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EFFECT OF ACCELERATORS (TIPA, TEA) & LIMESTONE POWDER ON MORTAR, FRESH AND HARDENED PROPERTIES OF CONCRETE

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ABSTRACT

The present aims to investigate the compressive strength of mortar and mechanical properties of different grade of concrete (i.e. M20, M25, M30) by adding Tri-Isopropanol Amine (TIPA), Tri-Ethanol Amine (TEA), and Limestone Powder (LP). TEA and LP were kept constant (1.2ml/l of water & 7% by weight of cement respectively) in mortar and concrete both. The study was carried out to compare the properties of control mix [TIPA (0%)] with other mixes [TIPA (0.05%) & TIPA (0.1%) by weight of cement] of mortar and concrete. Workability (slump and compaction factor) and mechanical properties i.e. compressive strength, split tensile strength & flexural strength of all grades of concrete (M20, M25 & M30) were investigated. The result showed that the compressive strength of mortar and workability of different grades of concrete (i.e. M20, M25 & M30) was the maximum with TIPA (0.1%) in comparison to control mix TIPA (0%) and TIPA (0.05%). The result also showed that mechanical properties i.e. compressive strength, split tensile strength and flexural strength of different grades of concrete (i.e. M20, M25 and M30) was the maximum with TIPA (0.05%) in comparison to control mix TIPA (0%) and TIPA (0.1%)

Keywords- *Concrete, TIPA, TEA, Mix, Grade, Streangth..*

Introduction

Concrete consist a composition of filler and binder. The binder is in form of cement paste "glues" the filler and forms a synthetic conglomerate. The materials used as a binder are cement and water, and for the filler it can be fine or coarse aggregate. Cement, as we know, is a mixture prepared by burning limestone and clay together at temperatures of 1400 to 1600 C.

Water is main constituent, and when it is mixed with cement, it forms a paste which binds the aggregate together. Then a process is done by water which is called hydration. The water quality used here should be pure otherwise it affects the process of hydration. Too much of water reduces concrete strength, while too little will make the concrete unworkable. Because of all this for good concrete a proper amount of the water to cement ratio is required.

Aggregates are inert materials which available in nature in various shapes, sizes, and materials ranging from fine particles of sand to large, coarse rocks. In concrete mixer cement is the most expensive so its content is low in mix and aggregates contains around 70 to 80 percent of the mix.

Concrete has properties like fire resistant, non-combustible material, ability to withstand at high temperatures. Also concrete has low tensile strength, low ductility, low strength- to – weight ratio, and is susceptible to cracking. After all these limitations Concrete remains an important material of choice for many applications.

Some admixtures are also added to concrete mix, just before or during mixing, to modify its properties. Admixtures are used for following purposes:

- To increase the initial stage strength.
- To control the initial and final setting time.
- To increase the workability.
- To increase the strength.

These are classified into two categories:

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MINERAL ADMIXTURES

(a) Fly ash
(b) Silica fume
(c) Ground granulated blast furnace slag
(d) Rice husk ash

CHEMICAL ADMIXTURES

(a) Accelerating admixture- A material which increases the rate of hydration of a hydraulic cement, reduce the setting time.
(b) Retarding admixture – A material which delays the setting time of cement paste.
(c) Water reducing admixture – A material which either increases workability of freshly mixed mortar or concrete without increasing water – cement ratio. Any of following can be used as water reducing admixtures.
(i) Lignosulphonic acid and its salts.
(ii) Hydroxylated carboxylic acids.
(iii) Formaldehyde derivatives such as MF and NSF.
(d) Air – entrained admixture – A material which causes air to be entrapped in the form of bubble to increase workability and resistance to freezing and thawing.
(e) Super plasticizing admixture – A material which impart very high workability with excessive decrease in water content (at least 20%) for given workability.

LITRATURE REVIEW

Heinz et al (2009) carried out work on mortar in which 25% fly ash was used. In this investigation TEA was involved to check its effect on fly ash solubility. Cement, quartz sand and water were used in 1:3:0.5 proportions. It was found that early strength of mortar increased.

Nochaiya et alin (2009) carried out study on mortar having w/(c+ f.a) ratio of 0.5. fly ash was used as replacement of cement by 5, 10, 20, and 30%. It was found that water requirement decreased and initial setting time and final setting time workability and compressive strength increased. Limbachiya et al in (2012) carried out study on three concrete mix of 20, 30, and 35 grade with 30% replacement of cement by fly ash in each grade recycled aggregates were used to replace coarse aggregate by 0, 30, 50 and 100% in each grade. It was reported that flexural strength & clastic modulus decreased but compressive strength increased.

Hannesson et al (2011) carried out study on concrete of 80 MPa. Fly ash was used to replace cement by 20, 40, 60, 80 and 100%. The study of slag with same percentage was carried out oto compare the result. The result showed less early age compressive strength and the setting tiem was near to setting time of control specimen.

Boga et at carried out investigation on M- 30 grade concrete with 15, 30, and 45% replacement of cement by fly ash. It was reported that at 15 % replacement split tensil strength increased byt it decreased for 30 and 45% replacement.

Kuder Katherine et al (2012) studied experimentally M60 with fly ash replacement of cement by 60, 80, and 90% by wt of cement. Also combination of fly ash (FA) and slag (SL) was tested out at 60, 80, and 90% replacement to compare the results. It was reported that at (60, 80)% replacement of cement by fly ash compressive strength increased. Elastic modulus increased with 60, 80% replacement after that becomes constant. In the case of different combinations of fly ash and slag it was found that they all had higher compressive strength (except 80% 75FA- 25 SL) than only fly ash replacement.

Yilmaz Bulent et al (2007) worked on mortar having cement sand ratio as 1:3 with w/c = 0.5. Clinker was first replaced with gypsum by 5% and then by fly ash (5, 10, 20, and 40%) and then by combination of fly ash, lime stone and dolomite lime stone at (5, 10, and 15)% were applied. In case of only fly ash setting time prolonged and compressive strength decreased.

Vahid et al (2012) worked on mortar with replacement of cement by fly ash at (20, 60)% and w/c 0.45. Slag was also tested separately with 60% replacement of cement by fly ash. It was found that degradation of mechanical properties occurred on exposer to heat.

Xianming et al (2011): worked on mortar with w/c 0.45 and M35 concrete. Fly ash was used to replace cement by 20 and 25% by wt of cement. It was reported that 1 and 7 day strength decreased and 28 day strength increased.
Above table depicts that the optimum replacement to cement by fly ash in the case of mortar was 15%. Also in case of concrete optimum replacement to cement by fly ash was found near 15%. The study also analyzed that it was better to use fly ash with components like lime stone and TEA (Triethanol amine).

Aggoun et al (2006) investigated on effect of calcium nitrate on setting and hardening of cement paste. Pastes with two types of cement were taken as on had normal and other had low tricalcium silicate content. With former cement mix very from M10 to M15 and for later cements M20 to M25. Effect of TIPA (Triisopropanol amine) on alone and in combination with CN was taken. Results showed that TIPA and (TIPA+CN), both cases enhances the compressive strength. w/c was 0.3.

Sandberg Paul (2013) investigated on cement paste as well as on mortar. For paste w/c 0.35 was taken (1-6) in which gypsum quantity varied and for mortar (7-10) in which different amount & type of quartz sand was used. w/c used for mortar was 0.42. 200 ppm TIPA was added by wt of cement & added to mix water. Results showed significant strength gain in both paste and mortar (10% & 9% respectively).

EXPERIMENTAL WORK

The selection of mix materials and their required proportion is done through a process called mix design. There are number of methods for determining concrete mix design. The methods used in India are in compliance with the BIS (Bureau of Indian Standards). The objective of concrete mix design is to find the proportion in which concrete ingredients- cement, water, fine aggregates and coarse aggregates should be combined in order to provide the specified strength, workability and durability and possibly meet other requirements as listed in standards such as IS: 456-2000. The specifications of a concrete mix must therefore define the materials and strength, workability and durability to be attained. IS: 10262-1982 gives the guidelines for concrete mix designs. In the study, mix design for 3 grades (M20, M25 & M30) has been done. In each grade TEA and LP were kept constant at 1.2 ml/l of water mixed in concrete and 7% by weight of cement content respectively where as TIPA was varied in 3 steps i.e 0, 0.05% and 0.1% by weight of cement used in concrete mix. Specimens were casted in each category of variation for each grade of concrete.

ACCELERATORS (TIPA,TEA) AND LP

TIPA from Alfa Aesar, Heysham LA3 2XY, ENGLAND has been used in the present study. The admixture was used by percentage of mass of cement for all three mix proportion. The physical and chemical properties of TIPA, TEA and LP have been shown in Table 3.5 to 3.10 respectively.

TABLE 3.5 PHYSICAL PROPERITES OF TIPA

Description	Specification	QC Method
Water content (KF)	<2.5%	KF
Assay (GC)	>94.0%	AS2
Comment	Physical form varies with water content	CO

TABLE 3.6 CHEMICAL PROPERTIES OF TIPA

Description	White to yellow waxy solid or melt

Melting Point	48-52^O C
Boiling Point	189-191^O C/23mm
Density	1.00
Flash Point	160^O C

TABLE 3.7 PHYSICAL PROPERTIES OF TEA

Properties	Results
Colour	Pale Yellow
Odour	Ammonical
Solubility	Miscible with water

TABLE 3.8 CHEMICAL PROPERTIES OF TEA

Properties	Results
Minimum	28%
Wt per ml at 20^O C	1.122-1.128
Refractive Index	1.484-1.488

TABLE 3.11 MIX PROPORTION (WEIGHT/M^3 OF CONCRETE)

Grade	Cement	F.A	C.A. (10mm)	C.A. (20mm)	W/C	TEA	LP	TIPA
M20	383.5	611.42	702.826	508.94	0.485	0	0	0
	356.65	611.42	702.826	508.94	0.485	1.2	7	0.05
	356.65	611.42	702.826	508.94	0.485	1.2	7	0.1
M25	410	592.196	700.91	507.57	0.453	0	0	0
	381.3	592.196	700.91	507.57	0.453	1.2	7	0.05
	381.3	592.196	700.91	507.57	0.453	1.2	7	0.1
M30	504.065	536.68	686.96	497.45	0.369	0	0	0
	468.78	536.68	686.96	497.45	0.369	1.2	7	0.05
	468.78	536.68	686.96	497.45	0.369	1.2	7	0.1

TESTING PROCEDURE

After the specified period of curing the specimens were taken out of the curing tank and their surfaces were wiped off. The various tests performed are described below.

a) Compressive strength of mortar cubes at 3, 7 and 28 days.
b) Compressive strength of cubes of different grades of concrete at 7, 28 and 90 days.
c) Split Tensile strength of cylinders of different grades of concrete at 7, 28 and 90 days.

d) Flexural strength of beams of different grades of concrete at 7, 28 and 90 days.

In the present work, mortar & concrete consist of Limestonr Powder (7% by wt of cement), TEA (1.2 ml/ 1 of water) and TIPA (0-0.1%). LP, TEA were kept constant and TIPA was varied in (0, 0.05% and 0.1% by wt of cement). Casting of specimens was carried out for mortar and mechanical properties (compressive strength, split tensile strength and flexural strength and flexural strength) in all the above mentioned categories. The cinoressive strength of mortar with variation in percentage of TIPA has been shown in table.4.1 and fig. 4.1. Also the workability (slump and compaction factor), compressive strength, split tensile strength and flexural strength of M-20, M-25 and M-30 at 3, 7 and 28 days have been shown in table 4.2-4.13 and fig 4.2-4.16 respectively.

TABLE 4.1 EFFECT OF VARIATION OF PERCENTAGE OF TIPA ON COMPRESSIVE STRENGTH OF MORTAR

S.No.	TIPA (% by wt of cement)	Compressive Strength at different age in days (MPa)		
		3	7	28
1	0	21.06	34.77	42.09
2	0.05	24.10	35.70	45.20
3	0.1	28.84	36.69	46.96

Enhancement in compressive strength of mortar with TIPA (0.05%) was observed as 14.4%, 2.6% & 7.3% at 3, 7 and 28 days respectively. Addition of TIPA (0.1%) enhanced compressive strength of mortar by 36.94%, 5.52% and 11.57% at 3, 7 and 28 days respectively. The experimental results showed enhancement in early age compressive strength of mortar & also a continuous increase in compressive strength of mortar at all ages. The results are in conformity with that in reported studies. (Aggoun S.)

TABLE 4.2 EFFECT OF VARIATION OF TIPA ON WORKABILITY OF M-20 GRADE OF CONCRETE

TIPA (% by wt of cement)	0	0.05	0.1
Slump (mm)	70	80	85
Compaction Factor	0.86	0.88	0.92

TABLE 4.3 EFFECT OF VARIATION OF PERCENTAGE OF TIPA ON WORKABILITY OF M-25 GRADE OF CONCRETE

TIPA (% by wt of cement)	0	0.05	0.1
Slump (mm)	60	70	75
Compaction Factor	0.88	0.90	0.92

TABLE 4.4 EFFECT OF VARIATION OF PERCENTAGE OF TIPA ON WORKABILITY OF M-30 GRADE OF CONCRETE

TIPA (% by wt of cement)	0	0.05	0.1
Slump (mm)	65	75	85
Compaction Factor	0.85	0.88	0.90

TABLE 4.5 EFFECT OF VARIATION OF PERCENTAGE OF TIPA ON COMPRESSIVE STRENGTH OF M-20 GRADE OF CONCRETE

S.No.	TIPA (% by wt of cement)	Compressive strength (age in days)		
		7	28	90
1	0	18.05	28.2	31.82
2	0.05	29.42	43.26	45.68

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3	0.1	28.71	41.81	43.99

TABLE 4.6 EFFECT OF VARIATION OF PERCENTAGE OF TIPA ON COMPRESSIVE STRENGTH OF M-25 GRADE OF CONCRETE

S.No.	TIPA (% by wt of cement)	Compressive strength (age in days)		
		7	28	90
1	0	24.5	32.9	36.25
2	0.05	32.54	45.49	47.88
3	0.1	30.90	42.05	44.21

TABLE 4.7 EFFECT OF VARIATION OF PERCENTAGE OF TIPA ON COMPRESSIVE STRENGTH OF M-30 GRADE OF CONCRETE

S.No.	TIPA (% by wt of cement)	Compressive strength (age in days)		
		7	28	90
1	0	30.66	39.67	43.62
2	0.05	33.31	46.49	49.73
3	0.1	32.29	44.54	46.30

TABLE 4.8 EFFECT VARIATION OF PERCENTAGE OF TIPA ON SPLIT TENSILE STRENGTH OF M-20 GRADE OF CONCRETE

S.No.	TIPA (% by wt of cement)	Split Tensile Strength (age in days)		
		7	28	90
1	0	1.48	2.45	2.80
2	0.05	2.36	3.70	4.18
3	0.1	2.30	3.61	4.00

TABLE 4.9 EFFECT VARIATION OF PERCENTAGE OF TIPA ON SPLIT TENSILE STRENGTH OF M-25 GRADE OF CONCRETE

S.No.	TIPA (% by wt of cement)	Split Tensile Strength (age in days)		
		7	28	90
1	0	2.13	2.86	3.37
2	0.05	2.72	4.19	4.64
3	0.1	2.66	3.76	4.39

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TABLE 4.10 EFFECT VARIATION OF PERCENTAGE OF TIPA ON SPLIT TENSILE STRENGTH OF M-30 GRADE OF CONCRETE

S.No.	TIPA (% by wt of cement)	Split Tensile Strength (age in days)		
		7	28	90
1	0	2.60	3.64	4.23
2	0.05	2.89	4.37	4.87
3	0.1	2.81	4.27	4.58

TABLE 4.11 EFFECT OF VARIATION OF PERCENTAGE OF TIPA ON FLEXURAL STRENGTH OF M-20 GRADE OF CONCRETE

S.No.	TIPA (% by wt of cement)	Flexural Strength (age in days)		
		7	28	90
1	0	2.039	3.136	4.167
2	0.05	3.815	6.596	7.481
3	0.1	3.117	4.485	5.733

TABLE 4.12 EFFECT OF VARIATION OF PERCENTAGE OF TIPA ON FLEXURAL STRENGTH OF M-25 GRADE OF CONCRETE

S.No.	TIPA (% by wt of cement)	Flexural Strength (age in days)		
		7	28	90
1	0	3.25	3.841	4.406
2	0.05	4.242	7.465	7.843
3	0.1	3.49	5.316	6.47

TABLE 4.13 EFFECT OF VARIATION OF PERCENTAGE OF TIPA ON FLEXURAL STRENGTH OF M-30 GRADE OF CONCRETE

S.No.	TIPA (% by wt of cement)	Flexural Strength (age in days)		
		7	28	90
1	0	3.481	4.705	7.879
2	0.05	4.285	8.06	8.605
3	0.1	4.182	6.48	7.196

CONCLUSION

Following conclusions have been drawn based on the observations and discussion of test results:

Compressive strength of mortar

The compressive strength of cement sand mortar increases at early age and also follows the same trend at all ages. The maximum strength was observed at TIPA (0.1%).

Workability of concrete

1) The workability (slump & compaction factor) was the maximum with 0.1% TIPA than control mix and 0.05% TIPA for M-20 grade of concrete.
2) The workability (slump & compaction factor) was the maximum with 0.1% TIPA than control mix and 0.05% TIPA for M-25 grade of concrete.
3) The workability (slump & compaction factor) was the maximum with 0.1% TIPA than control mix and 0.05% TIPA for M-30 grade of concrete.

Compressive strength

The experimental results showed enhancement in early age compressive strength for all grades of concrete and also at all ages.

1) The compressive strength of concrete was the maximum with TIPA (0.05%) than control mix and TIPA (0.1%) for M-20 grade of concrete.
2) The compressive strength of concrete was the maximum with TIPA (0.05%) than control mix and TIPA (0.01%) for M-25 grade of concrete.
3) The compressive strength of concrete was the maximum with TIPA (0.05%) than control mix and TIPA (0.01%) for M-30 grade of concrete.

It has been observed from the results that maximum compressive strength was obtained with TIPA (0.05%) in M-20 grade of concrete.

Split Tensile Strength

1) The split tensile strength of concrete was the maximum with TIPA (0.05%) than control mix and TIPA (0.1%) for M-20 grade of concrete.
2) The split tensile strength of concrete was the maximum with TIPA (0.05%) than control mix and TIPA (0.1%) for M-25 grade of concrete.
3) The split tensile strength of concrete was the maximum with TIPA (0.05%) than control mix and TIPA (0.1%) for M-30 grade of concrete.

The experimental results showed enhancement in the split tensile strength at early ages for all grades of concrete and at all ages with TIPA (0.05%).

It has been observed from the results that maximum split tensile strength was obtained with TIPA (0.05%) in M-20 grade of concrete.

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