SCOPE OF THE WORK

The scope of this investigation is to study the strength characteristics of pumice powdered concrete of M20 (low grade concrete) & M40 (high grade concrete) by conducting destructive tests like compressive, split tensile and flexural strength test. In the present study, an attempt has been made to investigate the strength parameters of concrete when cement is replaced with pumice powder by adding at various percentages like 0%, 5%, 10%, 15%, 20%, 25%, and 30%. Moreover, no such attempt has been made in replacing with the waste material i.e. pumice powder at highest percentages to prepare M20 and M30 grade of pumice powdered concrete. The strength characteristics are calculated at 7, 28 days and compared the test results with the nominal mix of concrete.

LITERATURE REVIEW

Lakshmi Kumar Minapu et.al (2014) In Design of concrete structures, light weight concrete plays a prominent role in reducing the density and to increase the thermal insulation. These may relate of both structural integrity & serviceability. More environmental and economical benefits can be achieved if waste materials can be used to replace the fine light weight aggregate. The new sources of Structural aggregate which is produced from environmental waste is Natural aggregates, synthetic light weight aggregate The use of structural grade light weight concrete reduces the self weight and helps to construct larger precast units. In this study, an attempt has been made to study the Mechanical Properties of a structural grade light weight concrete M30 using the light weight aggregate pumice stone as a partial replacement to coarse aggregate and mineral admixture materials like Fly Ash and Silica Fume. For this purpose along with a Control Mix, 12 sets were prepared to study the compressive strength, tensile strength and flexural strength. Each set comprises of 4 cubes, 2 cylinders and 2 prisms. Slump test were carried out for each mix in the fresh state. 28-days Compressive test, Tensile Strength and Flexural Strength tests were performed in the hardened state. The study is also extended for blending of concrete with different types of mineral admixtures. The test results showed an overall strength & weight reduction in various trails. Therefore, the light weight concrete is no way inferior for construction purpose.

Veeranjaneya reddy V et.al (2018) This paper investigates the experimental study about pumice powder(PP) which is used as replacement for cement which enhances the flexural strength of the structural member. In this project dif erent proportion of pumice powder has been added as partial replacement in cement at various percentage like 0%,5%,10%,15% and 20%. The mechanical properties of Pumice powder concrete. (i.e.) Compressive strength, Splitting tensile and flexural strength test were investigated on pumice powder concrete at various ages of curing. the reinforcement concrete beam is tested under two point loading and the behavior of reinforcement concrete beam with various percentage of pumice powder was compared with conventional beam.

Amruta Salunkhe et.al (2019) The aim of the study is to find the compressive strength of concrete with Pumice aggregate (PS) and Metakaoline (MK) with different temperature exposure (both heating and cooling regimes). The different temperature conditions adopted for heating regimes are 300 and 500°C whenever for cooling methods are performed normal (at room temperature) , water and furnace cooling (Specimens in the furnace). The concrete with 20% Metakaoline replaced for cement and fine aggregate replaced with 10,20 and 30% of pumice aggregates with water binder ratio 0.41. The results show that 30% Pumice stone with 20% MK performed heater in different temperature regimes compared to other mixture in terms of compressive strength.

M.Mohamed Ilyas et.al (2019) In this study, Cement concrete is prepared by using cement and metakaolin as a binder, sand as fine aggregate and pumice stone as coarse Aggregate. Bureau of Indian Standard (BIS) method is used to proportionate the concrete. The concrete and constituent mortar cubes are casted by different ratio and proportion and cured. The cubes are tested at various ages to find the compressive strength. The main cause of the fracture on the concrete cubes are through the pumice aggregate. The law of mixtures are used to compute the characteristic strength of the aggregates. In this project to compare the different ages of strength are to be analysed for the improvement of compressive and tensile strength. The mortar strength can be altered by adjusting the watercement ratio. This method can be used to reproportion the concrete by the law of mixtures and Abrams' law as basis. Abrams' law is a concept in civil engineering. The law states the strength of a concrete mix is inversely related to the mass ratio of water to cement. As the water content increases, the strength of concrete decreases.

Mamman Adamu Idi et.al (2020) The study investigated strength properties of concrete using pumice aggregate as partial replacement of coarse aggregate. The study sought to determine whether pumice aggregate can be used in structural concrete and achieve same degree of strengths to that of conventional aggregate concrete. What necessitated the research is the rapid population growth and increase rate of depletion of natural resources. However the rate of environmental degradation can be reduced by diversifying materials and sources of aggregates for convectional aggregates extracted from quarrying. Materials such as pumice aggregate are suitable substitute for conventional aggregate. The study was conducted through experimental research approach whereby laboratory experiments were conducted before coming up with a feasible conclusion and recommendation. DOE mixed design was adopted. Properties of aggregates such as aggregate crushing value and aggregate impact value were carried out; Slump test and compacting factor test of concrete were also carried out. Fresh and hardened concrete were obtained through outcome of experimental results and presented using tables and graphs. The study established that with pumice aggregate content the result shows slightly reduced compressive, tensile and flexural strengths as compared to the control concrete. Concrete produced with pumice as coarse aggregate meet the required strength at 28 days. Control concrete had higher compressive strength at 28 days of 1.05% compared to 5% pumice aggregate. Also control concrete had higher tensile strength at 28 days of 0.59% compared to 5% pumice aggregate in addition control concrete had higher flexural strength at 28 days of 4.41% compared to 5% pumice aggregate Concrete with pumice as coarse aggregate is optimum at 5% for all curing days which meet the required strength at 28 days but can be replaced up-to 15% aggregate replacement. This study recommends the use of admixture to improve in general the properties of concrete. Keyword: Pumice Aggregate, Aggregate Crushing Value, Aggregate Impact Value, Slump Test Compacting Factor Test, Compressive Strength, Tensile Strength, Flexural Strength.

S Sagar et.al (2021) In design of concrete structures, concrete plays an important role in the contemporary background as raw material for construction has been decreased. Therefore construction industry has acquaint with novel methods by making use of the available waste material for partial replacement by using alternative aggregates instead of ordinary aggregates. In this study, pumice stone is used as replacement materials for concrete where it is found in the abyssal of the red clay or in deepest portion of the ocean, and partially replacing by Pumice, blends with cement. The physical, mechanical and durability properties of concrete was investigated by conduction compressive strength and tensile strength on the ordinary and replaced concrete with varied percentage of pumice from 5% to 30%. It's obsereved that environmental and economical benefits can be achieved if waste materials can be used to replace the coarse aggregate in order to use the waste materials effectively in areas with abundant availability of materials. This thesis work on the effectiveness of partial substitutions of pumice for coarse aggregate in producing adequate strength gain. In the present thesis work comparison of fresh concrete and hardened properties of concrete for both conventional concrete and Replaced concrete for varying percentage of replacement of pumice stone to coarse aggregate and based on the experimental results, it's concluded that 25% partial replacement by pumice gives maximum compresive strength.

Safiel Tumaini Chambua et.al (2021) Concrete structures suffer serious deterioration under a corrosive environment. Consequently, the service life of these concrete structures is decreased and deteriorates under combined attack of sulphate and chlorides. Most studies confined on single deteriorating factor such as sulphate attack only or chloride attack only but the current study focused on the influence of natural pumice (NP) and natural scoria (NS) on the strength performance of concrete exposed to the combined attack of sulphate and chloride. Portland cement (PLC) was replaced with NP or NS at a substitution level of 10%. Concrete samples were cured in water for the curing period of 28 days. Afterwards, the specimens were immersed in 5% sodium sulphate (Na2SO4), 5% sodium chloride (NaCl), and combined sodium sulphate and chloride solutions for additional curing of 28, 56, and 90 days. /e results were compared between concrete mixes with NP or NS and control mix (CT) with PLC. /e effects of sulphate, chloride, and combined sulphate and chloride were evaluated in terms of change in weight, variation in compressive strength, and degree of damage. Conclusively, the application of NP and NS has extraordinary potential to be utilized as a cementitious material in concrete to increase the resistance against aggressive salts.

Karthika R.B et.al (2021) Concrete is the commonly used manufactured building material in the world, owing to its usefulness and relatively low cost. One of the disadvantages of conventional concrete is its high self-weight. This heavy self-weight of concrete will result in uneconomical structural material. To decrease the self-weight of concrete, the coarse aggregate is replaced partially by lightweight aggregate. This is known as lightweight concrete having low density, reduction of dead load and to increase thermal insulation. There are two types of lightweight aggregate - natural lightweight aggregate and artificial lightweight aggregate. One of the most commonly available natural lightweight aggregate called pumice aggregate is used as a replacement for coarse aggregate. Pumice aggregate is used because of its low density than conventional coarse aggregate, and it is easily available. Lightweight concrete is prepared by partially replacing the coarse aggregate with pumice aggregate by 50%, 80% & 100%. The conventional concrete and pumice lightweight aggregate concrete is made by using mix M30 with Conplast SP430 admixture.The mechanical and durability properties of conventional concrete and pumice lightweight aggregate concrete are compared by conducting various destructive and non-destructive tests and favorable replacement.

V.Sathish et.al (2022) The main scope of this study is to find various properties of concrete with replacement of cement by pumice stone powder. Now a days many of research are going to find the best possible alternate for cement in concrete. In this work pumice stone powder was partially replaced as cement in the range 10%, 20%, 30%, 40%. The fresh and hardened properties of concrete with pumice stone is to be compared with conventional concrete. Pumice powder, generated by the stone processing industry, is an inert by-product possessing excellent cementitious characteristics. Utilization of pumice powder in concrete can reduce the cost of construction and at the same time address the waste disposal problem. This study is focused on the strength properties of pumice powder in pozzolan concrete .The results indicate that the fresh and hardened properties of the modified mix with pumice stone powder as improved considerably. The use of pumice powder as a substitute for cement in the concrete mixture also has the ability to improve the compressive, and tensile strength of concrete.

SUMMARY

The review of number literature shows the importance of usage of pumice powder usage in the field of research. The findings shows that the materials like pumice powder can be incorporated to improve the properties of concrete. The results shows the improved characteristics of concrete in terms of destructive tests. The current study is concerned with incorporation of pumice powder in concrete mix and to know the strength characteristics and quality of the concrete mix.

METHODOLOG

MATERIALS AND THEIR PROPERTIES

The Raw materials that are used in the production of concrete are mentioned below.

- Coarse aggregates
- Fine aggregates
- Cement
- Pumice powder
- Potable water

COARSE AGGREGATE

The material whose particles are of size are retained on IS sieve of size 4.75mm is termed as coarse aggregate and containing only so much finer material as is permitted for the various types described in IS: 383-1970 is considered as coarse aggregate. Aggregates are the major ingredients of concrete. They constitute 70-80% of the total volume, provide a rigid skeleton structure for concrete, and act as economical space fillers. Because at least three-quarters of the volume of the concrete is occupied by aggregate, it is not surprising that its quality is of considerable importance. The properties of aggregate greatly affect the durability and structural performance of concrete. Aggregate was originally viewed as an inert material dispersed throughout the cement paste largely for economic reasons. It is possible, however, to take an opposite view and to look on aggregate as a building material connected in to a cohesive whole by means of the cement paste, in a manner similar to masonry construction. In fact, aggregate is not truly inert and its physical, thermal and sometimes also chemical properties influence the performance of concrete. Aggregate is cheaper than cement and it is, therefore, economical to put in to the mix as much of the former and as little of the later possible. But economy is not only the reason for using aggregate, it confers considerable technical advantages on concrete, which has a higher volume stability and better durability than hydrated cement paste alone. Aggregates should be of uniform quality with respect to shape and grading. The size of coarse aggregated depends upon the nature of the work. The coarse aggregate used in this experimental investigation is 20mm and 10mm size, crushed and angular in shape as shown in Figure 3.4. The aggregates are free from dust before used in the concrete.

The following tests have been conducted on coarse aggregates.

- Specific Gravity
- Fineness modulus
- Bulk density
- Sieve analysis

properties of coarse aggregates

S.NO	Property	values
1	Specific gravity	2.67
2	Fineness modulus	6.01
3	Bulk densityLoose Compacted	14 KN/m3 16 KN/m3
4	Nominal maximum size	20mm

Fine aggregate

The size of the fine aggregate is below 4.75mm. Fine aggregates can be natural or manufactured. The grade must be throughout the work. The moisture content or absorption characteristics must be closely monitored. The fine aggregate as shown in Figure 3.2 used is natural sand obtained from the river Godavari conforming to grading zone-II of Table 3 of IS: 10262-2009. The results of various tests on fine aggregate are given in Table 3.2. The fine aggregate shall consist of natural sand or, subject to approval, other inert materials with similar characteristics, or combinations having hard, strong, durable particles. The use of concrete is being constrained by urbanization, zoning regulations, increased cost and environmental concern. The following tests have been conducted on fine aggregates.

- Specific Gravity
- Bulk density
- Sieve analysis (fineness modulus)

properties of fine aggregates

S.NO	Property	values
1	Specific gravity	2.60
2	Fineness modulus	2.32
3	Bulk density Loose Compacted	 12 KN/m3 15 KN/m3
4	Grading	Zone-ii

ORDINARY PORTLAND CEMENT

Ordinary Portland cement is used for general constructions. The raw materials required for manufacture of Portland cement are calcareous materials, such as limestone or chalk and argillaceous materials such as shale or clay. The manufacture of cement consists of grinding the raw materials, mixing them intimately in certain proportions depending upon their purity and composition and burning them in a kiln at a temperature of about 13000C to 15000C at which temperature, the material sinters and partially fuses to form nodular shaped clinker. The clinker is cooled and ground to a fine powder with addition of about 2 to 3% of gypsum. The product formed by using the procedure is a “Portland Cement”. In the present experimental work KCP 53 grade ordinary Portland cement was used.

Cement

The cement is to be tested in the laboratory for its quality requirement limitations as per Indian Standards. The cement used was ordinary Portland cement of OPC 53 grade (KCP 53 grade) as shown in Figure 3.1 confirming to IS: 12269-2013.Various tests are conducted to know the physical properties of cement and the results are tabulated below in Table 3.1. All 16 the tests conducted are as per the norms of standard specifications given in IS 4031 and the results are tabulated.

properties of cement

S.NO	property	values
1	normal consistency	31%
2	Specific gravity	3.14
3	Initial setting time	94 minutes
4	final setting time	197 minutes

PUMICE POWDER

Pumice stone is a natural sponge-like lightweight aggregate formed during the rapid cooling and solidification of molten lava. It is a a kind of igneous rock that is formed when a volcano erupts. After suitable preparation, it can be used as an aggregate to produce lightweight concrete or as a cementitious material to produce blended cement or geopolymer.

Geology of Pumice Stone

Pumice stone is defined as a volcanic rock consisting of bubbles or vesicles in a glass matrix generated by the effervescence of gases and rapid freezing of molten material after an eruption, according to (Doanld, 1992). Volcanic materials are referred to in a variety of ways, such as pyroclastic and tephra. These phrases refer to deposits that are either fractured or unconsolidated. Pumice stone is classified as extrusive, meaning it was created by the fast cooling of magma at the earth's surface (Assfawossen, 2006). As a result, pumice deposits are susceptible to weathering and the majority of pumice deposits are geologically young. Volcanic ash and pumice are non-consolidated materials that are ejected during volcanic eruptions and consist of a mixture of minerals and glassy phases. The fine counterpart is volcanic ash, whereas the coarse counterpart is pumice. They are frequently found combined or interstratified because during volcanic eruptions, coarse material is deposited first, followed by finer material. Volcanic ashes and pumices have long been mixed with Portland cement and other ingredients to form blended cements. This material's pozzolanic action is linked to its siliceous components. Since ground pumice is used as a cement substitute, its environmental impact is directly proportional to the reduction in CO2 emissions associated with cement manufacturing. The use of Portland cement in concrete has a significant impact on greenhouse gas emissions; cement producers account for around 7% of global man-made CO2 emissions, which is why new rules and legislation are requiring reductions in greenhouse gas emissions. As a result, cement makers and concrete contractors are looking for alternatives, such as less CO2-intensive supplemental cementitious ingredients, to reduce their carbon footprint (Little, 2010). The use of ground pumice instead of cement will result in significant CO2 reductions, paving the path for a more sustainable future.

USES OF PUMICE POWDER

- Pumice is widely used to make lightweight concrete or insulated low density cinder blocks.
- It is also used as an abrasive, especially in polishes, pencil erasers, cosmetic exfoliants and the production of stonewashed jeans.
- When used as an additive for cement, a fine grained version of pumice called pozzolan is mixed with lime to form a light weight, smooth, plaster-like concrete.
- It is used as aggregate in light weight concrete, as landscaping aggregate, and as an abrasive in a variety of industrial and consumer products.
- The pumice is used as a decorative ground cover in landscaping and planters.
- It is used as drainage rock and soil conditioner in plantings.
- It is used as a traction material on snow covered roads.
- It is used as a traction enhancer in tire rubber and absorbent in cat litter.
- It is used as a light weight filter for pottery clay and also used as a fine grained filter media.

physical properties of pumice powder

S.NO	properties	values
1	Specific gravity	2.99

chemical properties of pumice powder

S.no	constituents	percentage
1	Lime(CaO)	51
2	Silica(SiO2)	15
3	Magnesium oxide(MgO)	3.13
4	Aluminum (Al2O3)	2.99

5	Calcium sulphate(Ca_2SO_4)	4.5

REQUIREMENTS OF CONCRETE MIXDESIGN

The requirements which form the basis of selection and proportioning of mix ingredients are:

- The minimum compressive strength required from structural consideration
- The adequate workability necessary for full compaction with the compacting equipment available.Maximum water-cement ratio to give adequate durability for the particular siteconditions.
- Maximum cement content to avoid shrinkage cracking due to temperature cycle in massconcrete.

Mix Proportions 1 m^3 Concrete for Trail

Cement	= 367.00 kg/ m^3
Water	= 161.67litre
Fine aggregate:	= 686.02 kg
Coarse aggregate	= 1209.89 kg
Water Cement ratio	= 0.44

Water	Cement	Fine aggregate	Coarse aggregate
0.44	1	1.86	3.29

Mix Design Summary

quantities of materials used in concrete of M20 grade

Type of Concrete	Mix Grade	Waterlits	CementKg/ m^3	Pumice powder Kg/m3	Fine aggregate Kg/ m^3	Coarse aggregate Kg/ m^3
Normal Concrete		161.67	323.00	0	723.2	1211.7
		0.50	1		2.23	3.75
5% of pumice powder		161.67	306.85	16.15	723.2	1211.7
		0.50	1		2.23	3.75
10% of pumice powder	M20	161.67	290.7	32.3	723.2	1211.7
		0.50	1		2.23	3.75
15% of pumice powder		161.67	274.55	48.45	723.2	1211.7
		0.50	1		2.23	3.75
20% of pumice powder		161.67	258.40	64.60	723.2	1211.7
		0.50	1		2.23	3.75
25% of pumice powder		161.67	242.25	80.75	723.2	1211.7
		0.50	1		2.23	3.75
30% of pumice powder		161.67	226.1	96.9	723.2	1211.7
		0.50	1		2.23	3.75

quantities of materials used in concrete of M30 grade

Type of Concrete	Mix Grade	Waterlits	CementKg/ m³	Pumice powder Kg/m3	Fine aggregate Kg/ m³	Coarse aggregate Kg/ m³
Normal Concrete	M30	161.67	367.00	0	686.02	1209.89
		0.44	1		1.86	3.29
5% of pumicepowder		161.67	348.65	18.35	686.02	1209.89
		0.44	1		1.86	3.29
10% of pumicepowder		161.67	330.3	36.70	686.02	1209.89
		0.44	1		1.86	3.29
15% of pumicepowder		161.67	311.95	55.05	686.02	1209.89
		0.44	1		1.86	3.29
20% of pumicepowder		161.67	293.60	73.40	686.02	1209.89
		0.44	1		1.86	3.29
25% of pumicepowder		161.67	275.25	91.75	686.02	1209.89
		0.44	1		1.86	3.29
30% of pumicepowder		161.67	256.90	110.1	686.02	1209.89
		0.44	1		1.86	3.29

SUMMARY

In this chapter M20 and M30 grade concrete materials their properties and mix calculations are presented. Based on materials, mix design proportions and mix design summary are presented for both M20 and M30 grade concretes. In the next chapter experimental works, the concept of making of concrete and testing procedure are explained in detail.

EXPERIMENTAL WORK

OBJECTIVE OF TESTING

It was proposed to investigate the properties of concrete, cast with addition of pumice powder at various percentages and cured. In this experimental work, Physical properties of materials used in the experimental work were determined. Grades of concrete M20 and M30 is mixed and cured. The specimens were cured for 7 and 28 days and tested for strengthcharacteristics by using compressive strength, split tensile, flexural strength.

Specimens casted to find mechanical properties

Specimen Cast	Specimen Size (mm)	**% of pumice powder added**							
		M20&M30 GRADE							
		0	**5**	**10**	**15**	**20**	**25**	**30**	
		Days		Days		Days		Days	
		7	**28**	**7**	**28**	**7**	**28**	**7**	**28**
Cubes	150x150x150	3	3	3	3	3	3	3	3
Cylinders	150x300	3	3	3	3	3	3	3	3
Beams	150x150x500	3	3	3	3	3	3	3	3

PROCESS OF MANUFACTURING OF CONCRETE

Aggregates

The coarse aggregate was kept completely immersed in clean water for 24 hours for water absorption. After 24 hours, the aggregate was gently surface dried. It was then spread out and exposed to the atmosphere until it appears to be completely surface dry. For fine aggregate, considering the huge time to be taken to become surface dry from wet condition, it was not immersed in water. Instead the water was sprinkled then it was spread out and exposed to the atmosphere until it appears to be completely surface dry.

Batching

Batching means measuring the quantities of constituents of concrete required for the preparation of concrete mix. Weight batch method is adopted to measure the quantities. The quantities of fine aggregate, coarse aggregate, cement, water and Super plasticizer and adding hypo sludge for each batch were measured by a weighing balance according to the mix proportions obtained by the mix design.

Mixing

The object of mixing is to coat the surface of all aggregate particles with Cement paste and to blend all the ingredients of concrete into a uniform mass. Though mixing of the materials is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency. In this study the process of machine mixing was adopted.

Casting of Concrete Cubes

The test moulds were kept ready before preparing the mix. Moulds were cleaned and oiled on all contacts surfaces then fixed on vibrating table firmly. The concrete is filled into moulds in three layers and then vibrated. The top surface of concrete is struck off to level with a trowel. Thenumber and date of casting were put on the top surface of the cubes as shown in Figure 5.1

Casting of Specimens

Curing

The cast moulds are dried then the moulds are unmolded then cubes were kept for curing in potablewater.

Workability

Workability is a property of fresh concrete. It is, however, also a vital property as far as the finished product is concerned because concrete must have workability such that compaction to maximum density is possible with a reasonable amount of work or with the amount that we prepared to put in under given conditions. According to ACI, workability is that property of the freshly mixed concrete or mortar whichdetermines the ease and homogeneity with which it can be mixed, placed, consolidated and finished.

Workability of the concrete can be measured in many ways. Here, workability in terms of slump and compaction factor was considered for the present study.

Slump Cone Test

This test is used extensively in site all over the world. The slump test does not measure the workability of concrete, but the test is very useful in detecting variations in the uniformity of a mix of given nominal proportions. The slump test is done as prescribed by IS: 516-1959. The apparatus for conducting the slump test essential consists of a metallic mould in the form of a cone having the internal dimensions as under

Bottom diameter : 200 mm Top diameter : 100 mm

The mould for slump is a frustum of a cone, 300 mm high. It is placed on a smooth surface with the smaller opening at the top, and filled with concrete in three layers. Each layer is tamped twenty five times with a standard 16 mm diameter steel rod, rounded at the end, and the top surface is tapered off by means of sawing and rolling motion of the tamping rod. The mould must be firmly fixed against its base during the entire operation; this is facilitated by handles or foot- rests brazed to the mould. Immediately after filling, the cone is slowly lifted vertically up, and theunsupported concrete will now slump – hence the name of the test. The difference in level between the height of the mould and that of highest point of subsided concrete is measured.This difference in height in mm is taken as slump of concrete.

STRENGTH PROPERTIES OF CONCRETE

Compressive Strength Test

Compressive strength is the ability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates. Compressive strength of concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not.Concrete compressive strength for general construction varies from 15 MPa (2200 psi) to 30 MPa (4400 psi) and higher in commercial and industrial structures. Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during production of concrete etc. Compression test was conducted on 150mm×150mm×150mm cubes as shown in Figure. Concrete specimens were removed from curing tank and cleaned. In the testing machine, the cube is placed with the cast faces at right angles to that of compressive faces, then load is applied at a constant rate of 1.4 kg/cm^2/minute up to failure and the ultimate load is noted. The load is increased until the specimen fails and the maximum load is recorded. The compression tests were carried out at 7 days, 28 days and days. For strength computation, the average load of three specimens is considered for each mix. The average of three specimens was reported as the cube compressive of strength.

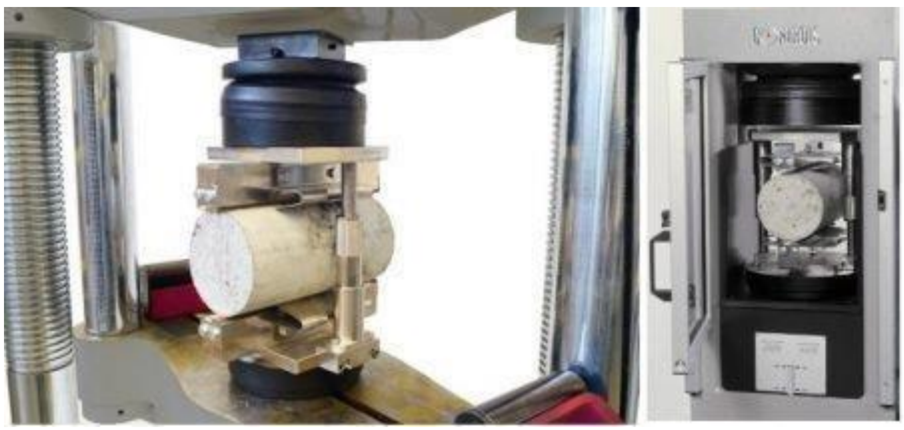
$$\text{Cube compressive strength} = \frac{\text{Load}}{\text{Area of cross section}}$$

compression testing machine

Test for compressive strength is carried out either on cube or cylinder. Various standard codes recommends concrete cylinder or concrete cube as the standard specimen for the test. American Society for Testing Materials ASTM C39/C39M provides Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

Split Tensile Strength Test

The tensile strength of concrete is one of the basic and important properties which greatly affect the extent and size of cracking in structures. Moreover, the concrete is very weak in tension due to its brittle nature. Hence. it is not expected to resist the direct tension. So, concrete develops cracks when tensile forces exceed its tensile strength. The cylinder specimen is of the size 150 mm diameters and 300mm length. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of compression testing machine as shown in Figure 5.3 and the load is applied until failure of cylinder, along its longitudinal direction. The cylinder specimens are tested at 7 days, 28 days and90 days. The average of three specimens was reported as the split tensile strength.



testing cylinder on compression testing machine

Therefore, it is necessary to determine the tensile strength of concrete to determine the load at which theconcrete members may crack. Furthermore, splitting tensile strength test on concrete cylinder is a method to determine the tensilestrength of concrete. The procedure based on the ASTM C496 (Standard Test Method of Cylindrical Concrete Specimen) which similar to other codes like IS 5816 1999.

Flexural Strength Test

Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of yield. It is measured in terms of stress, here given the symbol.

The flexural strength would be the same as the tensile strength if the material were homogeneous. In fact, most materials have small or large defects in them which act to concentrate the stresses locally, effectively causing a localized weakness. When a material is bent only the extreme fibers are at the largest stress so, if those fibers are free from defects, the flexural strength will be controlled by the strength of those intact 'fibers'. However, if the same material was subjected to only tensile forces then all the fibers in the material are at the same stress and failure will initiate when the weakest fiber reaches its limiting tensile stress. Therefore, it is common for flexural strengths to be higher than tensile strengths for the same material. Conversely, a homogeneous material with defects only on its surfaces (e.g., due to scratches) might have a higher tensile strength than flexural strength. If we don't take into account defects of any kind, it is clear that the material will fail under a bendingforce which is smaller than the corresponding tensile force. Both of these forces will induce the same failure stress, whose value depends on the strength of the material.

Flexural testing machine

SUMMARY

In this chapter experimental works are presented. Objective of testing, i.e. Ordinary Portland cement, fine aggregate, coarse aggregate, pumice powder is used in process of manufacturing of concrete, workability of fresh concrete and testing of hardened concrete procedures are explained in detail. The method described will be used to study the observations of fresh and hardened concrete properties. In the next chapter observations and discussions are presented.

OBSERVATIONS AND DISCUSSIONS

SLUMP CONE TEST

The slump cone test was conducted for all the seven mixes for both M20 and M30 grades of pumice powder mix. Slump for different mixes are shown in Table 6.1 and 6.2

Slump Cone Results of pumice powder mix

S. No	**Mix**	**Slump(mm)**
1	Nominal Mix for M20 grade	100
2	Pumice powder -5% for M20 grade	95
3	Pumice powder -10% for M20 grade	90
4	Pumice powder -15% for M20 grade	90
5	Pumice powder -20% for M20 grade	85
6	Pumice powder -25% for M20 grade	80
7	Pumice powder -30% for M20 grade	70

Slump Cone Results of pumice powder mix

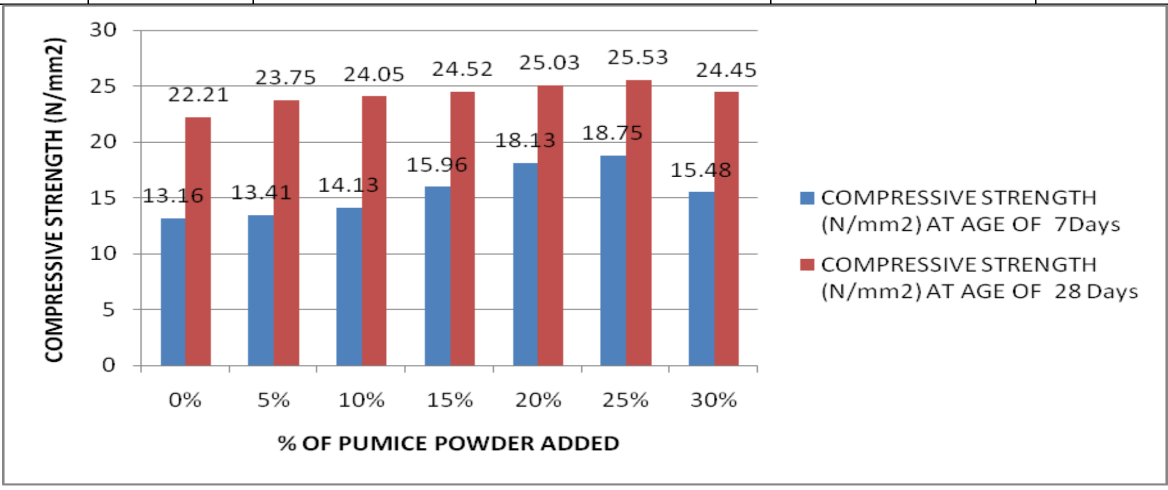
S. No	**Mix**	**Slump(mm)**
1	Nominal Mix for M30 grade	120
2	Pumice powder -5% for M30 grade	100
3	Pumice powder -10% for M30 grade	95
4	Pumice powder -15% for M30 grade	85
5	Pumice powder -20% for M30 grade	85
6	Pumice powder -25% for M30 grade	80
7	Pumice powder -30% for M30 grade	80

COMPRESSIVE STRENGTH

The compressive strength of the concrete was done on 150 x 150 x 150 mm cubes. A total of 36 cubes were cast for the four mixes. i.e., for each mix 6 cubes were prepared. Testing of the specimens was done at 7 days, and 28 days at the rate of three cubes for each mix on that particular day. The average value of the 3 specimens is reported as the strength at that particular age. The compressive strength test was conducted for all the mixes and the results are shown in the Table 6.3 below.

Compressive Strength Test Results of M20 grade of pumice powder mix

S. No	Mix Grade	Mix	COMPRESSIVE STRENGTH (N/mm^2)	
			7Days	28 Days
1	M20	Normal Mix	13.16	22.21
2		Pumice powder -5% for M20 grade	13.41	23.75
3		Pumice powder -10% for M20 grade	14.13	24.05
4		Pumice powder -15% for M20 grade	15.96	24.52
5		Pumice powder -20% for M20 grade	18.13	25.03
6		Pumice powder -25% for M20 grade	18.75	25.53
7		Pumice powder -30% for M20 grade	15.48	24.45



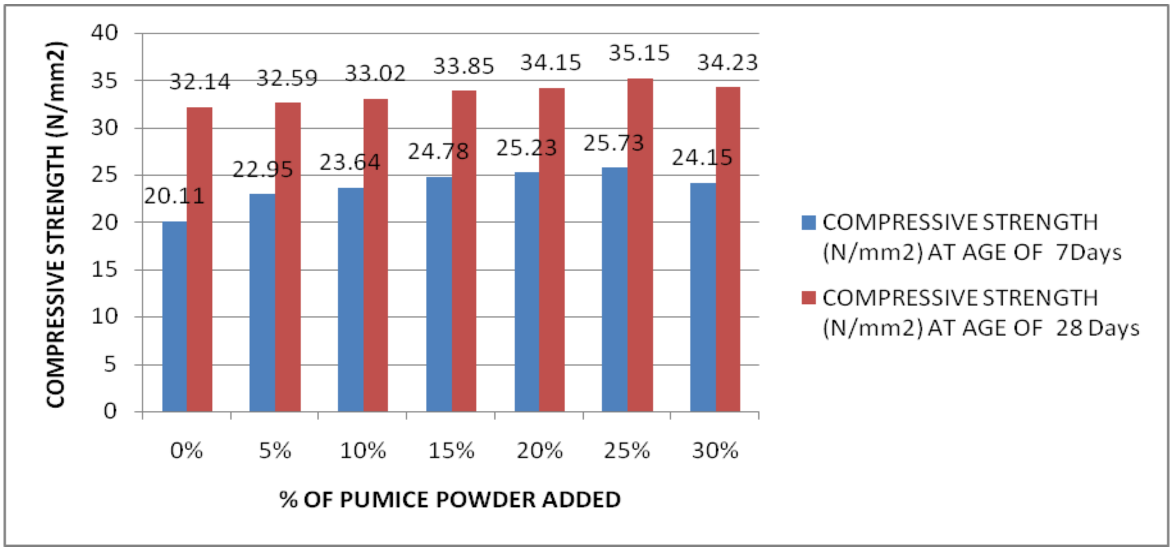
Compressive Strength Test Results of M20 grade of pumice powder mix

Above figure shows the variation of compressive strength of concrete with different replacement levels of hypo sludge with cement. It can be observed that the compressive strength of concrete increase up to 25% of pumice powder. Then after, the compressive strength decreases. The compressive strength values obtained by testing standard cubes made with various percentage of pumice powder cured with potable water. The normal mix strength was observed that the Compressive Strength of cured concrete at the age of 7 days is 13.16 N/mm^2 and 28days is 22.21 N/mm^2. By using pumice powder it was observed that the Compressive Strength obtained at every percentage is more than the nominal mix. The maximum value attained at the 25 % replacement.

Compressive Strength Test Results of M30 grade of pumice powder mix

S. No	Mix Grade	Mix	COMPRESSIVE STRENGTH (N/mm^2)

			7Days	28 Days
1	M30	Normal Mix	20.11	32.14
2		Pumice powder -5% for M20 grade	22.95	32.59
3		Pumice powder -10% for M20 grade	23.64	33.02
4		Pumice powder -15% for M20 grade	24.78	33.85
5		Pumice powder -20% for M20 grade	25.23	34.15
6		Pumice powder -25% for M20 grade	25.73	35.15
7		Pumice powder -30% for M20 grade	24.15	34.23



Compressive Strength Test Results of M30 grade of pumice powder mix

Above figure shows the variation of compressive strength of concrete with different replacement levels of pumice powder with cement. It can be observed that the compressive strength of concrete increase up to 25% of pumice powder. Then after, the compressive strength decreases. The compressive strength values obtained by testing standard cubes made with various percentage of pumice powder cured with potable water. The normal mix strength was observed that the Compressive Strength of cured concrete at the age of 7 days is 20.11 N/mm^2 and 28days is 32.14 N/mm^2. By using pumice powder it was observed that the Compressive Strength obtained at every percentage is more than the nominal mix. The maximum value attained at the 25 % replacement.

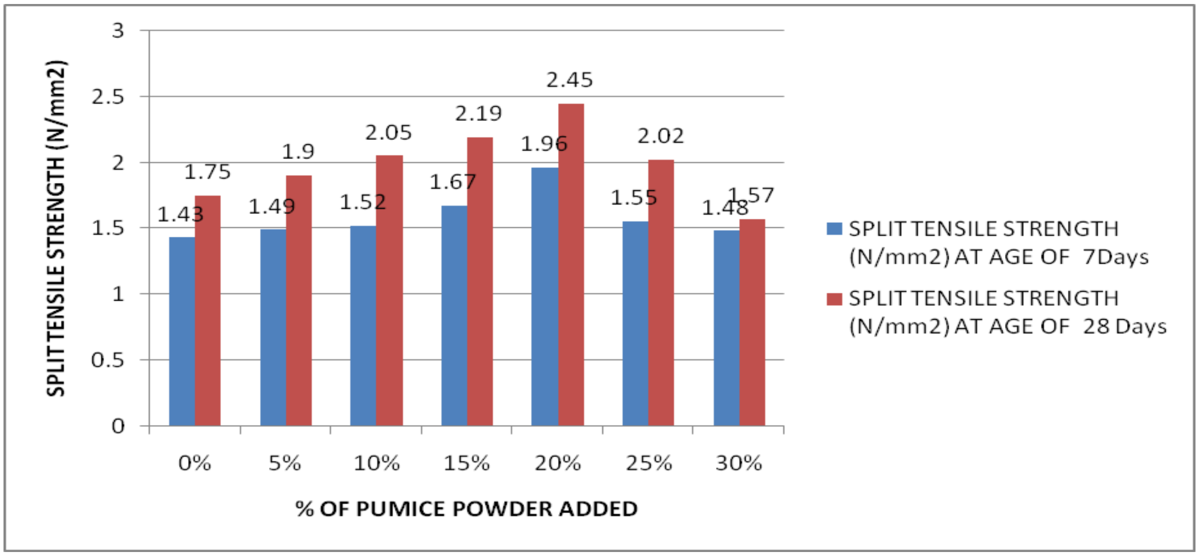
SPLIT TENSILE STRENGTH

The indirect tensile strength was measured on 150 x 300 mm cylinders and the results were shown in Table 6.5 below. Three specimens were tested each time and the average value at the particular age was reported as the tensile strength of the concrete

split tensile Strength Test Results of M20 grade of pumice powder mix

S. No	Mix Grade	Mix	SPLIT TENSILE STRENGTH (N/mm^2)	
			7Days	28 Days
1	M20	Normal Mix	1.43	1.75
2		Pumice powder -5% for M20 grade	1.49	1.90
3		Pumice powder -10% for M20 grade	1.52	2.05
4		Pumice powder -15% for M20 grade	1.67	2.19
5		Pumice powder -20% for M20 grade	1.96	2.45
6		Pumice powder -25% for M20 grade	1.55	2.02
7		Pumice powder -30% for M20 grade	1.48	1.57

split tensile Strength Test Results of M20 grade of pumice powder mix

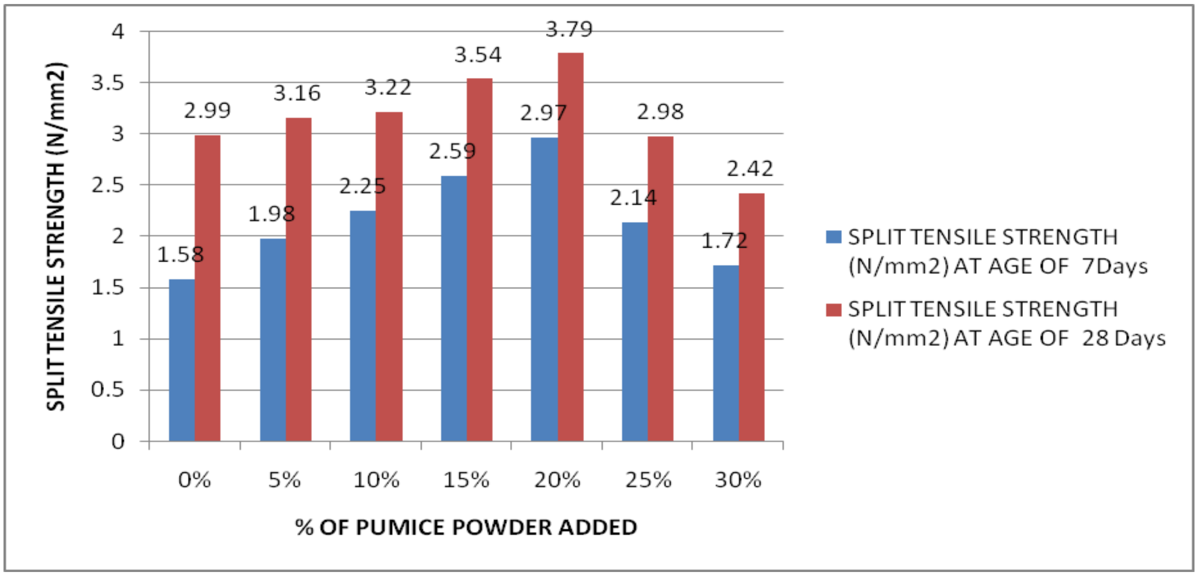


Above figure shows the variation of splitting tensile strength of concrete with different replacement levels of pumice powder with cement. It was observed that the splitting tensile strength of concrete increase up to 20% of pumice powder. The splitting tensile values obtained by testing standard cylinders made with various percentage of pumice powder cured with potable water. The normal mix strength was observed that the splitting tensile strength of cured concrete at the age of 7 days is 1.43 N/mm^2 and 28days is 1.75 N/mm^2. By using pumice powder it was observed that the splitting tensile strength obtained at every percentage is more than the nominal mix. The maximum value attained at the 20% replacement.

split tensile Strength Test Results of M30 grade of pumice powder mix

S. No	Mix Grade	Mix	SPLIT TENSILE STRENGTH (N/mm^2)	
			7Days	28 Days
1	M30	Normal Mix	1.58	2.99
2		Pumice powder -5% for M20 grade	1.98	3.16
3		Pumice powder -10% for M20 grade	2.25	3.22
4		Pumice powder -15% for M20 grade	2.59	3.54
5		Pumice powder -20% for M20 grade	2.97	3.79
6		Pumice powder -25% for M20 grade	2.14	2.98
7		Pumice powder -30% for M20 grade	1.72	2.42

split tensile Strength Test Results of M30 grade of pumice powder mix



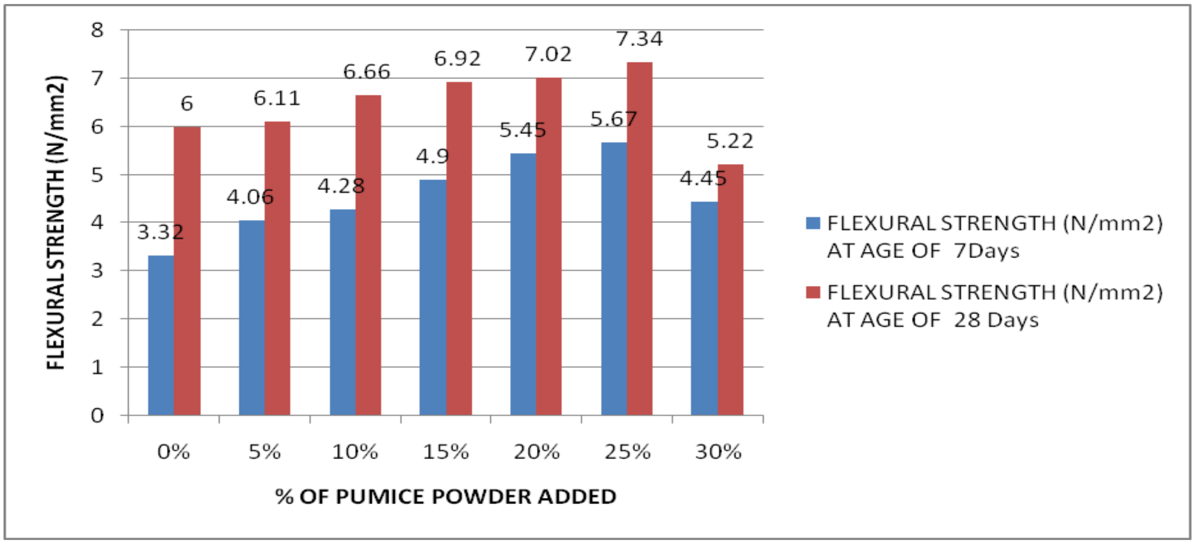
Above figure shows the variation of splitting tensile strength of concrete with different replacement levels of pumice powder with cement. It was observed that the splitting tensile strength of concrete increase up to 20% of pumice powder. The splitting tensile values obtained by testing standard cylinders made with various percentage of pumice powder cured with potable water. The normal mix strength was observed that the splitting tensile strength of cured concrete at the age of 7 days is 1.58 N/mm^2 and 28days is 2.99 N/mm^2. By using pumice powder it was observed that the splitting tensile strength obtained at every percentage is more than the nominal mix. The maximum value attained at the 20% replacement.

FLEXURAL STRENGTH

Flexural strength of the concrete was determined from modulus of rupture test on beam specimens of 100 x 100 x 500 mm size. Here also, specimens were cast out of which three specimens were tested for each mix at 7days, 28 days.

flexural Strength Test Results of M20 grade of pumice powder mix

S. No	Mix Grade	Mix	FLEXURAL STRENGTH (N/mm^2)	
			7Days	28 Days
1	M20	Normal Mix	3.32	6.00
2		Pumice powder -5% for M20 grade	4.06	6.11
3		Pumice powder -10% for M20 grade	4.28	6.66
4		Pumice powder -15% for M20 grade	4.90	6.92
5		Pumice powder -20% for M20 grade	5.45	7.02
6		Pumice powder -25% for M20 grade	5.67	7.34
7		Pumice powder -30% for M20 grade	4.45	5.22

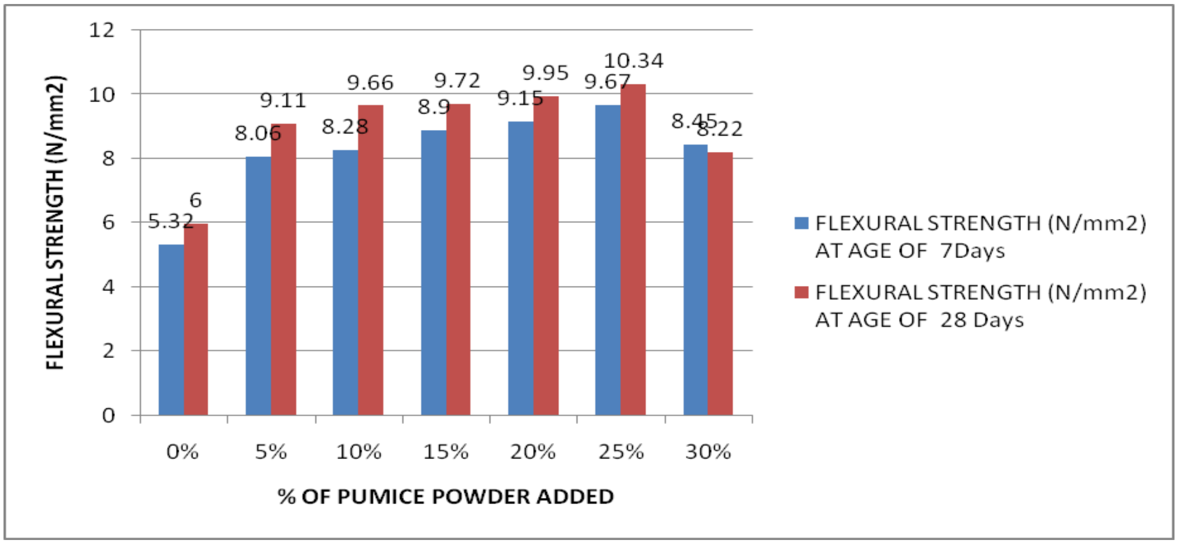


flexural Strength Test Results of M20 grade of pumice powder mix

Above figure shows the variation of flexural Strength of concrete with different replacement levels of pumice powder with cement. It was observed that the flexural Strength of concrete increase up to 20% of pumice powder. The flexural Strength values obtained by testing standard prisms made with various percentage of pumice powder cured with potable water. The normal mix strength was observed that the flexural Strength of cured concrete at the age of 7 days is 3.32 N/mm^2 and 28days is 6.00 N/mm^2. By using hypo sludge it was observed that the flexural Strength obtained at every percentage is more than the nominal mix. The maximum value attained at the 25% replacement.

flexural Strength Test Results of M30 grade of pumice powder mix

S. No	Mix Grade	Mix	FLEXURAL STRENGTH (N/mm^2)	
			7Days	28 Days
1	M30	Normal Mix	5.32	6.00
2		Pumice powder -5% for M20 grade	8.06	9.11
3		Pumice powder -10% for M20 grade	8.28	9.66
4		Pumice powder -15% for M20 grade	8.90	9.72
5		Pumice powder -20% for M20 grade	9.15	9.95
6		Pumice powder -25% for M20 grade	9.67	10.34
7		Pumice powder -30% for M20 grade	8.45	8.22



flexural Strength Test Results of M30 grade of pumice powder mix

Above figure shows the variation of flexural Strength of concrete with different replacement levels of pumice powder with cement. It was observed that the flexural Strength of concrete increase up to 20% of pumice powder. The flexural Strength values obtained by testing standard prisms made with various percentage of pumice powder cured with potable water. The normal mix strength was observed that the flexural Strength of cured concrete at the age of 7 days is 3.32 N/mm^2 and 28days is 6.00 N/mm^2. By using hypo sludge it was observed that the flexural Strength obtained at every percentage is more than the nominal mix. The maximum value attained at the 2 5% replacement.

SUMMARY

In this chapter experimental work results are presented. Workability of fresh concrete and testing of hardened concrete procedures are explained in detail. The observations on test results were presented and will be used to study the behaviour of fresh and hardened concrete properties. In the next chapter conclusions and scope of future research work were presented.

CONCLUSIONS

In this study series of the experiments have been conducted on concrete with the addition of pumice powder as partial replacement of OPC. In the pumice powder was used as partial replacement of OPC in different percentage that is 0%, 5%, 10%, 15%,20%, 25%, and 30% of the dry weight of the cement. the experiments were conducted on M20 & M30 grade of concrete as per relevant IS-code practice based on the test results obtained from this study the following conclusion can be drawn.

From the compressive strength test results for both concrete grades i.e. M20 & M30, it is foundthat the with the addition of pumice powder the strength is increased than the conventional concrete.

- There is strength reduction with the addition of more than 25% of pumice powder due to theimpurities present in pumice powder like free lime, loss on ignition and other raw minerals.
- However the strength attained with the mix of pumice powder complies with the target strength upto a replacement of 25%.
- When the pumice powder addition is greater than 25%, the strength produced by the concrete isgetting reduced.

From the above finding we can conclude that there is no remarkable variation in the compressive strength calculated by using compression testing machine.

- The maximum value obtained for M20 grade of concrete is at 25% replacement with cement. And the replaced strength values are more when compared with conventional mix.

- The maximum value obtained for M30 grade of concrete is at 25% replacement with cement. And the replaced strength values are more when compared with conventional mix.

From the above finding we can conclude that there is no remarkable variation in the split tensile strength calculated by using compression testing machine.

- The maximum value obtained for M20 grade of concrete is at 20% replacement with cement. And the replaced strength values are more when compared with conventional mix.
- The maximum value obtained for M30 grade of concrete is at 20% replacement with cement. And the replaced strength values are more when compared with conventional mix.

From the above finding we can conclude that there is no remarkable variation in the flexural strength calculated by using flexural testing machine.

- The maximum value obtained for M20 grade of concrete is at 25% replacement with cement. And the replaced strength values are more when compared with conventional mix.
- The maximum value obtained for M30 grade of concrete is at 25% replacement with cement. And the replaced strength values are more when compared with conventional mix.

Scope of Furtherstudy

The experimental study can be carried out for higher strength concretes like M40, M50 and above. This work was carried out on replacement of cement in concrete with pumice powder and other industrial wastes like fly ash, rice husk ash ceramic powder. So, that we can reduce the usage of cement and cost of the project.

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