EXPLORING THE STRENGTH CHARACTERISTICS OF CONCRETE WITH "RAPIDITE" AS AN ADMIXTURE

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ABSTRACT: Rapidite is a revolutionary artificial pozzolana admixture obtained from thermally activated ordinary clay which greatly enhances the properties of ordinary concrete and become the central to the research in the making of special concrete. The use of Rapidite and various chemical admixtures have become staple ingredients in the production of concrete with designed strength in excess of 50Mpa or where service environments, exposure or life cycle cost considerations dictate the use of High performance concrete (HPC). The overall objective of the present study is to study the effect of adding Rapidite in concrete on its performance. It is decided to explore compressive strength, Split tensile strength, and Flexural strength of concrete on addition of different percentages of Rapidite and also to study durability by observing the effect of acid curing. For this Mix proportions of OPC concrete for M20 by IS method (9103-1999) were determined. The mix proportion with partial replacement such as 0%, 0.6%, 1.2%, 1.8% and 2.4% of Rapidite with OPC were calculated. The concrete specimens such as cubes for compressive strength, cylinders for split tensile test, prisms for flexural strength with replacement of Rapidite with OPC for M20 grade concrete were prepared and cured the specimens for 3 days, 7 days, and 28 days. The compressive strength of concrete found increased when cement is replaced by Rapidite for M20 grade of concrete. At 1.8% replacement of cement by Rapidite the concrete attained maximum compressive strength for M20 grade of concrete. The split tensile strength of concrete is increased when cement is replaced with Rapidite. The split tensile strength is maximum at 1.8% of replacement. The flexural strength of concrete is also increased when the cement is replaced by Rapidite. At 1.8% replacement, the flexural strength is maximum.

KEYWORDS: Rapidite, Compressive Strength, Flexural Strength, Split tensile strength

I. INTRODUCTION

1.1 GENERAL

The quest for the development of high strength and high performance concretes has increased considerably in recent times because of the compelling demands from the construction industry. In the last three decades, supplementary cementitious materials such as fly ash, silica fume and ground granulated blast furnace slag have been judiciously utilized as cement replacement materials as these can significantly enhance the strength and durability characteristics of concrete in comparison with ordinary Portland cement (OPC) alone, provided there is adequate curing. Addition of Rapidite is one of the latest developments in this field. Winter has some peculiarities that affect construction in general and concreting in particular. Its duration is different in different parts of globe, but cold weather with white frosts may also happen in spring and autumn not just in winter only. In India certain regions experience sub-zero temperatures in winter. Concrete structures in such regions undergo cycles of freezing and thawing and their durability is affected due to frost action. Fresh concrete contains considerable quantity of fresh water which gets converted into ice lenses at freezing temperature. The ice formation in fresh concrete results in about 9% rise in volume and causes permanent damage to concrete and structural integrity cannot be recovered even if the concrete is made to harden later at high temperature. Thus, in winters, especially in Kashmir where the temperatures are below zero degree in winters some admixtures need to be added to nullify the effects of cold temperature on the strength of concrete. Rapidite is a commonly used admixture in Kashmir during winter to accelerate the strength gain of concrete. On adding water to cement, paste is formed which gradually stiffens and then hardens. The stiffening of cement paste is called setting. Actually, setting is a process of transformation from an initial state, a scattered concentrated suspension, to a final state, a connected and strengthened system of particles. This transformation in the practice of cement and concrete is obtained by chemical reactions between cement particles and water (i.e. hydration of cement). Normal setting of cement is associated with the hydration of Alite (C_3S) and formation of calcium silicate hydrate (C-S-H) phase. Cement paste / concrete sets gradually under the standard laboratory conditions (temperature ~ 23°C and relative humidity not less than 90%). But outside the laboratory concreting has to be done under the prevailing climatic conditions. In many countries or certain regions of countries, fresh concrete is subjected to cold weather. American Concrete Institute (ACI) defines cold weather when two conditions exist for three consecutive days:

i) The average daily temperature falls below 5°C, and

ii) Air temperature does not rise above 10°C for more than half a day in any 24 hour period. Cold weather leads to delay in setting and hardening of concrete, freezing of concrete at early age and thawing which leads to formation of ice needles in concrete and thus cavities are formed after thawing of ice needles which seriously impair the structural integrity of concrete and results in considerable loss of strength. In extreme cases, effects of cold weather may make

the concrete an absolutely useless friable mass. On the other hand, if the concrete is sufficiently hardened when freezing conditions are likely to prevail, there will not be much harm to structural integrity of concrete. If the concrete has sufficiently hardened, the water that has been mixed for making concrete will have been utilized either being used up in hydration process or lost by evaporation. Due to the formation of cement gel, the capillary cavities also will have been very much reduced, with the result that there exists very little of free water in the body of concrete to freeze. Accelerating admixture is an admixture that accelerates the hardening or the development of early strength of concrete.
The rates of chemical reactions between clinker materials in cements and water may be altered by adding small amounts of chemical substances to the cement-water mix. Substances affecting these rates to give an overall increase in the hydration rate, i.e. an accelerating effect, are termed accelerating admixtures or simply accelerators. Hence, an accelerator is added to concrete for the purpose of shortening setting time and/or increasing early strength development. In the first case the main action of the accelerator occurs in the plastic state of the cement paste, while in the latter case the accelerator acts primarily in the hardened state. Some accelerators affect either setting or hardening, while several accelerate both setting and hardening. Accelerating admixtures are usually termed ‘chloride based’ or ‘chloride free’ and may be principally set or hardening accelerators. Care is needed to ensure that the correct one is selected for the required application. Most Concrete specifications restrict the use of calcium chloride or admixtures containing calcium chloride to plain unreinforced concrete and ban it for structural concrete that contains embedded metal.

1.2 ADMIXTURES IN CONCRETE
As per Indian standard (IS 9103:1999) admixtures are “Any material other than water, aggregates, and hydraulic cement and additives like pozzolana or slag and fibre reinforcement used as an ingredient of concrete or mortar and added to the batch immediately before or during its mixing to modify one or more of the properties of concrete in the plastic or hardened state.” Admixtures confer several beneficial effects on concrete including reduction in water requirements, increased workability, controlled setting, accelerated hardening, improved strength, better durability, desired coloration and volume changes. The major reasons for using admixtures are:

- To achieve certain properties in concrete more effectively than by other means.
- To maintain the quality of concrete during the stages of mixing, transporting, placing, and curing in adverse weather conditions.
- To overcome certain emergencies during concreting operations.

Despite these considerations, it should be borne in mind that no admixture of any type or amount can be considered a substitute for good concreting practice. Rapidite is a commonly used admixture in cold areas during winter to accelerate the strength gain of concrete. It acts as accelerator. It also acts as antifreeze, depressing the freezing point of water and hence protecting the fresh concrete.

1.3 RAPIDITE
Rapidite is a specially developed Concrete Set Accelerator, a ready-to-use, liquid admixture. It accelerates initial setting time (cement-water chemical reaction: Hydration) of normal mortar and concrete and acts as anti-freeze within cement concrete. It improves workability and strength while fastening the hydration of cement. It makes the mix easier to place and speeds construction by shortening the initial set and curing time. Time and labor are saved, because forms and other protection can be removed earlier and finishing can be started. Rapidite is recommended for use during cool and cold weather to accelerate the set time and reduce the risk of frozen mortar and concrete mixes. Some important benefits are listed below.

- Accelerates initial set time.
- Increases compressive strength.
- Provides Anti –freeze properties.
- Speeds up hydration of cement.
- Increases workability of concrete or mortar mix in colder temperatures.

1.4 PROPERTIES OF CONCRETE THAT CONTAINS RAPIDITE
Usually Rapidite is used for cold weather concreting but we carried out our project in warm climate when the temperature was around 200 Celsius so as to study its suitability and hence influence on various properties of concrete under such conditions. The effect of a commonly used admixture Rapidite in cold areas on the strength of concrete at 20oCelsius is studied in this work. Casting was done at 20oCelsius because generally in field during concreting it is not necessary that the temperature will remain constant, variation of temperature is natural phenomenon. Our aim is to find variation on properties of concrete especially, strength, workability, etc and also find out whether use of Rapidite above freezing temperature is acceptable or not. In this research work the Percentage of Rapidite was varied to find its effect on the strength. We did two castings for every percentage of Rapidite, one plain and one with admixture, and found relative change in various properties of concrete at various ages. Rapidite used in our work was procured from local vendors.
The properties of Rapidite admixture are:

- Colour- Lemon-Orange
- Appearance-Clear bright Liquid
- Relative Density -1g/ml

1.5 STRENGTH PARAMETERS
Rapidite is used as accelerating admixture in the dosage range of 0.6% to 2% by weight of cement. Concrete specimens with varying percentage of rapidite were tested for compressive strength, splitting tensile strength and flexural strength. The results obtained were compared with results of normal M-20 concrete mix and it was found that maximum increase in compressive strength, splitting tensile strength and flexural strength occurred for concrete mix

containing 1.8% rapidite by weight of cement at 7 days age. However, there was no considerable increase in compressive strength, splitting tensile strength and flexural strength at 28 days age. The results indicated the beneficial effects of admixture in concrete subjected to cold weather.

1.6 APPLICATIONS OF RAPIDITE IN CONCRETE

- Fiber cement & Ferro cement products, glass fiber reinforced concrete, motors, stuccoes, repair materials, pool plasters etc.
- In pre-cast concrete works.
- In tall and heavy structures where high strengths are required.
- In combination with other chemical admixtures and steel fibers, it is suitable for repair works,
- In the manufacture of concrete pipes, Rapidite addition has shown to increase the external load bearing capacity of the pipes and increased resistance against chemical attack.
- Concrete containing Rapidite is known as to have improved resistance to freezing, thawing, chloride penetration and deeper scaling making it useful for road construction,
- Fiber cement & Ferro cement products, glass fiber reinforcement concrete, mortar, stuccoes, repair materials, pool plasters etc.
- The low permeability and absorption of the Rapidite mixed cement concrete as well as it enhanced resistance to deterioration in a variety of chemically aggressive environments, found a gainful use in shortcrete applications in chemical, mining, paper and pulp industries.

1.7 ADVANTAGES OF RAPIDITE

- Increased compressive and flexural strengths
- Reduced permeability
- Increased resistance to chemical attack
- Increased durability
- Enhanced workability and finishing of concrete
- Reduced shrinkage, due to "particle packing" making concrete denser
- Improved color by lightening the color of concrete making it possible to tint lighter integral colour.
- Reduced potential for efflorescence, which occurs when calcium is transported by water to the surface where it combines with carbon dioxide from the atmosphere to make calcium carbonate, which precipitates on the surface as a white residue.

1.8 OBJECTIVE OF THE PRESENT WORK

The overall objective of the present study is to study the effect of adding Rapidite in concrete on its performance; however the task is divided in to specific objectives to achieve step by step through experimental procedures.

To prepare the concrete specimens such as cubes for compressive strength, cylinders for split tensile test, prisms for flexural strength and also cubes for durability studies in laboratory with 0%, 0.6%, 1.2%, 1.8% and 2.4% replacement of Rapidite with OPC for M20 grade concrete with water to cement ratio of 0.5.To evaluate the mechanical characteristics of concrete such as compressive strength, split tensile test, flexural strength. To evaluate and compare the results obtained.

II. MATERIALS & METHODS

2.1 MATERIAL PROPERTIES:

The materials used in the experimental work namely cement, fine aggregate and coarse aggregate (20mm, 10mm) have been tested in laboratory for use in mix designs. The details are presented below.

Cement

Ordinary Portland cement of 43 grade (Rasi-Cement) was used in this investigation. The details of tests conducted on cement are described below.

Specific gravity of cement

Specific gravity of the cement is calculated by using density bottle method.

Cement specific gravity: 3.15

Initial and final setting time test on cement

Initial and final setting time test on cement is obtained by vicat's apparatus, for the initial setting time of the cement vicat's needle should penetrate to a depth of 33 to 35mm from the top, for final setting time the vicat's needle should pierce through the paste more than 0.5mm. We need to estimate the

initial and final setting time as per IS: 4031 (Part 5) – 1988.

Initial setting time of test cement: 90 mins

Final setting time of test cement : 3 hrs 30 mins (210 mins)

Standard consistency test

The Standard consistency test of a cement paste is defined as that consistency which will permit vicat's plunger having the 10mm diameter and 50mm length to penetrate to a depth of 33 to 35 from the top of the mould.The basic aim is to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031 (Part 4) – 1988.

Standard consistency of test cement: 33%

Fine aggregate:

Aggregate:

Fine Aggregate:

The specific gravity of fine :aggregates is 2.64

Fineness Modulus = 2.25

Coarse Aggregate:

The specific gravity of coarse aggregates is 2.72

Fineness Modulus=7.27

Rapidite: The accelerating admixture Rapidite was ordered and procured from Jaichittra Inc., No. 52/7, 1st Floor, E. S. P. E. E. Complex, No. 52, Brindavan Street, West Mambalam, Chennai - 600033, Tamil Nadu, India.

2.2 IS CODE METHOD OF MIX DESIGN (IS 9103:1999)

This method was developed as per IS 9103:1999. This Indian standard (First Revision) was adopted by the Bureau of Indian standards, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by Civil Engineering Division Counsil. Indian standard institution has brought out mix design procedure mainly based on work done in national laboratories. This method can be adapted to both medium strength and high strength concrete. The basic assumption made in the mix design is that the compressive strength of workable concrete is by and large, governed by the water-cement ratio. Another most convenient relationship applicable to normal concrete is that for a given type, shape, size and grading of aggregates, the amount determines its workability and the other factors which affecting the properties of concrete are quality of cement, water and aggregates, batching, transporting, placing, compacting and curing etc.

Mix Proportions for One Cubic meter of Concrete

Cement	Fine Aggre	Coarse Aggre	Water
kg/m^3	kg/m^3	kg/m^3	lit
338.2	641.07	1226	186

Designed ratio is 1 :1.9 : 3.62 : 0.55

Among the trail mix conducted, the above mix gave required workability and required strength.

2.3 CASTING AND CURING OF TEST SPECIMENS

The specimens of standard cubes (l50mmX150mmX150mm) 9No.s, Standard prisms (100mmx 100mm x 500mm) 3No.s and Standard cylinders of (150mm diameter 300mm height) 3Nos are cast for each cycle. In all 240 specimens the cement was replaced by Rapidite by (0%, 0.6%, 1.2%, 1.8% and 2.4%) with M20 case mix case were cast for 3 days, 7 days and 28days curing.

Mixing

Measured quantities of coarse aggregate and fine aggregate were spread out over an impervious concrete floor. The dry ordinary Portland cement and Rapidite were spread out on the aggregate and mixed thoroughly in dry state until uniform colour is obtained. Water measured exactly by weight mixed the super plasticizer, is added to the dry mix and is mixed thoroughly to obtain homogeneous concrete.

Placing and Compacting

The cube mould of the standard size, the prism mould of standard size, the cylinder mould of standard size confirming to IS 10086-L982 are cleaned. All care is to be taken for any irregular dimensions. The joint between the sections of the mould, the inner side and the bottom of the mould are to be greased properly.

The mould are arrange on the vibrating platform for casting. The mix is placed in three layers; each layer is compacted using table vibrator to obtain dense concrete

Curing

After 24 hours of casting the test specimens cubes, cylinders and prisms are de-moulded and immediately immersed in clean and fresh water tank and allow it for curing for 3 days, 7 days and 28days.

2.4 TEST PROGRAMME

All the tests conducted were described here.

Test for Workability

Slump Cone Test

Slump cone test is a very common test for determination of workability of concrete. This test was carried out for both the mixes M20, before casting the specimens.

2.5 Test for Compressive Strength of Concrete

On the date of testing i.e., after for 3 days, 7 days and 28days of using the cube specimens were removed from the water tank and placed on flat surface for 10 minutes to wipe off the surface water and grit, and also removes the projecting fines on the surface of the specimens. Before placing the specimen in the testing machine the bearing surfaces of the testing machine was wiped clean, and the cube specimen also cleaned. The cube specimen was placed in the machine, of 2000kN capacity. The load was applied at a rate of approximately 140 kg/cm /min until the resistance of the specimen to the increasing load can be sustained. The compressive strength of the specimen was calculated by dividing the maximum load applied on the specimen during the test by the cross sectional area of the specimen for which average of three values of three cubes and the individual variation is more than ±15% of the average was observed. The test results for compressive strength are presented for 0%, 0.6%, 1.2%, 1.8% and 2.4% of rapidity concrete for M20 grades of concrete at room temperature for 3 days, 7 days and 28days respectively.

2.6 Test for Split Tensile Strength of Concrete

Immediately after removal of cylinder specimens kept on the surface, water and grit shall be removed from the surfaces, which are to be in contact with the packing strips and the bearing surfaces of the testing machine was wiped clean. The cylinder specimen was placed horizontally in the centering with packing skip (wooden strip)/or loading pieces carefully positioned along the top and bottom of the plane of loading of the specimen. The wooden pieces were placed on top of the cylinder and bottom of the cylinder, so that the specimen is located centrally, all these arrangements are shown in Plate 3.4 .The load was applied without shock and increased continuously at a nominal rate within the range 1.2 N/mm^2/min to 2.4 N/mm^2/min until failure of the specimen. The maximum load applied was recorded at failure.

The test results for split tensile strength are presented 0%, 0.6%, 1.2%, 1.8% and 2.4% of rapidite concrete for M20 grades of concrete at room temperature for 3 days, 7 days and 28days respectively.Then the split tensile strength fct of the specimen was calculated by using the following formula.

$$fct = \frac{2P}{(\Pi x L x d)}$$

Where P = Maximum load in Newton's applied to the specimen.

L = Length of the specimen in mm

d = Cross sectional dimension of the specimen in mm

2.7 Test for Flexural Strength of Concrete

The prism specimens were removed from the water tank on for 3 days, 7 days and 28days placed for 10 minutes to wipe off the surface water. The dimensions of each specimen were noted before testing. Before placing the specimen in the testing machine the bearing surfaces of the supporting and loading rollers were wiped off clean and any loose sand or other material was removed from the surfaces of the specimen. The specimen was placed in the machine in such a manner that the load was applied to the uppermost surface as cast in the mould, along two lines spaced 13.33cm apart. The axis of the specimen was carefully aligned with the axis of the loading device. The load was applied through two similar steel rollers, 38mm in diameter, mounted at the third points of the supporting span that is spaced at 13.33cm center to centre. The load was applied without shock and increased continuously at a rate of 180 kg/min until the specimen failed. The maximum load applied to the specimen during the test was recorded. The appearance of the fractured faces of concrete and unused features in the type of failure was noted.

(i) if a> 13.33 cm

$$fb = \frac{(p\,x\,l)}{(b\,x\,d^2)}$$

(ii) if a< 13.33 cm

But a < 11.0 cm

$$fb = \frac{(3p\,x\,a)}{(b\,x\,d^2)}$$

Where b = measured width in cm of specimen.
d = length in cm of the span on which the specimen
L = length in cm of the span on which the specimen, and
P = maximum load in kg applied to the specimen
If a < 11.0 cm, the results of the test are discarded.
The test results for Flexural strength are 0%, 0.6%, 1.2%, 1.8% and 2.4% of Rapidite concrete for M20 grades of concrete at room temperature for 3 days, 7 days and 28days respectively.

III. RESULTS & DISCUSSION

3.1 DISCUSSION OF TEST RESULTS

This paper deal with the interpretation of the test results obtained from various tests conducted. The effect of addition of Rapidite at various percentages on, compressive strength, split tensile strength, and flexural strength has been discussed based on the results obtained.

3.2 EFFECT OF VARIATION OF RAPIDITE ON COMPRESSIVE STRENGTH

The test was carried out to obtain compressive strength of M20 grade concrete. The compressive strength of concrete is tested for 0%, 0.6%, 1.2%, 1.8% and 2.4% replacement of Rapidite and the values are presented in Table no 3.1and also graphs were plotted below in figure 3.1.

Table 3.1Compressive Strength of concrete for M20

S.No	% of Rapidite	Compressive Strength(N/mm^2)		
		3 days	7 days	28 days
1	0%	10.4	16.9	25.74
2	0.6%	12.3	18.6	26.9
3	1.2%	13.6	19.2	26
4	1.8%	14.5	20.1	26.3
5	2.4%	13.4	19.8	26.01

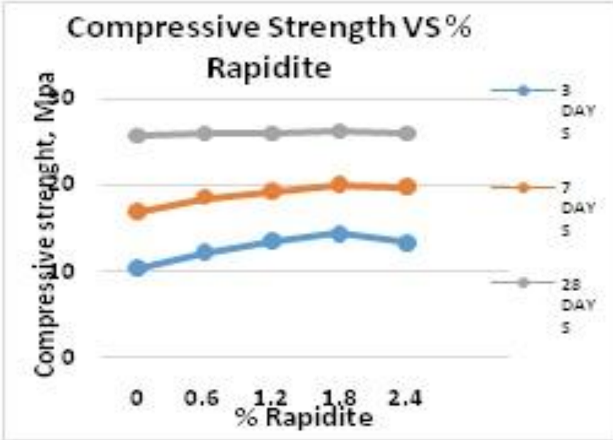

Figure 3.1 Graph showing Compressive Strength VS Rapidite

From both table and graphs it is observed that at about 1.8% replacement of cement with Rapidite, concrete attains its maximum compressive strength for both M20 grade concretes, when the replacement exceeds 1.8%, the compressive is found to be decreasing suddenly at 2.4% of Rapidite.

3.3 EFFECT OF VARIATION OF RAPIDITE ON SPLIT TENSILE STRENGTH

The test was carried out to obtain split tensile strength of M20 concrete. The split tensile strength of concrete is tested for 3 days, 7 days, 28 days for 0%, 0.6%, 1.2%, 1.8% and 2.4% replacement of Rapidite and the values are presented in table no 3.2 and also graph were plotted below figure 3.2.

Table 3.2 Split tensile Strength of concrete for M20

S.No	% of Rapidite	Split tensile strength(N/mm^2)		
		3 days	7 days	28 days
1	0%	0.8	1.8	2.1
2	0.6%	0.94	1.9	2.23
3	1.2%	0.97	1.99	2.3
4	1.8%	1.03	2.1	2.34
5	2.4%	0.96	1.97	2.2

From both table and graph it is observed that at about 1.8 % replacement of cement with Rapidite, concrete attains its maximum split tensile strength for both M20 grade concretes, when the replacement exceeds 1.8%, the compressive is found to be decreasing suddenly at 2.4%.

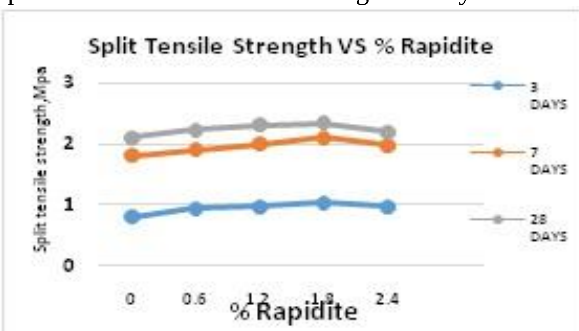

Figure 3.2 Spilt tensile strength VS % Rapidite

3.4 EFFECT OF VARIATION OF RAPIDITE ON FLEXURAL STRENGTH

The test was carried out to obtain flexural strength of M20 and M40 grade concrete. The flexural strength of concrete is tested for 3days, 7 days, 28 days for 0%, 0.6%, 1.2%, 1.8% and 2.4% replacement of Rapidite and the values are presented in table no 3.3and also graphs were plotted below figure 3.3.

Table 3.3 Flexural Strength of concrete for M20

S.No	% of Rapidite	Flexural Strength(N/mm^2)		
		3 days	7 days	28 days
1	0%	1.26	2.56	3.67
2	0.6%	1.32	2.68	3.76
3	1.2%	1.34	2.72	3.69
4	1.8%	1.37	2.79	3.71
5	2.4%	1.36	2.77	3.68

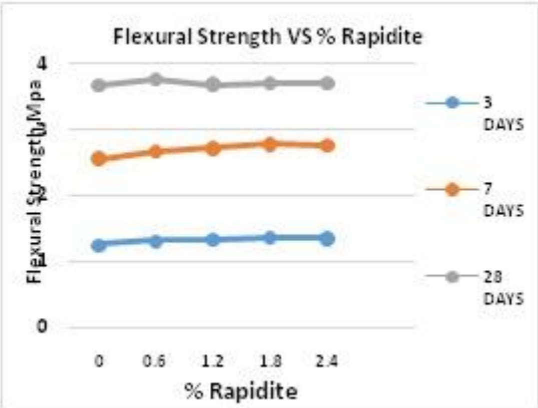

Figure 3.3 Graph showing Flexural Strength VS % Rapidite

From both table and graph it is observed that at about 1.8% replacement of cement with Rapidite, concrete attains its maximum flexural strength for both M20 grade concretes, when the replacement exceeds 1.8%, the compressive is found to be decreasing suddenly at 2.4% of Rapidite.

IV. CONCLUSION

Based on the analysis of experimental results and discussion there upon the following conclusions can be drawn.

- The compressive strength of concrete increased when cement is replaced by Rapidite for M20 grade of concrete. At 1.8% replacement of cement by Rapidite the concrete attained maximum compressive strength for both M20 grade of concrete.
- The split tensile strength of concrete is increased when cement is replaced with Rapidite .The split tensile strength is maximum at 1.8 % of replacement.
- The flexural strength of concrete is also increased when the cement is replaced by Rapidite. At 1.8% replacement, the flexural strength is maximum.
- Workability of concrete decreases with the increase in Rapidite replacement level.

SCOPE OF FURTHER STUDY

- Studies on replacements levels of high grade concrete can be carried out.
- Beams with different shear span to effective depth ratios, varying percentages of tensile reinforcement and varying percentages of Rapidite , may be investigated.
- Combination of Rapidite with different other admixture can be carried out.
- Other levels of replacement with Rapidite can be researched.
- For use of Rapidite concrete as a structural material, it is necessary to investigate the behavior of reinforced Rapidite concrete under flexure, shear, torsion and compression.
- The study may further be extended to know the behavior of concrete whether it is suitable for pumping purpose or not as present day technology is involved in ready mix concrete where pumping of concrete is being done to large heights.

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