

Experimental Investigation on the Performance and Durability of Self-Curing Self-Compacting Concrete Using Polyethylene Glycol and Liquid Paraffin Wax

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Abstract — Variations in concrete performance are frequently associated with inadequate compaction and insufficient curing, particularly in structural members containing congested reinforcement. Self-compacting concrete (SCC) is capable of flowing and consolidating under its own weight, whereas self-curing concrete is intended to maintain the internal moisture required for continued cement hydration without depending entirely on external curing. The present experimental investigation combines these two concepts to evaluate the performance and durability of self-curing self-compacting concrete using polyethylene glycol of two molecular weights, PEG 4000 and PEG 200, together with light and heavy grades of liquid paraffin wax as self-curing agents. The agents were incorporated at dosages ranging from 0.1% to 1.0% by mass of cement in three SCC mixes, designated A, B and C, having different water-cement ratios. Fresh-state performance was assessed through slump-flow, T50, V-funnel, J-ring and L-box tests in accordance with the workability requirements adopted for SCC. Hardened concrete performance was investigated through compressive strength, acid-attack resistance and sorptivity tests. The experimental results were compared with conventional SCC and conventionally cured specimens in order to examine the influence of the different self-curing compounds and their dosages. The investigation demonstrates that self-curing SCC can provide durability characteristics comparable with conventionally cured concrete while reducing dependence on external curing. The study therefore supports the potential use of PEG and liquid paraffin wax as internal curing agents in SCC where conventional curing and mechanical compaction are difficult to achieve.

Keywords— self-curing; polyethylene glycol (PEG); liquid paraffin wax (LPW); compressive strength; acid attack; sorptivity.

I. INTRODUCTION

Variations in the performance of concrete can for the most part be traced back to inadequate compaction together with poor curing. This creates a need for a concrete that is able to travel freely past densely packed reinforcement and still develop sound performance without depending on external curing. Self-curing serves to meet the internal water demand of the concrete whereas self-compacting concrete is formulated so that it may be placed in awkward locations and within crowded reinforcement. The purpose of the present study is to draw on the merits of both self-curing and self-compacting behaviour at once. The work makes use of several self-curing compounds namely polyethylene glycol (PEG) having molecular weights of 4000 (PEG 4000) and 200 (PEG 200) along with light and heavy grades of liquid paraffin wax for dosages between 0.1 and 1% of the cement mass introduced into the mixing water. Three mixes labelled A B and C and prepared with different w/c ratios were examined in the study.

The fresh mixes were examined by workability tests that is slump flow T50, V-funnel J-ring and L-box while compressive

strength acid attack and sorptivity were measured so as to establish the durability characteristics of the hardened concrete. A comparison was drawn between conventional SCC and self-cured SCC in terms of workability compressive strength acid attack and sorptivity.

Self-Compacting Concrete (SCC) belongs to a newer generation of concrete that has drawn considerable attention ever since Okamura first introduced it in Japan towards the end of the 1980s as a route to more durable concrete structures. It has since found extensive application where concrete must be placed in heavily reinforced members under awkward casting conditions. Such uses demand a fresh mix that is highly fluid yet well knit together. SCC may be described as a concrete able to spread and consolidate under nothing more than its own weight needing little or no vibration while remaining sufficiently cohesive to be handled without segregating or bleeding. Its role is to secure complete filling and reliable structural behaviour in densely reinforced members. The arrival of SCC represents a valuable step forward for the construction sector in tackling the shortcomings of ordinary cast-in-place concrete. Because its placement does not hinge on the

competence of the workforce the layout of the member or the size and quantity of reinforcing steel and because it flows readily while resisting segregation it can be pumped over greater distances. Chief among its benefits are a reduced construction time and assured compaction even in the tightly confined regions where vibrating and compacting are troublesome. Further advantages of SCC include

SCC is a flowing mixture well suited to placement under difficult conditions and in members congested with reinforcement all without vibration. In essence a self-compacting or self-consolidating concrete has to:

possess enough fluidity to consolidate itself without any outside energy stay uniform within the form both during and after placing and

1. Research objectives

- With the foregoing considerations in mind the present study has been framed around the following objectives.
- To develop Self-Compacting Concrete whose fresh properties conform to the EFNARC specifications.
- To assess the durability of Self-Compacting Concrete both with and without self-curing agents.
- To compare the several self-curing agents (namely PEG200 PEG4000 liquid paraffin wax light and liquid paraffin wax heavy) and to determine the optimum dosage of each for securing better durability.

II. LITERATURE REVIEW

Concrete with a view to bettering its qualities. Among them was Ozawa who pursued his own line of research apart from Okamura during the summer of 1988.

Nan su et al [3] put forward a straightforward mix-design procedure for SCC. First the quantity of aggregate needed is settled after which the binder paste is used to fill the spaces between the aggregate particles so that the resulting concrete has the required flow self-compacting ability and other SCC qualities. The amounts of aggregate binder and mixing water along with the type and quantity of superplasticizer (SP) are the chief factors that shape the properties of SCC. The concrete was assessed through slump flow V-funnel L-flow U-box and compressive strength tests and the outcomes show that the method reliably yields high-quality SCC. The procedure fixes the Aggregate Packing Factor (PF) and its bearing on strength flow and self-compactability.

A.Ferhat Bingol Ilhan Tohumcu [6] reported on the influence of air water and steam curing on the compressive strength of SCC. For the experiments they made SCC with silica fume replacing cement at 5% 10% and 15% and fly ash at 25% 40% and 55%. Raising the silica fume replacement was found to raise compressive strength whereas increasing the fly ash content lowered it. The greatest strengths came from standard-cured specimens and for the steam-curing regime the best result was obtained from the 55% replacement group treated at 70 degrees C for 16 hours.

S. Venkateswara Rao M.V. Seshagiri Rao P. Rathish Kumar [12] developed both standard and high-strength Self-Compacting Concrete (SCC) using different aggregate sizes and following Nan-su's mix-design procedure. The results showed that SCC can be produced with graded aggregate of any size while still meeting the SCC criteria. Compressive flexural and split-tensile strengths were measured at 3 7 and 28 days for the standard and high-strength SCC with the various aggregate sizes. A 10 mm aggregate with 52% fly ash in the total powder gave the best mechanical properties for standard SCC while a 16 mm aggregate with 31% fly ash improved the high-strength SCC.

A.S. El-Dieb [16] studied the water retention of concrete using a water-soluble polymeric glycol as the self-curing agent. To gauge the water retention of self-curing concrete the weight loss of the concrete and its internal relative humidity were tracked over time. Water movement through the concrete was characterised by measuring absorption percentage permeable-voids percentage water sorptivity and water permeability and these were followed with age. The influence of mix proportions such as cement content and water/cement ratio on the performance of self-curing concrete was also examined. In the study the water retention and hydration of concrete containing self-curing agents were compared with those of conventional concrete and water transport through it was compared with that of conventional concrete kept continuously moist and air-cured. The self-curing agent was dosed at 0.02% by weight of cement held constant across all the self-curing mixes. The work covered concrete with cement contents from 350 to 450 kg/m³ at water-cement ratios of 0.3 to 0.4 for self- conventional and air-curing comparing the results across the various tests.

Semion Zhutovsky Konstantin Kovler [18] described a way of countering self-desiccation and autogenous shrinkage by using pre-saturated lightweight aggregates as internal curing agents. Durability measures such as resistance to chloride penetration air permeability water absorption and mass loss were applied to HPC mixes with w/c ratios from 0.21 to 0.33.

Liang et al [21] noted that adding a combination of a wax preferably paraffin wax and a glycol preferably polyethylene glycol (PEG) to concrete brings about internal curing that in many respects equals or better conventional curing methods.

Jau [22] compared the action of a self-curing agent on ordinary Portland cement concrete (OPC) and on self-consolidating concrete (SCC). The self-curing agent amounted to 1-2% of the cement weight. Both OPC and SCC were tested for water loss and compressive strength at several relative humidity (RH) levels.

a low dosage of polyethylene glycol is more effective in achieving self-curing concrete than a high dosage.

III. MATERIALS AND METHODS

The experimental work began with the task of settling on mix proportions that met the fresh-state requirements of self-compacting concrete under the EFNARC specifications. Standard cast-iron cube moulds measuring 150 mm x 150 mm x 150 mm were employed for casting the standard cubes.

Each mould was assembled so that no gaps remained between its plates any small openings being sealed with plaster of paris. The moulds were then oiled and made ready for casting. Twenty-four hours after casting the specimens were struck and moved to the curing tank where they were kept immersed in water for the intended curing period.

The programme involved casting and testing three mixes (A B and C) of Self-Compacting Concrete incorporating the self-curing compounds PEG4000 PEG200 Liquid Paraffin Wax Light and Liquid Paraffin Wax Heavy. Each grade of SCC comprised thirteen batches: one plain SCC without any self-curing agent three batches with PEG 4000 at 0.1% 0.5% and 1% by weight of cement three with PEG 200 at the same dosages three with Liquid Paraffin Wax Light at 0.1% 0.5% and 1% and three with Liquid Paraffin Wax Heavy at the same levels.

The mix proportion for each grade was arrived at using the modified Nan Su method and water-reducing admixtures were introduced as needed until the mixes displayed the desired properties. Four cubes were cast per batch two of which were subjected to the 5% HCl (hydrochloric acid) and sorptivity durability tests after 28 days. The specimens cast are set out in fig. 4.1.

The various materials employed in the study were Self-Curing Compounds- PEG4000 PEG200 Liquid Paraffin Wax Light and Liquid Paraffin Wax Heavy.

Cement: The cement used in the study was 53 Grade Ordinary Portland cement conforming to IS: 12269 [11]. Its specific gravity was 3.14 and its specific surface area 225 m²/g with initial and final setting times of 40 min and 560 min respectively.

Fine Aggregate: The fine aggregate conformed to Zone-2 of IS: 383 [12] and was drawn from a nearby river. Its specific gravity was 2.65 and the bulk density of the sand was 1.45 gram/c.c.

Coarse Aggregate: Crushed granite served as the coarse aggregate. Obtained from a local crushing unit it was well-graded material of 20 mm nominal size conforming to IS: 383 [12] with a specific gravity of 2.8 and a bulk density of 1.5 gram/c.c.

Micro silica: This is an amorphous (non-crystalline) form of silicon dioxide obtained as an ultrafine by-product of silicon and ferrosilicon alloy manufacture and made up of spherical particles averaging about 150 nm across. Its chief use is as a pozzolanic material in high-performance concrete.

With spherical particles under 1 micrometre in diameter averaging roughly 0.15 micrometre it is about a hundred times finer than an average cement grain. Its bulk density which depends on how far it has been densified in the silo ranges from 130 to 600 kg/m³ its specific gravity generally lies between 2.2 and 2.3 and its surface area typically falls between 15000 and 30000 m²/kg. For the best results the micro silica was dosed at 8% of the cement weight.

Super plasticizer: A high-range water-reducing admixture conforming to ASTM C94 commonly termed a super plasticizer was used to raise flow and workability at a reduced water-cement ratio without loss of compressive strength.

Such admixtures on dispersing the cement agglomerates sharply lower the viscosity of the paste by forming a thin film around the cement particles. The admixture adopted here was CHRYSO FLUID OPTIMA P-77 a polycarboxylic-ether-based product supplied by Chryso Chemicals India.

1. Mix proportions and fresh properties

Table 1. Physical Properties of CARBOWAX PEGs.

Product	Range of Average Molecular Weight	Range of Average Hydroxyl Number Mg KOH/g	Liquid Density g/cc	Liquid Density g/cc	Liquid Density g/cc	Melting or Freezing Range °C	Solubility in Water at 20°C % by wt	Viscosity at 100°C
Product	Range of Average Molecular Weight	Range of Average Hydroxyl Number Mg KOH/g	20°C	60°C	80°C	Melting or Freezing Range °C	Solubility in Water at 20°C % by wt	Viscosity at 100°C
PEG200	190 to 210	535 to 590	1.124	1.092	1.076	-65	Complete	4.3
PEG 4000	3600 to 4400	25 to 32	Solid	1.093	1.077	53 to 59	66	140.4

Table 2. Physical and Chemical Properties of Paraffin Wax.

Sr. No.	Characteristics	Liquid Paraffin Light	Heavy Liquid Paraffin
1.	Specific gravity @ 25°C	Between 0.820 to 0.860	Between 0.850 to 0.880
2.	Dynamic viscosity @ 20°C	Between 25 to 80 mpas	Between 110 to 230 mpas
3	Appearance	Clear colour less liquid.	Clear colour less liquid.
3.	Solubility	Passes	Passes
4.	Sulphur compounds	Compiles as per standards	Compiles as per standards
5.	Solid paraffins	Compiles as per standards	Compiles as per standards
6.	Flash point (PMCC) °C	Min. 150 °C	Min 200 OC
7.	Acidity / alkalinity	Passes	Passes
8.	Light absorption @ 240-280 nm	Less than 0.1	Less than 0.1
9.	Readily carbonisable substances	Passes	Passes

Table 3. Place of Procurement and Viscosity of Self-Curing Agents.

	PEG 4000	PEG 200	Paraffin wax
Place of Procurement	M/S Central Drug House(P) Ltd. New Delhi	M/S Sdfcl Mumbai	M/S Sdfcl Mumbai
Viscosity AT 20°C	ABOUT 12 cS	53-63 Cs	< 33.5 cS

Table 4. Mix Proportions and Quantity of Materials Used for Mix A.

Sr.No.	Material	Quantity kg/m ³	Quantity for 9 cubes in Kg	Proportions
1)	Cement	500.00	18.00	1.000
2)	Fine Aggregate	800.00	28.80	1.600
3)	Coarse Aggregate	775.00	27.90	1.550
4)	Water	190.00	6.84	0.380
5)	Flyash	110.00	3.96	0.220
6)	MicroSilica	40	1.44	0.080
7)	SP	6.00	0.216	0.012
	Density	2421.00		

Table 5. Mix Proportions and Quantity of Materials Used for Mix B.

Sr.No.	Material	Quantity kg/m ³	Quantity for 9 cubes in Kg	Proportions
1)	Cement	430.00	16.50	1.000
2)	Fine Aggregate	847.10	32.52	1.970
3)	Coarse Aggregate	782.60	30.00	1.820
4)	Water	194.00	7.44	0.450
5)	Flyash	180.00	6.93	0.420
6)	SP	5.16	0.198	0.012
	Density	2438.86		

Table 6. Mix Proportions and Quantity of Materials Used for Mix C.

Sr.No.	Material	Quantity kg/m ³	Quantity for 9 cubes in Kg	Proportions
1)	Cement	360.00	16.00	1.000
2)	Fine Aggregate	860.00	38.24	2.390
3)	Coarse Aggregate	788.00	35.04	2.190
4)	Water	188.00	8.80	0.550
5)	Flyash	250.00	11.04	0.690
6)	SP	3.6	0.16	0.010
	Density	2449.60		

Table 7. Fresh Properties of Self-Compacting Concrete with PEG for Mix A.

	EFNARC RANGE	PLAIN SCC	PEG 4000	PEG 4000	PEG 4000	PEG 200	PEG 200	PEG 200
	EFNARC RANGE	0%	0.10%	0.50%	1%	0.10%	0.50%	1%
SLUMP FLOW(mm)	550-850	700	650	635	665	810	825	870
T 50 (sec)	2-5	3.69	3.72	3.41	3.29	3.8	3.44	2.5
J-RING (mm)	0-10	5	10	9	9	7	6	5
L-BOX	0.8-1.0	0.94	0.82	0.835	0.85	0.93	0.945	0.96
V-FUNNEL (Sec)	6-12	11.5	9.7	13.33	11.3	9.9	9.02	8.97
V 5min (sec)	9-15	17	11	16.3	14.2	12.4	13.5	13.36
SP %		1.2	1.2	1.2	1.2	1.2	1.2	1.2

Table 8. Fresh Properties of Self-Compacting Concrete with LPW for Mix A.

	EFNARC RANGE	PLAIN SCC	LPW Light	LPW Light	LPW Light	LPW High	LPW High	LPW High
	EFNARC RANGE	0%	0.10%	0.50%	1%	0.10%	0.50%	1%
SLUMPFLOW(mm)	550-850	700	645	660	675	775	745	695
T 50 (sec)	2-5	3.69	2.1	2.3	2.45	2.07	2.4	2.48
J-RING (mm)	0-10	5	10	9	8	6	7	7
L-BOX	0.8-1.0	0.94	0.87	0.895	0.9	0.91	0.9	0.9
V-FUNNEL (Sec)	6-12	11.5	9	11.8	11.9	9.55	10.46	9.25
V 5min (sec)	9-15	17	12	13.8	14.5	15	13.77	12
SP %		1.2	1.4	1.4	1.4	1.3	1.4	1.6

Table 9. Fresh Properties of Self-Compacting Concrete with PEG for Mix B

	EFNARC RANGE	PLAIN SCC	PEG 4000	PEG 4000	PEG 4000	PEG 200	PEG 200	PEG 200
	EFNARC RANGE	0%	0.10%	0.50%	1%	0.10%	0.50%	1%
SLUMPFLOW(mm)	550-850	700	660	790	795	625	610	690
T 50 (sec)	2-5	2.5	3.14	3.04	3.4	2.92	3.15	2.38
J-RING (mm)	0-10	7	8	5	5	8	9	8
L-BOX	0.8-1.0	0.92	0.91	0.945	0.955	0.86	0.83	0.88
V-FUNNEL (Sec)	6-12	7.02	6.3	7	7.5	7.72	7.27	6.12
V 5min (sec)	9-15	9.54	9.5	10.3	10.3	9.34	9.56	9.09
SP %		1.2	1.2	1.2	1.2	1.2	1.3	1.2

Table 10. Fresh Properties of Self-Compacting Concrete with LPW for Mix

	EFNARC RANGE	PLAIN SCC	LPW Light	LPW Light	LPW Light	LPW High	LPW High	LPW High
	EFNARC RANGE	0%	0.10%	0.50%	1%	0.10%	0.50%	1%
SLUMPFLOW(mm)	550-850	700	730	705	745	760	730	775
T 50 (sec)	2-5	2.5	2.87	3.43	3.26	3.21	3.53	2.27
J-RING (mm)	0-10	7	7	8	7	6	7	5
L-BOX	0.8-1.0	0.92	0.88	0.9	0.89	0.84	0.83	0.83
V-FUNNEL (Sec)	6-12	7.02	8.29	7.67	8.5	7.6	7.44	7.82
V 5min (sec)	9-15	9.54	12	12.9	13.3	11.42	11.4	12
SP %		1.2	1.2	1.2	1.2	1.2	1.2	1.2

Table 11. Fresh Properties of Self-Compacting Concrete with PEG for Mix C.

	EFNARC RANGE	PLAIN SCC	PEG 4000	PEG 4000	PEG 4000	PEG 200	PEG 200	PEG 200
	EFNARC RANGE	0%	0.10%	0.50%	1%	0.10%	0.50%	1%
SLUMPFLOW(mm)	550-850	670	590	640	560	650	660	770
T 50 (sec)	2-5	2.4	2.32	2.5	3.4	2.05	2	2.35
J-RING (mm)	0-10	8	7	7	7	6	6	5
L-BOX	0.8-1.0	0.87	0.875	0.88	0.89	0.93	0.92	0.955
V-FUNNEL (Sec)	6-12	9.77	6	6.52	8.3	6.429	5	6.85
V 5min (sec)	9-15	10.64	7.76	8.5	9.8	9.02	6.45	9.42
SP %		1.3	1	1	1	1	1	1

Table 12. Fresh Properties of Self-Compacting Concrete with LPW for Mix C.

	EFNARC RANGE	PLAIN SCC	LPW Light	LPW Light	LPW Light	LPW High	LPW High	LPW High
	EFNARC RANGE	0%	0.10%	0.50%	1%	0.10%	0.50%	1%
SLUMPFLOW(mm)	550-850	670	770	575	600	570	565	655
T 50 (sec)	2-5	2.4	2	3.56	3.98	2.14	2.99	2.39
J-RING (mm)	0-10	8	8	9	9	10	10	10
L-BOX	0.8-1.0	0.87	0.9	0.84	0.81	0.83	0.82	0.86
V-FUNNEL (Sec)	6-12	9.77	5.8	7.18	8.9	6.44	8.43	7.5
V 5min (sec)	9-15	10.64	7.8	9.69	11.89	7.22	8.98	10
SP %		1.3	1.2	1.3	1.4	1.4	1.2	1.1

2. Experimental setup and test images

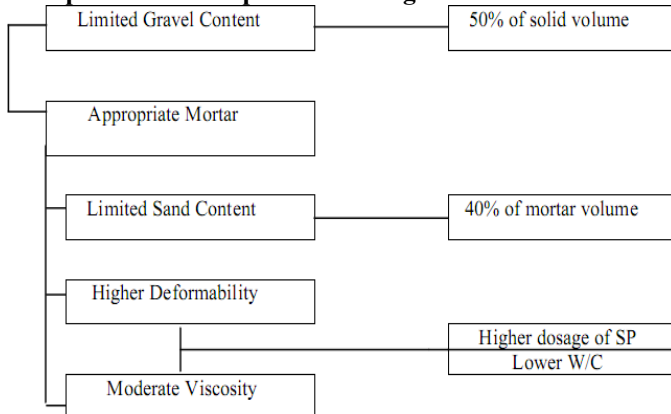


Fig. 1. Necessity of Self Compacting Concrete (SCC).

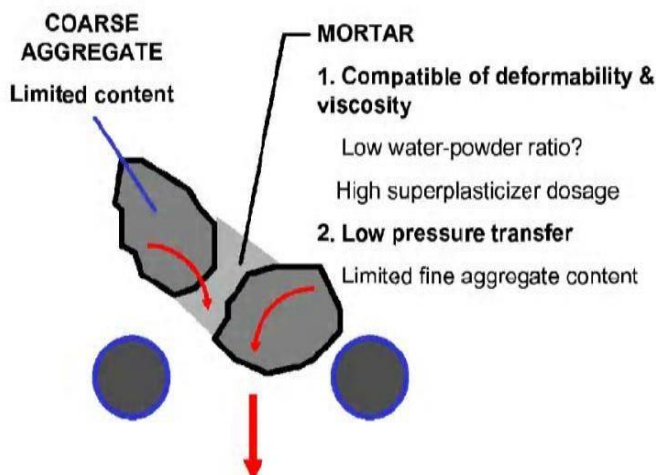


Fig. 2. Methods for achieving self-compactability.



Fig. 3. Abrams Slump Flow Equipment.

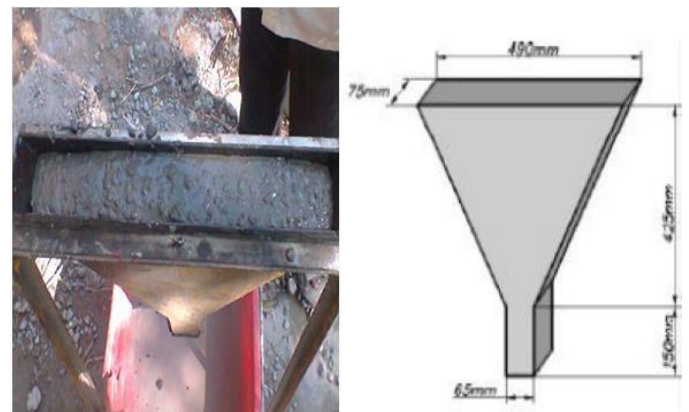


Fig. 4. J-Ring Equipment.



Fig. 5. Self-compacting concrete after mixing in 120 kg pan mixer.



Fig. 7. Cubes tested for compressive strength.



Fig. 6. Specimens kept for curing.

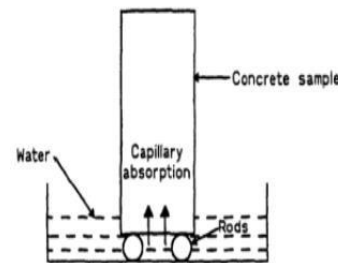


Fig. 8. Sorptivity test applying wax on the sides of the cube specimen.

IV. RESULTS AND DISCUSSION

The figure and table give the compressive strength of SCC both with and without self-curing compounds. The table makes it plain that adding the self-curing compounds brings about a fall in compressive strength. It may also be noted that PEG yields the best results among the curing agents.

1. Experimental result tables

Table 13. Average Compressive Strength of SCC with and without PEG.

	MIX A	MIX A	MIX B	MIX B	MIX C	MIX C
	7DAYS	28DAYS	7DAYS	28DAYS	7DAYS	28DAYS
I	49.64	68.87	42.52	52.39	36.04	52.19
W	52.84	75.73	43.29	60.13	41.46	56.4
H-0.1%	55.4	73.87	40.09	54.45	38.16	47.87
H-0.5%	50.23	66.12	45.91	52.39	35.7	48.39
H-1.0%	56.83	71.81	43.03	56.11	36.49	48.59
L-0.1%	51.6	61.61	40.42	49.34	33.85	43.23
L-0.5%	55.33	68.96	45.45	50.91	33.85	43.09
L-1.0%	55.85	66.81	43.03	51.01	34.43	47.8

Table 14. Average Compressive Strength of SCC with and without Paraffin Wax.

	MIX A	MIX A	MIX B	MIX B	MIX C	MIX C
	7DAYS	28DAYS	7DAYS	28DAYS	7DAYS	28DAYS
I	49.64	68.87	42.52	52.39	36.04	52.19
W	52.84	75.73	43.29	60.13	41.46	56.4
V-0.1%	54.15	69.36	42.18	48.07	37.47	44.08
V-0.5%	50.55	68.77	41.33	47.58	29.62	40.61
V-1.0%	52.19	68.67	40.48	48.17	31.68	45.91
P-0.1%	54.61	73.87	47.67	49.93	35.9	48.46
P-0.5%	60.49	71.02	47.87	52.38	33.94	52.97
P-1.0%	57.03	71.51	44.93	49.15	37.96	46.76

Table 15. Acid Attack Factor for Mix A Cubes Immersed in 5% HCl.

	ACID ATTACK FACTOR	ACID ATTACK FACTOR	ACID ATTACK FACTOR	ACID ATTACK FACTOR	ACID ATTACK FACTOR
	3 days	7 days	14 days	21 days	28 days
AW	0.175	0.3	0.45	0.6	0.725
AI	0.075	0.2	0.275	0.45	0.6
AH-0.1	0.175	0.225	0.35	0.6	0.675
AH-0.5	0.25	0.275	0.5	0.65	0.75
AH-1	0.1	0.225	0.4	0.45	0.65
AL-0.1	0.125	0.275	0.35	0.5	0.575
AL-0.5	0.2	0.275	0.275	0.35	0.45
AL-1	0.125	0.225	0.375	0.55	0.65
AV-0.1	0.175	0.325	0.45	0.45	0.55
AV-0.5	0.15	0.25	0.3	0.4	0.45
AV-1	0.15	0.3	0.35	0.55	0.6
AP-0.1	0.175	0.325	0.375	0.55	0.625
AP-0.5	0.125	0.2	0.375	0.5	0.625
AP-1	0.2	0.325	0.425	0.6	0.75

Table 16. Acid Attack Factor for Mix B Cubes Immersed in 5% HCl.

	Acid Attack Factor	Acid Attack Factor	Acid Attack Factor	Acid Attack Factor	Acid Attack Factor
	3 days	7 days	14 days	21 days	28 days
BW	0.125	0.25	0.4	0.5	0.525
BI	0.175	0.3	0.525	0.6	0.75
BH-0.1	0.2	0.35	0.475	0.525	0.725
BH-0.5	0.1	0.2	0.275	0.4	0.525
BH-1	0.3	0.4	0.5	0.6	0.725
BL-0.1	0.2	0.375	0.475	0.6	0.775
BL-0.5	0.175	0.275	0.425	0.525	0.65
BL-1	0.175	0.2	0.35	0.575	0.675
BV-0.1	0.075	0.225	0.35	0.425	0.575
BV-0.5	0.2	0.35	0.475	0.625	0.8
BV-1	0.2	0.325	0.35	0.4	0.575
BP-0.1	0.125	0.25	0.3	0.425	0.575
BP-0.5	0.3	0.375	0.5	0.675	0.825
BP-1	0.325	0.35	0.425	0.575	0.75

Table 17. Acid Attack Factor for Mix C Cubes Immersed in 5% HCl.

	ACID ATTACK FACTOR	ACID ATTACK FACTOR	ACID ATTACK FACTOR	ACID ATTACK FACTOR	ACID ATTACK FACTOR
	3 days	7 days	14 days	21 days	28 days
CW	0.2	0.25	0.3	0.425	0.5
CI	0.15	0.275	0.35	0.4	0.475
CH-0.1	0.225	0.45	0.4	0.6	0.675
CH-0.5	0.1	0.25	0.3	0.375	0.525
CH-1	0.125	0.275	0.4	0.65	0.775
CL-0.1	0.25	0.4	0.55	0.725	0.85
CL-0.5	0.15	0.3	0.4	0.55	0.75
CL-1	0.175	0.3	0.35	0.475	0.6
CV-0.1	0.25	0.375	0.525	0.65	0.775
CV-0.5	0.15	0.375	0.5	0.55	0.675
CV-1	0.225	0.275	0.425	0.55	0.65
CP-0.1	0.15	0.275	0.35	0.45	0.575
CP-0.5	0.1	0.175	0.275	0.375	0.55
CP-1	0.1	0.225	0.3	0.425	0.525

Table 18. Sorptivity for Mix A Cubes.

	18.97	37.94	65.72	100.39	141.98	173.89	200.79
INDOOR	0.00656	0.00410	0.00264	0.00181	0.00113	0.00105	0.00089
WET	0.00234	0.00117	0.00041	0.00022	0.00009	0.00008	0.00007
PEGH-0.1	0.00305	0.00234	0.00142	0.00106	0.00053	0.00056	0.00046
PEGH-0.5	0.00445	0.00269	0.00176	0.00133	0.00078	0.00077	0.00062
PEGH-1.0	0.00445	0.00269	0.00176	0.00128	0.00072	0.00069	0.00058
PEGL-0.1	0.00422	0.00234	0.00162	0.00115	0.00063	0.00072	0.00060
PEGL-0.5	0.00398	0.00246	0.00169	0.00111	0.00053	0.00059	0.00053
PEGL-1.0	0.00539	0.00305	0.00196	0.00128	0.00072	0.00077	0.00066
PWL-0.1	0.00492	0.00269	0.00162	0.00106	0.00059	0.00061	0.00044
PWL-0.5	0.00586	0.00363	0.00223	0.00151	0.00081	0.00084	0.00064
PWL-1.0	0.00468	0.00293	0.00169	0.00115	0.00072	0.00059	0.00046
PWH-0.1	0.00586	0.00351	0.00216	0.00155	0.00091	0.00097	0.00082
PWH-0.5	0.00539	0.00328	0.00196	0.00128	0.00075	0.00079	0.00062
PWH-1.0	0.00539	0.00305	0.00183	0.00137	0.00085	0.00084	0.00073

Table 19. Sorptivity for Mix B Cubes.

	18.97	37.94	65.72	100.39	141.98	173.89	200.79
BI	0.0028	0.0016	0.0009	0.0004	0.0005	0.0003	0.0003
BW	0.0033	0.0013	0.0005	0.0004	0.0002	0.0001	0.0001
BH-0.1	0.0084	0.0049	0.0031	0.0020	0.0013	0.0012	0.0010
BH-0.5	0.0049	0.0032	0.0019	0.0011	0.0006	0.0006	0.0005
BH-1.0	0.0045	0.0033	0.0020	0.0014	0.0008	0.0008	0.0007
BL-0.1	0.0096	0.0057	0.0034	0.0019	0.0013	0.0011	0.0009
BL-0.5	0.0126	0.0076	0.0050	0.0031	0.0022	0.0018	0.0016
BL-1.0	0.0094	0.0055	0.0035	0.0019	0.0015	0.0012	0.0012
BV-0.1	0.0077	0.0046	0.0027	0.0018	0.0010	0.0009	0.0008
BV-0.5	0.0073	0.0045	0.0027	0.0019	0.0012	0.0010	0.0008

BV-1.0	0.0084	0.0049	0.0030	0.0020	0.0016	0.0014	0.0012
BP-0.1	0.0066	0.0049	0.0032	0.0022	0.0018	0.0013	0.0012
BP-0.5	0.0103	0.0056	0.0034	0.0019	0.0014	0.0012	0.0011
BP-1.0	0.0063	0.0036	0.0022	0.0011	0.0008	0.0007	0.0007

Table 20. Sorptivity Values for Mix C.

	18.97	37.94	65.72	100.39	141.98	173.89	200.79
CI	0.0063	0.0041	0.0027	0.0015	0.0013	0.0009	0.0008
CW	0.0028	0.0014	0.0006	0.0004	0.0002	0.0001	0.0001
CH-0.1	0.0108	0.0076	0.0051	0.0029	0.0023	0.0016	0.0013
CH-0.5	0.0101	0.0069	0.0047	0.0023	0.0020	0.0014	0.0012
CH-1.0	0.0084	0.0054	0.0034	0.0018	0.0015	0.0011	0.0009
CL-0.1	0.0105	0.0076	0.0053	0.0033	0.0026	0.0019	0.0016
CL-0.5	0.0101	0.0069	0.0045	0.0023	0.0021	0.0015	0.0012
CL-1.0	0.0061	0.0045	0.0028	0.0015	0.0013	0.0009	0.0007
CV-0.1	0.0141	0.0096	0.0064	0.0039	0.0029	0.0021	0.0018
CV-0.5	0.0143	0.0095	0.0060	0.0037	0.0028	0.0020	0.0017
CV-1.0	0.0101	0.0068	0.0043	0.0026	0.0021	0.0014	0.0012
CP-0.1	0.0171	0.0100	0.0063	0.0040	0.0030	0.0022	0.0019
CP-0.5	0.0103	0.0061	0.0034	0.0021	0.0017	0.0013	0.0012
CP-1.0	0.0148	0.0085	0.0055	0.0035	0.0027	0.0020	0.0017

2. Graphical presentation of results



Figure 9 “Specimen of normal SCC immersed in 5% HCl”

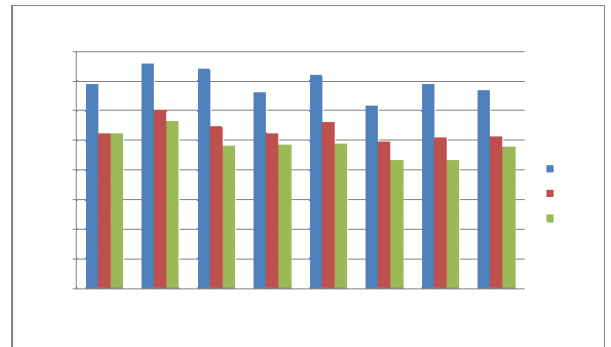


Figure 11 “Average compressive strength of SCC without and with PEG at 28 days”

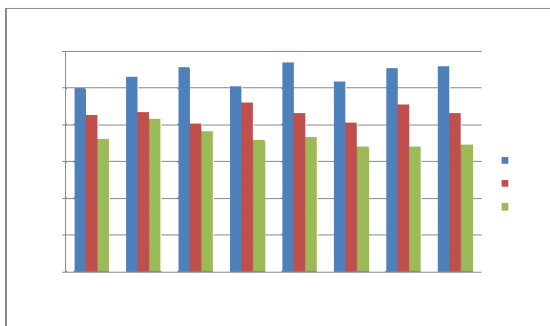


Figure 10 “Average compressive strength of SCC without and with PEG at 7 days”

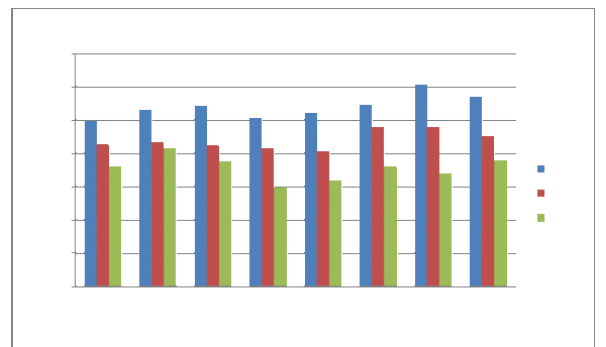


Figure 12 “Average compressive strength of SCC without and with Paraffin Wax at 7 days”

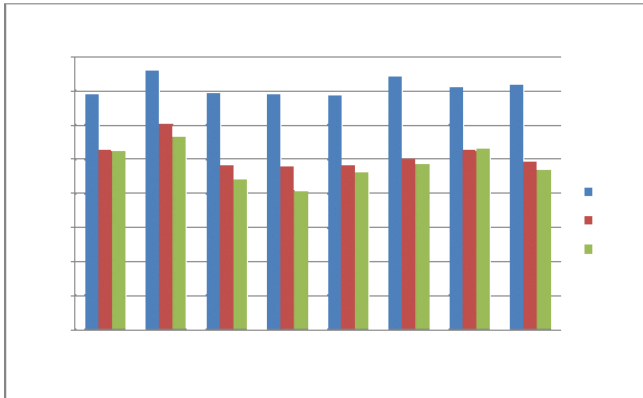


Figure 13 “Average compressive strength of SCC without and with Paraffin Wax at 28 days”

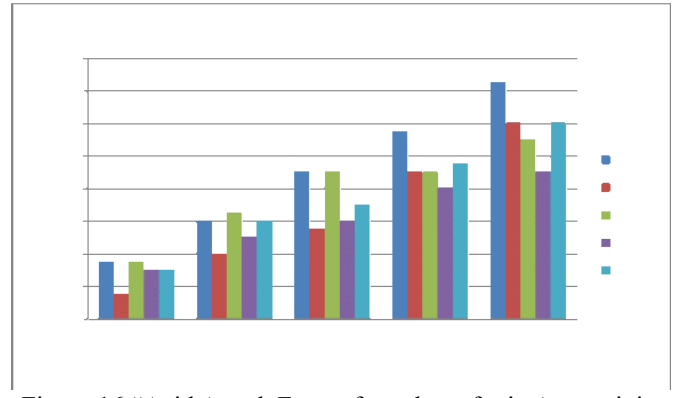


Figure 16 “Acid Attack Factor for cubes of mix A containing PWL”

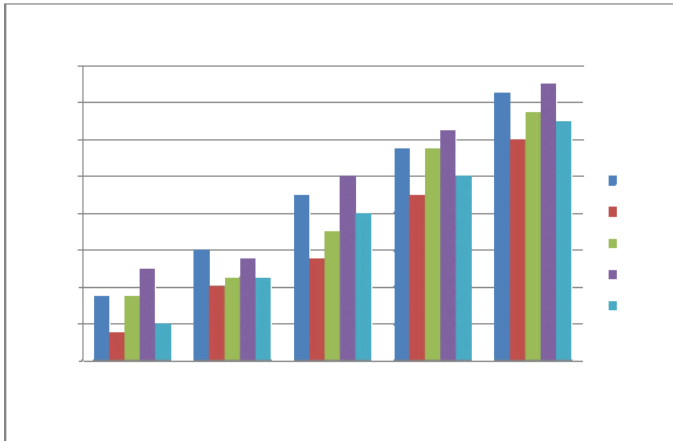


Figure 14 “Acid Attack Factor for cubes of mix A containing PEG4000”

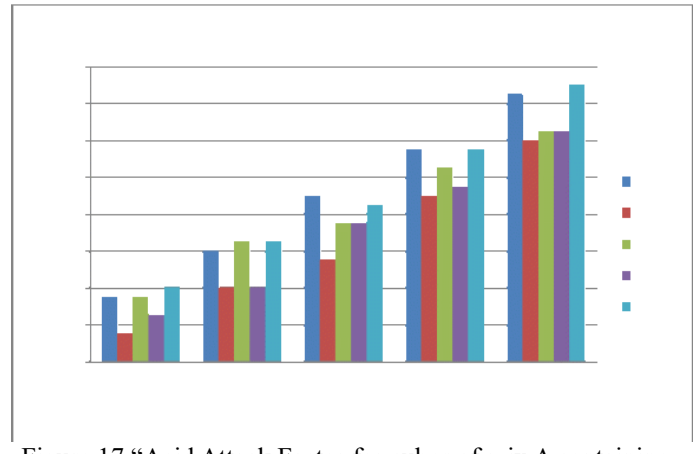


Figure 17 “Acid Attack Factor for cubes of mix A containing PWH”

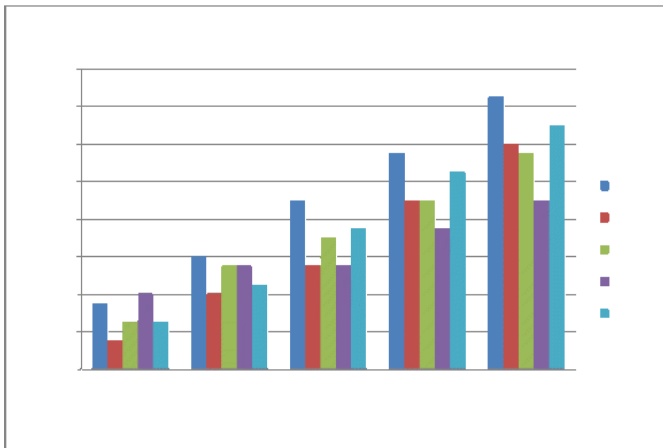


Figure 15 “Acid Attack Factor for cubes of mix A containing PEG200”

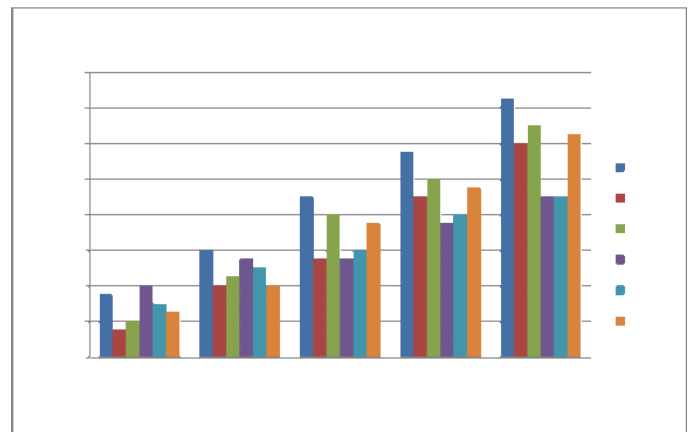


Fig 18 “showing the best self-curing agent along with optimum dosage for mix A”

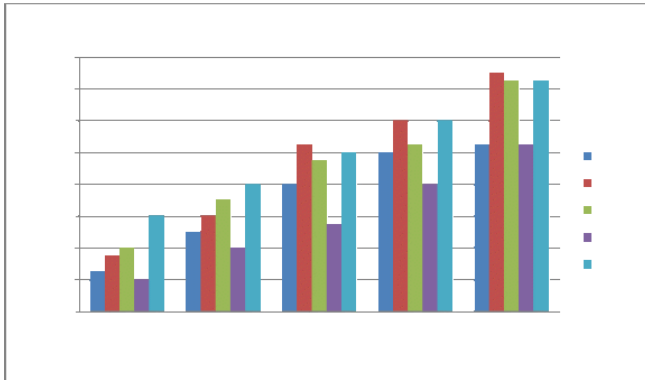


Figure 19 “Acid Attack Factor for cubes of mix B containing PEG4000”

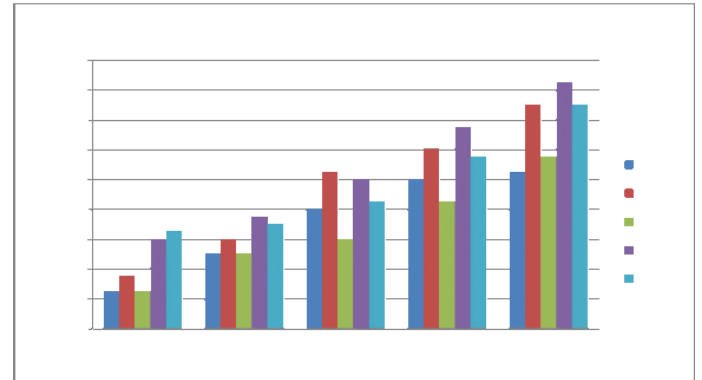


Figure 22 “Acid Attack Factor for cubes of mix B containing PWH”

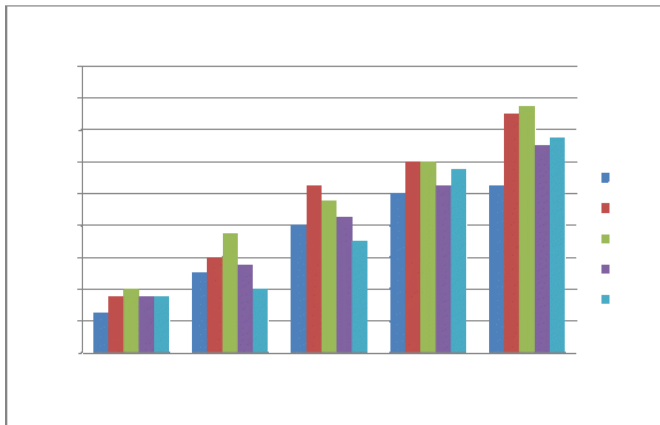


Figure 20 “Acid Attack Factor for cubes of mix B containing PEG200”

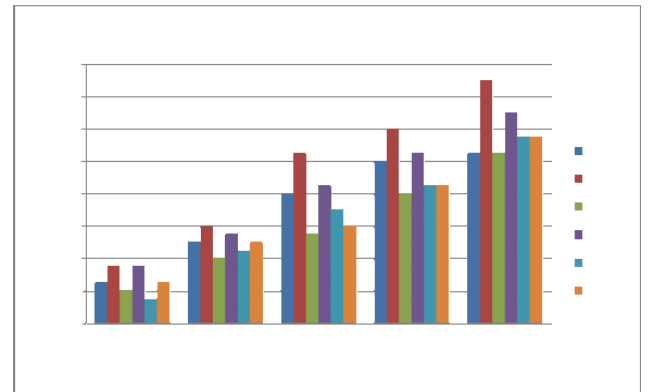


Fig 23 “showing the best self-curing agent along with optimum dosage for mix B”

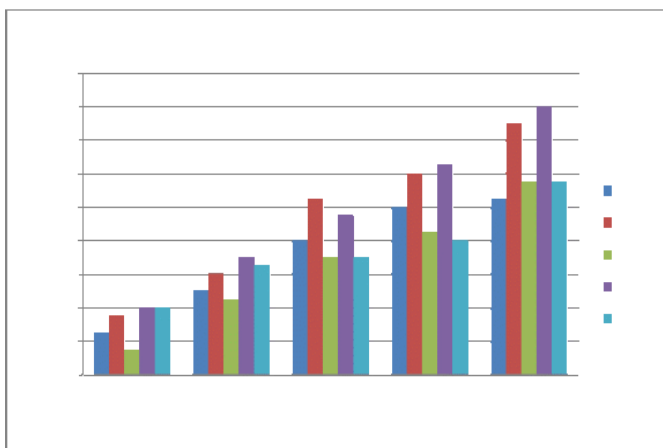


Figure 21 “Acid Attack Factor for cubes of mix B containing PWL”

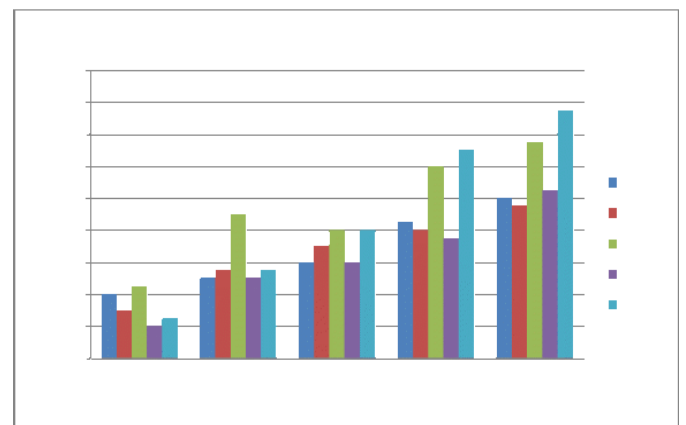


Fig 24 “Acid Attack Factor for cubes of mix C containing PEG4000”

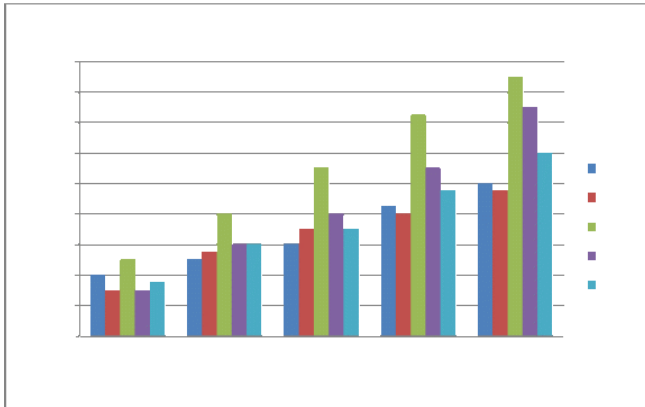


Fig 25 “Acid Attack Factor for cubes of mix C containing PEG200”

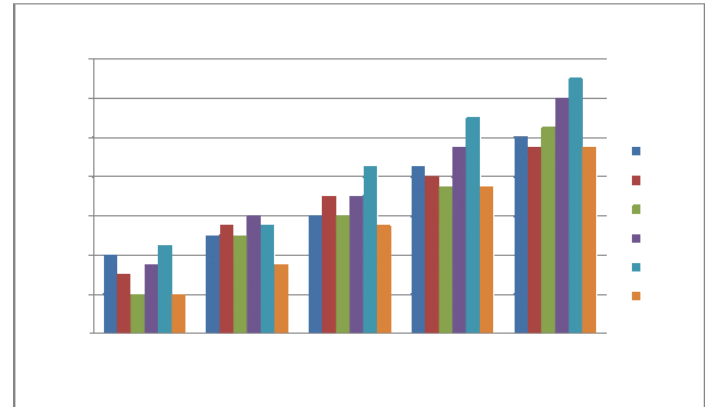


Fig 28 “showing the best self-curing agent along with optimum dosage for mix C”

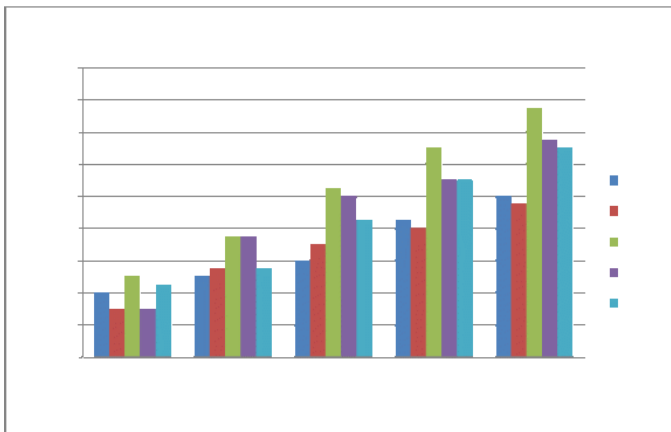


Figure 26 “Acid Attack Factor for cubes of mix C containing PWL”

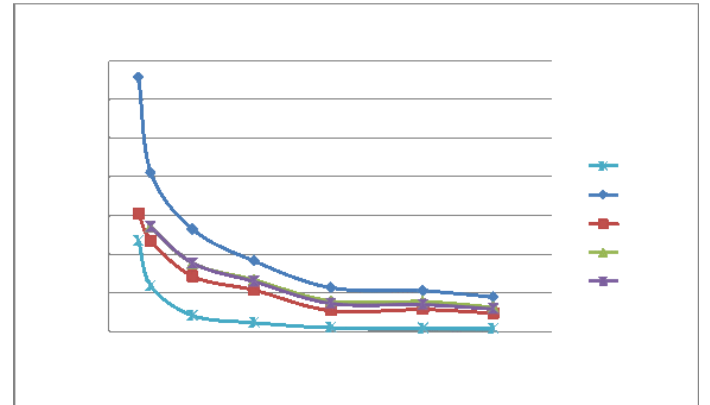


Figure 29 “Sorptivity Coefficient Vs time 0.5 for PEG 4000 of mix A”

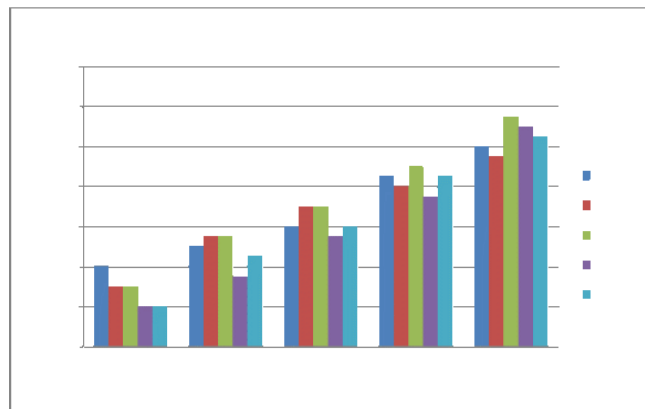


Figure 27 “Acid Attack Factor for cubes of mix C containing PWH”

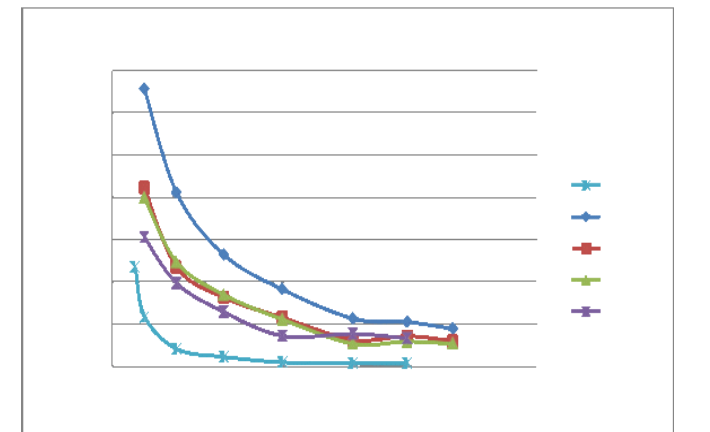


Figure 30 “Sorptivity Coefficient Vs time 0.5 for PEG 200 of mix A”

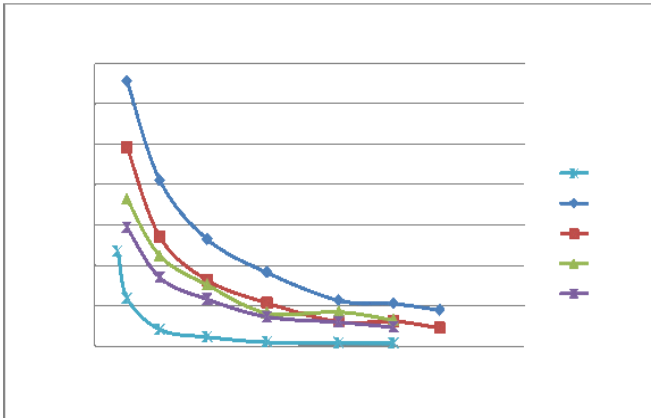


Figure 31 “Sorptivity Coefficient Vs time0.5 for LPWL of mix A”

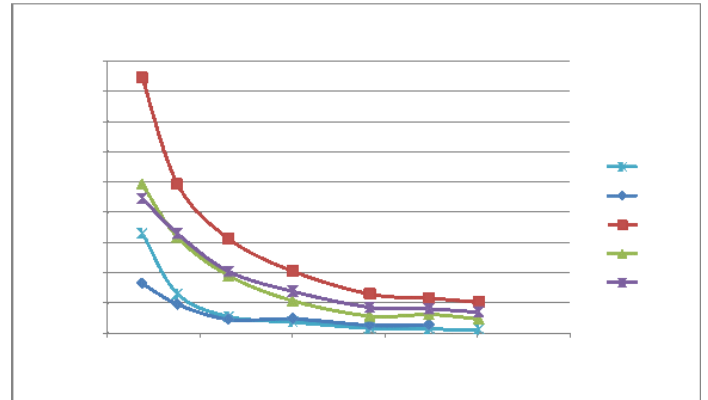


Figure 34 “Sorptivity Coefficient Vs time0.5 for PEG 4000 of mix B”

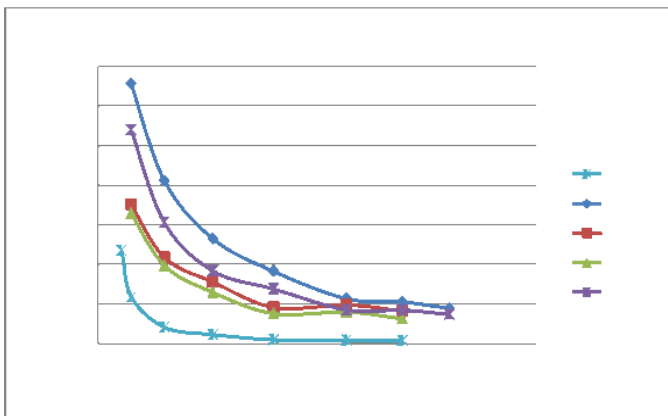


Figure 32 “Sorptivity Coefficient Vs time0.5 for LPWH of mix A”

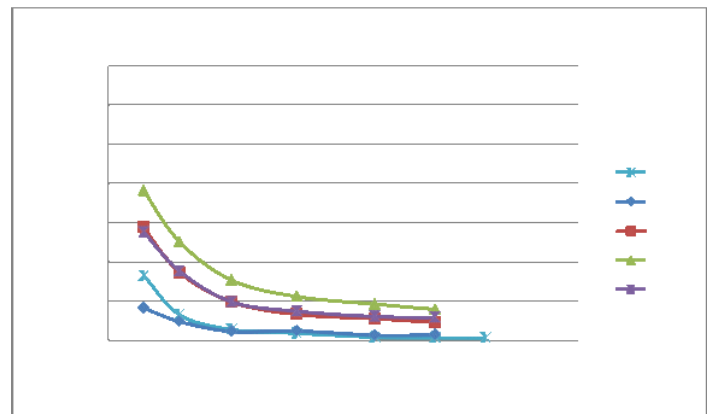


Figure 35 “Sorptivity Coefficient Vs time0.5 for PEG 200 of mix B”

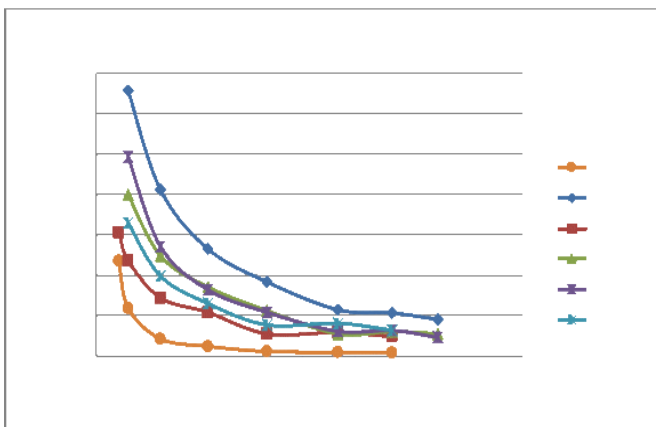


Figure 33 “showing the optimum dosage of self-curing compounds for mix A”

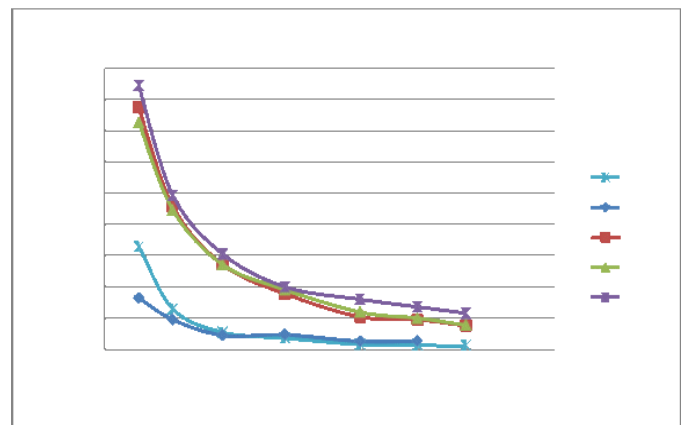


Figure 36 “Sorptivity Coefficient Vs time0.5 for LPWL of mix B”

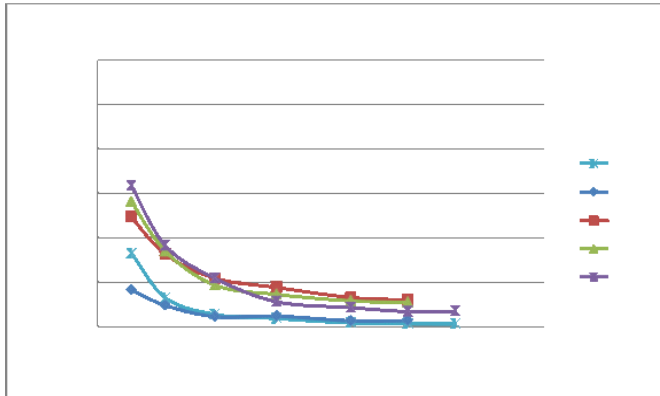


Figure 37 "Sorptivity Coefficient Vs time0.5 for LPWH of mix B"

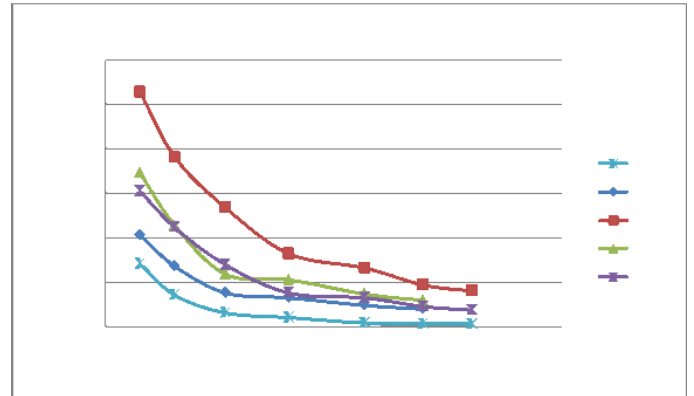


Figure 40 "Sorptivity Coefficient Vs time0.5 for PEG 200 of mix C"

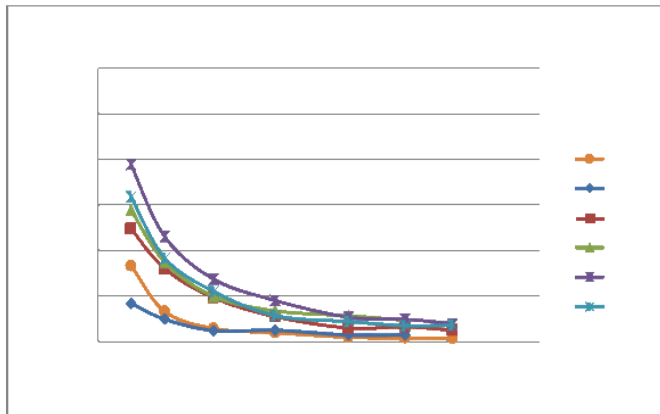


Figure 38 "showing the optimum dosage of self-curing compounds for mix B"

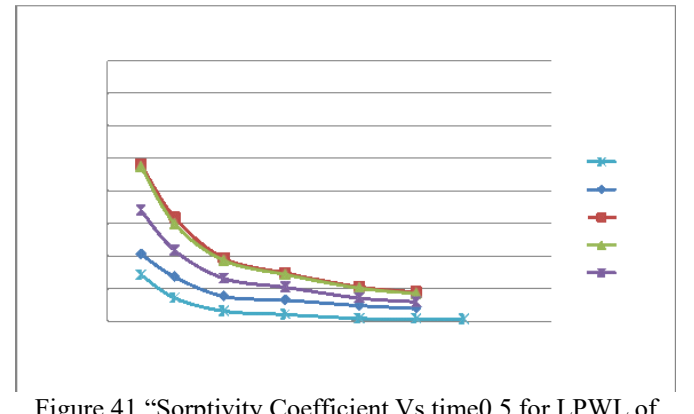


Figure 41 "Sorptivity Coefficient Vs time0.5 for LPWL of mix C"

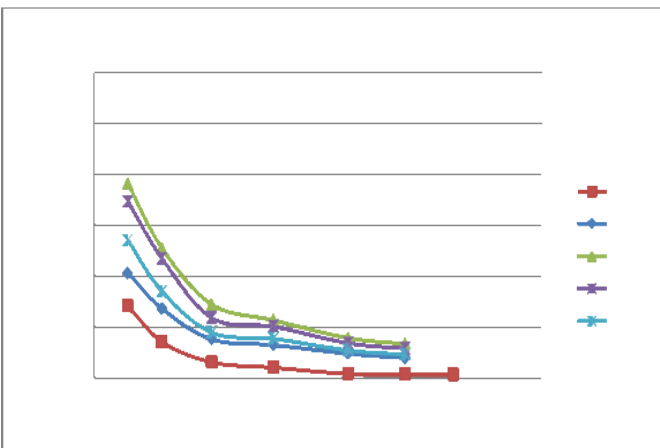


Figure 39 "Sorptivity Coefficient Vs time0.5 for PEG 4000 of mix C"

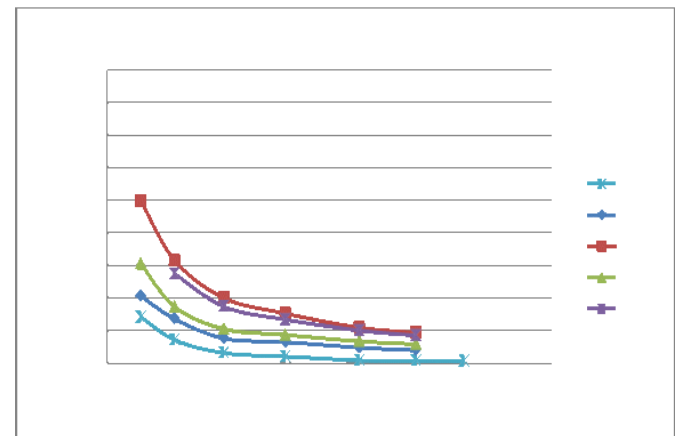


Figure 42 "Sorptivity Coefficient and time0.5 for LPWH of mix C"

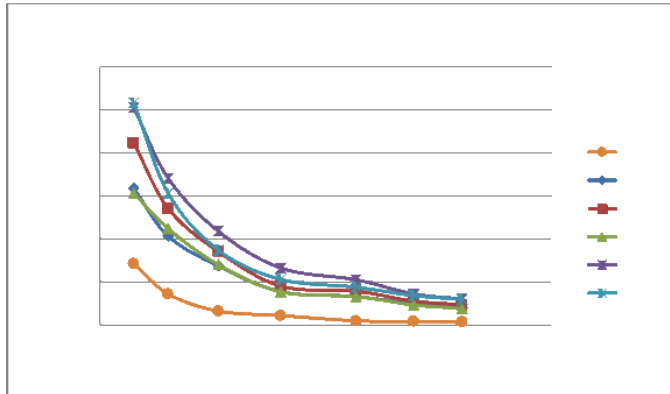


Figure 43 “showing the optimum dosage of self-curing compounds for mix C”

V. CONCLUSIONS

- Based on the experimental and analytical investigations the following conclusions have been drawn:
- There is a decrease in compressive strength of self-curing SCC with the increase in percentage of curing compounds for higher grade.
- Higher dosage of curing compound is required for lower grades of self-curing SCC.
- Resistance against acid attack decreased with increase in percentage dosage of self-curing compounds irrespective of grades.
- 0.5% is optimum dosage to get better resistance against acid attack for all curing compounds.
- Sorptivity decreased with decrease in dosage of PEG in both low and high molecular weights of PEG.
- Sorptivity is lowest in higher grades of concrete and it is true for every percentage replacement of all the curing compounds.
- This is true in case of general curing also.
- In case of higher grades of concrete even in case of water cured specimens sorptivity is lowest.
- 0.1% is optimum dosage for mix A considering all the factors viz. compressive strength acid attack and sorptivity.
- 0.1% of liquid paraffin wax is optimum for mix B.
- 0.5% of Liquid paraffin wax heavy is optimum for mix C.
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