"A STUDY ON THE EFFECT OF REDOSAGE OF PLASTICIZER ADMIXTURE ON THE COMPRESSIVE STRENGTH AND WORKABILITY OF CONCRETE"

A major Thesis

Submitted in Partial Fulfilment of

the Requirement for the Award of Degree of

MASTER OF ENGINEERING

In

STRUCTURAL ENGINEERING

By

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ACKNOWLEDGEMENT

With the sense of great pleasure and satisfaction I present this report entitled “A study on the effect of redosage of plasticizer admixture on the compressive strength and workability of concrete”

I am extremely thankful to **Dr. A. K. Gupta** for his invaluable support in the completion of this project. His ever encouraging attitude, guidance and whole hearted help was biggest motivation for me in making the project.

I express my sincere thanks to all my friends and staff of civil Engineering Department of Delhi College of Engineering who left no stone unturned whenever I needed their assistance.

Deepak Singhal

(Roll No-3503)

CANDIDATE'S DECLARATION AND CERTIFICATE

This is to declare that the major project entitled "A study on the effect of redosage of plasticizer admixture on the compressive strength and workability of concrete" is a bonafide record of work done by me,

Deepak Singhal for the partial fulfillment of the requirements for the degree in of Master in Civil Engineering (Structural Engineering) Delhi College of Engineering, Delhi.

This project has been carried out under the supervision of Dr. A.K.Gupta. I have not submitted the matter embodied in this dissertion for the award of any other degree.

Deepak Singhal

Enrollment No.04/Structure/03

University Roll no.3503

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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ABSTRACT

It is observed that the workability of concrete gets reduced till the time of placing of concrete. So,an attempt has been made to study the effect of redosage of plasticizer admixture on the compressive strength and workability of the design mix concrete.

For this four types of cements (43 grade) i.e. Shri Ultra, J.K, Birla and ACC and four types of plasticizer (1-rheobuild4604, 2-rheobuild 4600, 3-cemwet SP 3000, 4-fosroc conplast SP 430 SRV) are used.

In the present work, the HRWR is added to the mixing water as well as to the resulting concrete also at regular intervals to study its effects on workability and compressive strength.

1.1 **Introduction:**

From the stage of mixing, till it is transported, placed in the formwork and compacted, fresh concrete should satisfy a number of requirements:

i) The mix should be stable, in that it should not segregate during transportation and placing. The tendency of bleeding should be minimized.

ii) The mix should be cohesive and mobile enough to be placed in the form around the reinforcement and should be able to castable into the required shape.

iii) The mix should be amenable to proper and thorough compaction as possible in the situation of placing and with the facilities of compaction available.

iv) It should be possible to obtain a satisfactory surface finish.

The diverse requirement of mixability, stability, transportability, place ability, mobility, compatibility and finishability of fresh concrete are collectively referred to as workability. IS: 6461-1973 defines workability as that property of freshly mixed concrete or mortar which determines the ease and homogeneity with which it can be mixed, placed, compacted and finished. The optimum workability of fresh concrete varies from situation to situation.

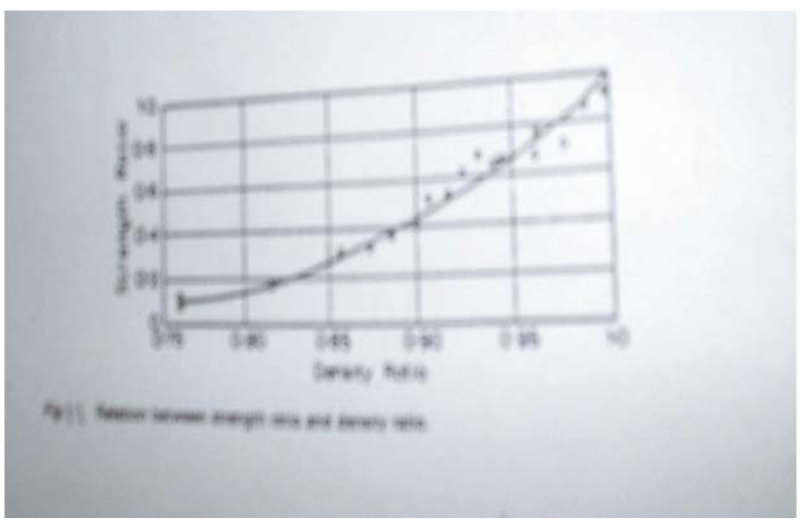
1.2 **Compressive strength:**

The compressive strength of hardened concrete is considered to be the most important property .It can be measured easily on standard sized cubes and is often taken as an index of the overall quality of concrete. Many other desirable properties of concrete, for example shear and tensile strength, modulus of elasticity, bond, impact, abrasion resistance and durability etc., are also taken to be related to the compressive strength, at least to a general extent.

1.3 **<u>The need for sufficient workability:</u>**

Workability is 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.

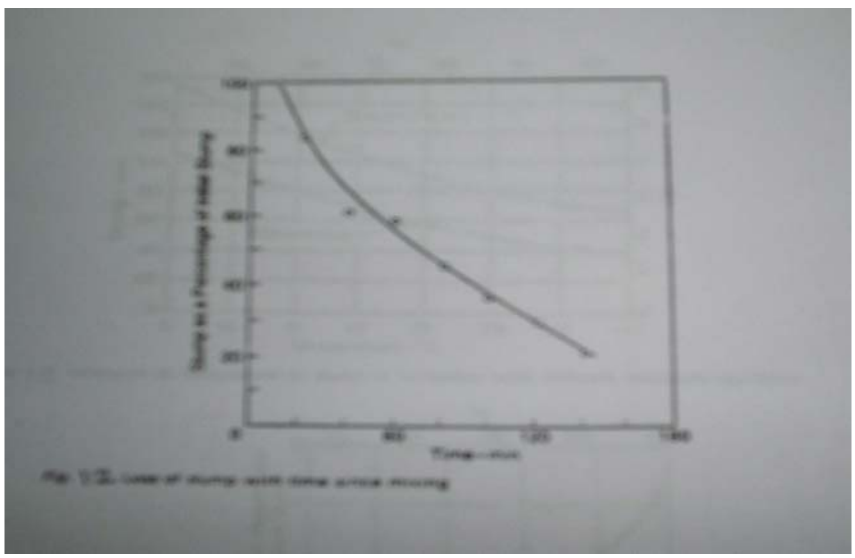
The need for compaction becomes apparent from a study of the relation between the degree of compaction and the resulting strength. It is convenient to express the former as a density ratio, i.e. a ratio of the actual density of the given concrete to the density of the same mix when fully compacted. Likewise, the ratio of the strength of the concrete actually (partially) compacted to the strength of the same mix when fully compacted can be called the strength ratio. The presence of voids in concrete greatly reduces its strength: 5% voids can lower strength by as much as 30%, as shown in figure 1.1.



1.4 **<u>Effect of time & temperature on workability:</u>**

Freshly mixed concrete stiffens with time. This should not be confused with setti -ng of cement. It is simply that some water from the mix is absorbed by the unsaturated aggregate, some is lost by evaporation.

The exact value of the loss in workability depends on several factors. First, the higher the initial workability, the greater the slump loss. Second, the rate of loss of slump is higher in rich mixes. Furthermore, the rate of loss depends on the properties of the cement: the rate is higher when the alkali content is high and when the sulfate content is too low. A typical loss of slump is shown in figure 1.2.



The change in workability with time depends also on the moisture condition of aggregate: the loss is greater with dry aggregate due to the absorption of water by aggregate.

The workability of a mix is also affected by the ambient temperature as shown in figure 1.3 and 1.4. It is apparent that on a hot day the water content of the mix would have to be increased for a constant early workability to be maintained. The loss of slump in stiff mixes is less influenced by temperature because such mixes are less affected by changes in water content.

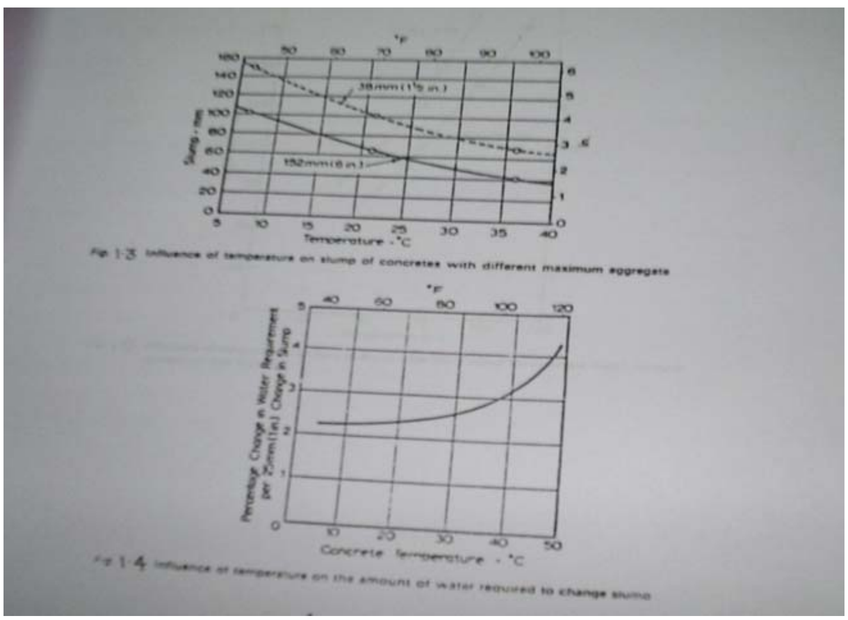


Fig 1.3 Influence of temperature on slump of concretes with different maximum aggregate

Fig 1.4 Influence of temperature on the amount of water required to change slump

Because workability decreases with time, it is important to measure slump after a predetermined time lapse since mixing. There is value in determining slump immediately after the discharge of the concrete from the mixture for the purpose of control of batching. There is also value in determining slump at the time of placing the concrete in the form work for the purpose of ensuring that the workability is appropriate for the means of compaction to be used.

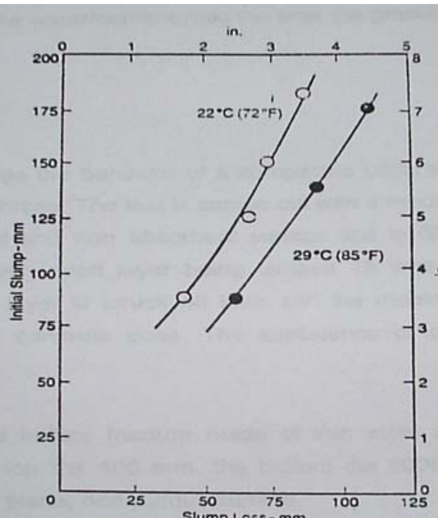


Fig. 1.5 Influence of temperature on loss of slump after 90 minutes for concrete with a cement content of 306 kg/m^3

1.5 **Water content:**

The main factor is the water content of the mix, expressed in kg /cubic meter of concrete. The water content is independent of the aggregate/cement ratio or of the cement content of the mix.

If the water content and the other mix proportions are fixed, workability is governed by the maximum size of aggregate, its grading, shape and texture. In particular, the higher the water/cement ratio the finer the grading required for the highest workability.

1.6 **Slump Test:**

The slump test indicates the behavior of a compacted concrete cone under the action of gravitational forces. The test is carried out with a mould; a slump cone is placed on a horizontal and non absorbent surface and is filled in three equal layers of fresh concrete, each layer being tamped 25 times with a standard tamping rod. The top layer is struck off level and the mould is lifted vertically without disturbing the concrete cone. The subsidence of concrete in mm is termed the slump.

The slump cone is a hollow frustum made of thin steel sheet with internal dimensions as: - the top dia 100 mm, the bottom dia 200mm and the height 300mm, it stands on a plane, non porous surface.

The tamping rod is 16 mm in dia and 0.6 m long. Slump test is suitable only for concrete of medium to high workabilities.

(I.e. slump 25 to 125 mm)

2.1 **Need for Chemical Admixture:**

Chemical admixtures are used to improve workability. They are capable to give high workability without segregation or bleeding. Concrete can be placed and compacted in congested reinforcement.

Admixtures, although not always cheap, do not necessarily represent additional expenditure because their use can result in concomitant savings, for example, in the cost of labour required to effect compaction, in the cement content which would otherwise be necessary, or in improving durability without the use of additional measures.

It should be stressed that, while properly used admixtures are beneficial to concrete, they are no remedy for poor quality mix ingredients, for use of incorrect mix proportions, or for poor workmanship in transporting, placing and compaction.

2.2 **Water Reducers:**

It is classified as low range, medium range and high range water reducers and depends on range of water content reducible. It is also called Plasticizers. When added to a concrete mix, plasticizers (water-reducing agents) are absorbed on the surface of the binder particles, causing them to repel each other and deflocculate. This results in improved workability and provides a more even distribution of the binder particles through the mix. It is covered in Type A Chemical Admixture of ASTM C 494. It lowers the water content and increases the strength. It can obtain higher slump using the same water content. It allows reducing cement content at same water-cement ratio. It aggravates slump loss problems and may improve pumpability. It tends to retard setting of concrete and sometimes has accelerators blended in to offset the retardation. The main types of plasticizers are lignosulphonic acids and their salts, hydroxylated carboxylic acids and their salts, and modifications of both. The typical dosage of a plasticizer varies from 200 **ml to 450 ml per 100 kg** of cementitious material. Plasticizers can reduce the water requirement of a concrete mix for a given workability, as a rule-of-thumb, **by about 10%**.

2.3 **<u>High Range Water Reducers (HRWR):-</u>**

These are called as special class of water reducers, i.e. and Superplasticizers. These admixtures are chemically distinct from normal plasticizers and although their action is basically the same, it is more marked. When these are used to produce flowing concrete, a rapid loss of workability can be expected and therefore they should be added just prior to placing. Superplasticizers are usually chemical compounds such as sulphonated melamine formaldehyde, sulphonated naphthalene formaldehydes, and modified lignosulphonates. It is covered in Types F (Water reducing High range) and G (Water reducing high range and retarding) Chemical Admixtures of ASTM C 494, and C 1017 Types 1 and 2. It reduces the water content of a given concrete from 12 to 25 %, which in turn increases strength and greatly increases the slump to produce "flowing" concrete. Adding a normal dosage to concrete having slump 75-100 mm will produce a concrete with a slump of about 200 mm, however within 30 to 60 minutes the concrete will return to its original slump.

Dosage:

The normal dosage of a superplasticizer is between 750 ml and 2500 ml per 100 kg of cementitious material.

2.4 **Testing of the superplasticizers:**

Several methods have been proposed for studying cement/superplasticizer interaction. An initial attempt consisted of extending the standards on water-reducing agents to the case of superplasticizers, only to ultimately realize that such an undertaking did not always meet with success. A number of standardization bodies decided to designate particular cement as a reference, whereas other bodies proposed using a mix of several cements. Both of these methods are acceptable for the purposes of testing a specific superplasticizer; they cannot however resolve the problems of a concrete manufacturer using cement other than the reference cement. Besides, a three-cement mix is of no practical interest herein. It thus becomes necessary to test a given superplasticizer directly with the desired cement.

2.5 **Superplasticizer–Cement Compatibility:**

It is important to establish a compatible superplasticizer- cement combination. When the two materials are well-matched, a large single dosage can lead to the retention of high workability for a sufficiently long period: 60 to 90 minute can be achieved.

While assessing compatibility, the required dosage of the superplasticizer should be established. The usual approach is to determine the percentage water reduction which will result in the same workability as an admixture free mix.

If the cement is finer, higher the dosage of a superplasticizer required to obtain a given workability. The chemical properties of cement, such as a high C_3A content (which reduces the effectiveness of a given dosage of the superplasticizer) and the nature of calcium sulfate used as a retarder, also affect the performance of superplasticizers. In searching for a suitable combination of cement and superplasticizers, it is sometimes easier to vary the superplasticizer.

2.6 **Compatibility:**

Until the present time, both compatible and incompatible expressions had always been used for describing the interaction between cements and superplasticizers. A cement/superplasticizer combination is said to be incompatible when a superplasticized0 concrete loses its initial slump very quickly. Some concretes lose their initial slump in less than 15 minutes, while others retain a slump of greater than 200 mm for 60 or even 90 minutes, without the presence of either bleeding or segregation and without any loss in strength at an age of 24 hours.

3.1) <u>Strength of Concrete:</u>

The compressive strength of concrete is defined as the load which causes the failure of specimen, per unit area of cross-section in uniaxial compression under given rate of loading. The compressive strength at 28 days after casting is taken as a criterion for specifying the quality of concrete. This is termed as Grade of concrete. IS: 456-2000 stipulates the use of 150 mm cube specimens.

3.2) **Water-Cement Ratio:**

The compressive strength of concrete at a given age and cured under prescribed conditions is assumed to depend primarily on two factors namely, W/C ratio and degree of compaction. The strength is affected by the air voids in the concrete. For a fully compacted concrete, its strength is taken to be inversely proportional to the W/C ratio which is defined as the ratio of mass of water added to the mass of cement in the mix.

If the aggregate/cement ratio is reduced, but the water/cement ratio is kept constant, the water content increases, and consequently the workability also increases.

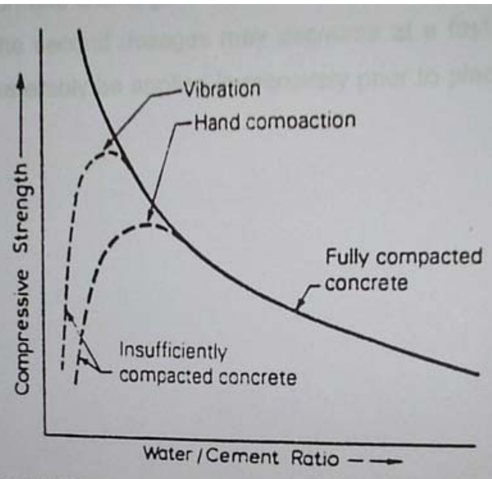


Fig 1·6 The relation between strength and water/cement ratio of concrete

3.3 **<u>Saturated Surface Dry Aggregate:</u>**

The pores may become reservoirs of free moistures inside the aggregate. The percentage of water absorbed by an aggregate when immersed in water is termed *Absorption of aggregate.* The aggregate which is saturated with water but contains no surface free moisture is termed the *saturated surface dry aggregate.*

3.4 **<u>Redosages of HRWR:</u>**

The effectiveness of superplasticizers is limited in duration, it may be advantageous to add the superplasticizers to the mix in two, or even more operations. If the workability is to be restored by the redosages some time after the original mixing, the amount of superplasticizer has to be adequate to act both on the cement particles and on the products of hydration. Therefore a high redosages of superplasticizer is necessary, a small redosage is ineffective (***D .Ravina and A .Mor, effects of superplasticizers, Concrete international)*** whereas repeated addition of the superplasticizers to the mix is beneficial from the stand point of workability, it may increase bleeding and segregation. Other side effects are set retardation and a change in the amount of entrained air, also the workability restored by the second dosages may decrease at a fast rate so that the redosages should preferably be applied immediately prior to placing and compaction of concrete.

Mixing of concrete

Mixing of Superplasticizer

Slump without superplasticizer

Slump with superplasticizer

Compaction of concrete

Casting of cubes

Curing of cubes

Measuring compressive strength

Cubes after measuring compressive strength

.

4.2 **Properties for material used:**

4.2.1 **Cement:**

Name of cements used in research work with their specific gravities are as follows:

Name of Cement	Specific Gravity
43 grade grasim cement	3.03
43 grade ACC cement	3.07
43 grade shri ultra cement	*3.15*
43 grade JK cement	3.33

4.2.2 **Admixture**:

Name of water reducing agents used in research work with their recommended dosage and redosage used in work are as follows:

Name of WRA	Recommended Dosage	Dosage And Redosage Used
CEMWET SP 3000	0.3 %-2.0%	10 ml/ kg cement for M20 concrete 15 ml/ kg cement for M25 concrete 20 ml/ kg cement for M30 and M35 5ml/kg cement Redosage (two steps)
Rheobuild(4600)	0.3 %-2.5%	same
Rheobuild(4604)	0.3 %-2.5%	same
Fosroc	0.8 % -1.6%	same

4.2.2.1 **CEMWET SP3000:**

A product of **ASIAN LABORATORIES (INDIA)**

Description:

It is high molecular weight condensates of **Naphthalene Formaldehyde Polymer.** It satisfied the requirements of IS 9103-99 and ASTM C-494, Type F&G.

The basic components of SEMWET SP3000 are synthetic polymers, which allow mixing of to be reduced considerably and concrete to be enhanced significantly, particularly at early ages. SEMWET SP3000 is a chloride free product.

Primary Uses:

- Production of plastic self-compacting concrete.
- Precast concrete, ready mixed concrete.
- Low water –cement ratio.
- In complicating formwork where reinforcement is congested.

Advantages:

CEMWET SP3000 makes the concrete highly flow able with a low water –cement ratio. It has excellent slump retention capability on standing and passes the requirements of IS 9103-99.

- The concrete treated with CEMWET SP3000 show higher strength.

- The increase in strength evidently at early stages remains at later stages.
- Due to reduction in water-cement ratio all other properties such as permeability, shrinkage, creep, workability, and modulus of elasticity are improved.

Typical Properties:

Color	Brown free flowing Liquid
Relative density	1.22
Chloride content	Nil to BS 5075 to IS: 456-2000
Nitrate content	Nil
Freezing point	0^0c, can be reconstituted if stirred after Thawing.
Air entraining	Maximum 1.5%

Dosage:

CEMWET SP3000 is normally dispensed at a rate of 0.3% to 2% per 100 kg of cement. Other dosage may be used, depended upon the materials and conditions. Trial Mixes are recommended prior to production of concrete outside these normal ranges.

4.2.2.2 **<u>Rheobuild 4604:</u>**

A product of **master builder Inc.**

Description:

Rheobuild 4604 is formulated from synthetic polymers specially designed to impart rheoplastic qualities to concrete.

The basic components of Rheobuild 4604 are synthetic polymers, which allow mixing of to be reduced considerably and concrete to be enhanced significantly, particularly at early ages. Rheobuild 4604 is a chloride free product.

Primary Uses:

- Micro silica concrete.
- Mass concrete pours.
- Ready mixed concrete.
- Long distance transport.
- Pumped concrete.

Advantages:

Rheobuild 4604 makes the concrete highly flow able with a low water –cement ratio. It has excellent slump retention capability on standing and passes the requirements of IS 9103-99.

- The concrete treated with Rheobuild 4604 show higher strength.

- The increase in strength evidently at early stages remains at later stages.
- Due to reduction in water-cement ratio all other properties such as permeability, shrinkage, creep, workability, and modulus of elasticity are improved.

Typical Properties:

Color	Brown free flowing Liquid
Specific gravity	1.23±0.01 at 25ºc
Nitrate content	Nil
Freezing point	0^0c, can be reconstituted if stirred after Thawing.
PH	6±1

Dosage:

Rheobuild 4604 is normally dispensed at a rate of 300 ml to 2000 ml per 100 kg of cement. Other dosage may be used, depended upon the materials and conditions. Trial Mixes are recommended prior to production of concrete outside these normal ranges.

4.2.2.3 **<u>Rheobuild 4600:</u>**

A product of **master builder Inc.**

<u>Description:</u>

Rheobuild 4600 is formulated from synthetic polymers specially designed to impart rheoplastic qualities to concrete.

The basic components of Rheobuild 4600 are synthetic polymers, which allow mixing of to be reduced considerably and concrete to be enhanced significantly, particularly at early ages. Rheobuild 4600 is a compatible with all Portland cements that meet recognized standards.

<u>Primary Uses:</u>

The excellent dispersion properties of Rheobuild 4600 make it the ideal admixture for precast and ready mixed concrete where low water cement ratios are required.

- Micro silica concrete.
- Mass concrete pours.
- Ready mixed concrete.
- Long distance transport.
- Pumped concrete.
- High workability without segregation and bleeding.

Advantages:

Rheobuild 4600 makes the concrete highly flow able with a low water –cement ratio. It has excellent slump retention capability on standing and passes the requirements of IS 9103-99.

- The increase in strength evidently at early stages remains at later stages.
- Due to reduction in water-cement ratio all other properties such as permeability, shrinkage, creep, workability, and modulus of elasticity are improved.

Typical Properties:

Color	Brown free flowing Liquid
Specific gravity	1.17±0.01 at 25ºc
Nitrate content	Nil
Freezing point	0^0c, can be reconstituted if stirred after Thawing.
PH	6 to 8

Dosage:

In normal concrete a dosage of between 0.8% and 2%. Other dosage may be used, depended upon the materials and conditions. Trial Mixes are recommended prior to production of concrete outside these normal ranges.

4.2.2.4 **Fosroc Conplast SP 430 SRV:**

A product of fosroc chemicals (India) Pvt.Ltd.

Description:

Fosroc is a dark brown liquid based on a blend of specially selected organic polymers. The plasticizing action of fosroc enables the production of high workability concrete, which maintains the workability for prolonged periods.

Primary Uses:

The excellent dispersion properties of Fosroc make it the ideal admixture for precast and ready mixed concrete where low water cement ratios are required.

- Micro silica concrete.
- Mass concrete pours.
- Ready mixed concrete.
- Long distance transport.
- Pumped concrete.
- High workability without segregation and bleeding.

Advantages:

Fosroc makes the concrete highly flow able with a low water –cement ratio. It has excellent slump retention capability on standing and passes the requirements of IS 9103-99.

- The increase in strength evidently at early stages remains at later stages.
- Due to reduction in water-cement ratio all other properties such as permeability, shrinkage, creep, workability, and modulus of elasticity are improved.

Typical Properties:

Color	Brown free flowing Liquid
Specific gravity	1.26 at 30^{o}c
Nitrate content	Nil
Freezing point	0^{0}c, can be reconstituted if stirred after Thawing.
Air entraint	less than 1.5%

Dosage:

In normal concrete a dosage of 3.5 ml to 10 ml per kg cement. Other dosage may be used, depended upon the materials and conditions. Trial Mixes are recommended prior to production of concrete outside these normal ranges.

4.2.3 **Water:**

Potable tap water was used for the mixing and curing of concrete.

4.2.4 **Fine Aggregate:**

Locally available badarpur sand was used as fine aggregate in mix Fine aggregate confirms to grading zone II of IS: 383-1963.Specific gravity of badarpur sand is 2.46

4.2.5) **Coarse Aggregate:**

Locally available crushed stone aggregate of 20 mm nominal size was used. Specific gravity of coarse aggregate is 2.60

4.2.6) **Size of Cubes:**

10 cm cubes were used for the research work. For each mix 3 cubes had been cast and their mean strength was taken for the comparisons.

4.3 **Mix Design as per Indian Standard**:

4.3.1**:**

Sl. No.	**Concrete Mix Design (Grade M20)**	
a)	**Design Stipulations**	
	1. Characteristic compressive strength required in the field at 28 days	20 N/ mm^2
	2. Maximum size of aggregate	20 mm (angular)
	3. Degree of workability	0.95 C.F
	4. Degree of quality control, and	Good
	5. Type of Exposure	Mild

b)	**Test Data or Materials**	
	1.Cement used-ordinary Portland cement satisfying the requirements of IS : 269-1976 [17]	
	1. Specific gravity of cement (**43 grade**)	3.10
	2. I) Specific gravity of coarse aggregate	2.60
	II) Specific gravity of fine aggregate	2.46
	4. Water absorption	
	I) Coarse aggregate	0.8%
	II) Fine aggregate	1.68%
	5. Free (surface moisture)	
	I) Coarse aggregate	0.4%
	II) Fine aggregate	0.8%
	6. Sieve analysis	
	I) Fine aggregate	Confirming to grading zone II of table 4 of IS: 383-1970.

c) **Target Mean Strength of Concrete:**

$f_t = f_{ck} + ks$

$f_t = 20 + 1.65 * 4$

$=26.6\ N/mm^2$

Where $f_t =$ target mean compressive strength at 28 days

$f_{ck} =$ 20, characteristic compressive strength at 28 days

S = 4, Standard deviations (from table 8 of IS456-2000)

K = 1.65 (Tolerance factor)

d) **Selection of Water-Cement Ratio:**

From figure 47 of SP: 23-1982, the water-cement ratio required for the target mean strength of 26.6 N/mm2 is 0.465. This is lower than the maximum value of 0.65 prescribed for 'Mild' exposure (from table 23 of SP: 23-1982)

e) **Selection of water and Sand Content:**

From table 42, for 20 mm nominal max size aggregate and sand confirming to grading zone II, water content/m^3 of concrete is equal to 186 kg and sand content as percentage of total aggregate by absolute volume is equal to 35 percent. For change in values in water-cement ratio, compacting factor, the following adjustment is required:

change in Condition (from table 44 of SP:23)	Adjustment Required in	
	Water Content %	**% Sand in Total Aggregate**
For Decrease in Water-Cement Ratio by (0.60 – 0.465 i.e. 0.135)	0	-2.7
For Increase in Compacting Factor (0.95-0.8) that is, 0.15	+4.5	0
Total	+4.5	-2.7

Therefore required sand contents as % of total aggregate by absolute volume = 35-2.7= 32.3%

Required water content = 186 + 8.37= 194.37 litre/m^3

f) **Determination of Cement Content:**

Water-cement ratio = 0.465

Water = 194.37 litre

Cement = 194.37/ 0.465 =418 kg/ m^3

This cement content is adequate for 'Mild' exposure condition (Table 23)

g) **Determination of Coarse and Fine Aggregate Content:**

From table 41, for the specified maximum size of Aggregate of 20 mm, the amount of entrapped air in the wet concrete is 2%. Taking this into account and applying equation,

$V= (W+ C/S_C + 1/P^* F_A/S_{fa}) * 1/1000$ &

V= (W+ C/SC + 1/1-P* CA/Sca) * 1/1000, where,

V=absolute volume of fresh concrete

=Gross volume (1 m^3) minus the volume of entrapped air,

Sc=specific gravity of cement,

W= mass of water (kg) per m^3 of concrete,

C=mass of cement (kg) per m^3 of concrete,

p=ratio of fine aggregate to total aggregate by absolute volume,

fa, Ca = total masses of fine aggregate and coarse aggregate, (kg) per m^3 of concrete respectively, and

Sfa, sca= specific gravities of saturated surface dry fine aggregate and coarse aggregate respectively.

0.98 m^3= (194.37 +418/3.10 +1/0.323* fa /2.46)*1/1000, and

0.98 m^3= (194.37 +418/3.10 +1/0.677* C_A /2.60)*1/1000, and

fa =517 kg/ m^3

C_a = 1145 kg/ m^3

The mix proportion then becomes:

Water	Cement	Fine aggregate	Coarse Aggregate
194.37	418	517	1145
0.465	1	1.24	2.74

h) **<u>Actual Quantities Required for the Mix per Bag of Cement:</u>**

The mix is, 0.465:1:1.24:2.74(by mass). For 50 kg of cement the quantity of material are worked out as below:

1) Cement = 50 kg
2) Sand =62 kg
3) Coarse aggregate = 137kg
4) Water:
   I) For water cement ration of 0.465, water = 23.25 litres
   II) Extra water to be added for absorption in case of coarse aggregate at (0.8% -0.4%) by mass = 0.55 litres
   Iii) Extra water to be added for absorption in sand at (1.68%- 0.8%) by mass = +.55litres
   iv) Actual water to be added = 23.25 +0.55 +0.55 = 24.35 litres

5) Actual quantity of sand required after allowing for mass of pre moisture =62-0.55=61.45 kg.

6) Actual Quantity of Coarse Aggregate Required = 137 – 0.55= 136.45 kg

Therefore, the actual quantities of different constituents required for the mix are:

Water = 24.35 litres

Cement = 50 kg

Sand =61.45 kg

Coarse Aggregate = 136.45 kg

4.3.2:

Sl. No.	**Concrete Mix Design (Grade M25)**	
a)	Design Stipulations 1)Characteristic compressive strength required in the field at 28 days 2)Maximum size of aggregate 3)Degree of workability 4)Degree of quality control, and 5)Type of Exposure	 $25\ N/mm^2$ 20 mm (angular) 0.90 C.F Good Mild
b)	**Test Data or Materials** 1)Cement used-ordinary Portland cement satisfying the requirements of IS : 269-1976 [17] 2)Specific gravity of cement (**43grade**) 3) Specific gravity of coarse aggregate II) Specific gravity of fine aggregate 4. Water absorption I) Coarse aggregate II) Fine aggregate	 3.10 2.60 2.46 0.8% 1.68%

	5. Free (surface moisture) I) Coarse aggregate II) Fine aggregate 6. Sieve analysis I) Fine aggregate	 0.4% 0.8% Confirming to grading zone II of table 4 of IS: 383-1970.

c) **Target Mean Strength of Concrete:**

$f_t = f_{ck} + ks$

$f_t = 25 + 1.65 * 4$

$= 31.6\ N/mm^2$

Where $f_t =$ target mean compressive strength at 28 days

$f_{ck} =$ 25, characteristic compressive strength at 28 days

S = 4, Standard deviations (from table 8 of IS456-2000)

K = 1.65 (Tolerance factor)

d) **Selection of Water-Cement Ratio:**

From figure 47 of SP: 23-1982, the water-cement ratio required for the target mean strength of 31.60 N/mm^2 is 0.425. This is lower than the maximum value of 0.65 prescribed for 'Mild' exposure (from table 23 of SP: 23-1982)

e) **Selection of Water and Sand Content:**

From table 42, for 20 mm nominal max size aggregate and sand confirming to grading zone II, water content/m^3 of concrete is equal to 186 kg and sand content as percentage of total aggregate by absolute volume is equal to 35 percent. For change in values in water-cement ratio, compacting factor, the following adjustment is required:

Change in Condition (from table 44 of SP:23)	**Adjustment Required in**	
	Water content %	**% Sand in Total Aggregate**
For Decrease in Water-Cement Ratio by (0.60 – 0.425)i.e. 0.175	0	-3.5
For Increase in Compacting Factor (0.9-0.8) that is, 0.10	+3.0	0
Total	+3.0	-3.5

Therefore required sand contents as % of total aggregate by absolute volume = 35-3.5= 31.5%

Required water content = 186 + 5.58 = 191.58 litre/m^3

f) **Determination of Cement Content:**

Water-cement ratio = 0.425

Water = 191.58 litres

Cement = 191.58/ 0.425 = 450.77 kg/ m^3

Limit to 450 kg/ m^3

g) **Determination of Coarse and Fine Aggregate Content:**

From table 41, for the specified maximum size of Aggregate of 20 mm, the amount of entrapped air in the wet concrete is 2%. Taking this into account and applying equation,

$V= (W+ C/S_C + 1/P^* f_a/S_{fa}) * 1/1000$ &

$V= (W+ C/S_C + 1/1-P^* c_a/S_{ca}) * 1/1000$, where,

V=absolute volume of fresh concrete

=Gross volume (1 m^3) minus the volume of entrapped air,

Sc=specific gravity of cement,

W= mass of water (kg) per m^3 of concrete,

C=mass of cement (kg) per m^3 of concrete,

p=ratio of fine aggregate to total aggregate by absolute volume,

f_a, c_a = total masses of fine aggregate and coarse aggregate, (kg) per m^3 of concrete respectively, and

S_{fa}, s_{ca}= specific gravities of saturated surface dry fine aggregate and coarse aggregate respectively.

$0.98\ m^3= (191.58 + 450/3.10 +1/0.315^* fa /2.46)*1/1000$, and

$0.98\ m^3= (191.58 + 450/3.10 +1/0.685^* C_a /2.60)*1/1000$, and

f_a = 498 kg/ m^3

$c_a = 1145$ kg/ m^3

The mix proportion then becomes:

Water	Cement	Fine Aggregate	Coarse Aggregate
191.58	450	498	1145
0.425	1	1.11	2.54

h) **Actual Quantities Required for the Mix per Bag of Cement:**

The mix is, 0.425:1:1.11:2.54(by mass). For 50 kg of cement the quantity of material are worked out as below:

1) Cement = 50 kg
2) Sand = 55.5 kg
3) Coarse aggregate = 127 kg
4) Water:

III) For water cement ration of 0.425 water = 21.25 litres

IV) Extra water to be added for absorption in case of coarse aggregate at (0.8% -0.4%) by mass = 0.51 litres.

V) Extra water to be added for absorption in sand at (1.68%- 0.8%) by mass = 0.49 litres.

Actual water to be added = 21.25 +0.51 +0.49 = 22.25lires.

5) Actual quantity of sand required after allowing for mass of pre moisture = 55.5-0.49=55 kg.

6) Actual Quantity of Coarse Aggregate Required = 127– 0.51= 126.49 kg

Therefore, the actual quantities of different constituents required for the mix are:

Water = 22.25 litres

Cement = 50 kg

Sand = 55 kg

Coarse Aggregate = 126.49kg

4.3.3

Sl. No.	Concrete Mix Design (Grade M30)	
a)	Design Stipulations 1)Characteristic compressive strength required in the field at 28 days 2)Maximum size of aggregate 3)Degree of workability 4)Degree of quality control, and 5)Type of Exposure	 30 N/ mm^2 20 mm (angular) 0.90 C.F Good Mild
b)	**Test Data or Materials** 1)Cement used-ordinary Portland cement satisfying the requirements of IS : 269-1976 [17] 2)Specific gravity of cement (**43grade**) 3) I) Specific gravity of coarse aggregate II) Specific gravity of fine aggregate 4. Water absorption I) Coarse aggregate II) Fine aggregate 5. Free (surface moisture) I) Coarse aggregate II) Fine aggregate	 3.10 2.60 2.46 0.8% 1.68% 0.4% 0.8%

	6. Sieve analysis I) Fine aggregate	Confirming to grading zone II of table 4 of IS: 383-1970.

c) **Target Mean Strength of Concrete:**

$f_t = f_{ck} + ks$

$f_t = 30 + 1.65 * 5 = 38.25$ N/mm^2

Where f_t = target mean compressive strength at 28 days

f_{ck} = 30, characteristic compressive strength at 28 days

S = 5, Standard deviations (from table 8 of IS456-2000)

K = 1.65 (Tolerance factor)

d) **Selection of Water-Cement Ratio:**

From figure 47 of SP: 23-1982, the water-cement ratio required for the target mean strength of 38.25 N/mm^2 is 0.37. This is lower than the maximum value of 0.65 prescribed for 'Mild' exposure (from table 23 of SP: 23-1982)

e) **Selection of Water and Sand Content:**

From table 42, for 20 mm nominal max size aggregate and sand confirming to grading zone II, water content/m^3 of concrete is equal to 186 kg and sand content as percentage of total aggregate by absolute volume is equal to 35 percent. For change in values in water-cement ratio, compacting factor, the following adjustment is required:

Change in Condition (from table 44 of SP:23)	**Adjustment Required in**	
	Water content %	**% Sand in Total Aggregate**
For Decrease in Water-Cement Ratio by (0.60 – 0.37 i.e. 0.23)	0	-4.6
For Increase in Compacting Factor (0.85-0.8) that is, 0.05	+3.0	0
Total	+ 3.0	-4.6

Therefore required sand contents as % of total aggregate by absolute volume = 35-4.6= 30.4%

Required water content = 186 + 5.58 = 191.58 litre/m^3

f) **Determination of Cement Content:**

Water-cement ratio = 0.37

Water = 191.58 litres

Cement = 191.58/ 0.37 = 517.78 kg/ m^3

Limit to 450 kg/ m^3

Water=450*0.37=166.5 litre

g) **Determination of Coarse and Fine Aggregate Content:**

From table 41, for the specified maximum size of Aggregate of 20mm, the amount of entrapped air in the wet concrete is 2%. Taking this into account and applying equation,

V= (W+ C/S_C + 1/P* f_a/S_{fa}) * 1/1000 &

V= (W+ C/S_C + 1/1-P* C_a/S_{ca}) * 1/1000, where,

V=absolute volume of fresh concrete

=Gross volume (1 m^3) minus the volume of entrapped air,

Sc=specific gravity of cement,

W= mass of water (kg) per m^3 of concrete,

C=mass of cement (kg) per m^3 of concrete,

p=ratio of fine aggregate to total aggregate by absolute volume,

f_a, C_a = total masses of fine aggregate and coarse aggregate, (kg) per m^3 of concrete respectively, and

S_{fa}, s_{ca}= specific gravities of saturated surface dry fine aggregate and coarse aggregate respectively.

0.98 m^3= (166.5+450/3.10 +1/0.304* fa /2.46)*1/1000, and

0.98 m^3= (166.5+450/3.10 +1/0.696* C_a /2.60)*1/1000, and

fa = 499.8 kg/ m^3

C_a= 1209 kg/ m^3

The mix proportion then becomes:

Water	Cement	Fine Aggregate	Coarse Aggregate
166.5	450	499.81	1209
0.37	1	1.11	2.68

h) **Actual Quantities Required for the Mix per Bag of Cement:**

The mix is, 0.37:1:1.11:2.68(by mass). For 50 kg of cement the quantity of material are worked out as below:

1) Cement = 50 kg
2) Sand =55.5 kg
3) Coarse aggregate = 134 kg

4) Water:

VI) For water cement ration of 0.37water = 18.5 litres.

VII) Extra water to be added for absorption in case of coarse aggregate at (0.8% -0.4%) by mass = 0.54 litres.

VIII) Extra water to be added for absorption in sand at (1.68%-0.8%) by mass =0.49 litres.

IX) Actual water to be added = 18.5 +0.54 +0.49=19.53 litres.

5) Actual quantity of sand required after allowing for mass of pre moisture = 55.5 -0.49 = 55 kg.

6) Actual Quantity of Coarse Aggregate Required = 134 – 0.54= 133.46 kg

Therefore, the actual quantities of different constituents required for the mix are:

Water = 19.53 litres

Cement = 50 kg

Sand = 55 kg

Coarse Aggregate = 133.46 kg

4.3.4:

Sl. No.	Concrete Mix Design (Grade M35)	
a)	Design Stipulations 1)Characteristic compressive strength required in the field at 28 days 2)Maximum size of aggregate 3)Degree of workability 4)Degree of quality control, and 5)Type of Exposure	 35 N/ mm^2 20 mm (angular) 0.90 C.F Good Mild
b)	**Test Data or Materials** 1)Cement used-ordinary Portland cement satisfying the requirements of IS : 269-1976 [17] 2)Specific gravity of cement (**43 grade**) 3) Specific gravity of coarse aggregate II) Specific gravity of fine aggregate 4. Water absorption I) Coarse aggregate II) Fine aggregate 5. Free (surface moisture) I) Coarse aggregate II) Fine aggregate	 3.10 2.60 2.46 0.8% 2.0% 0.4% 0.8%

	6. Sieve analysis I) Fine aggregate	Confirming to grading zone II of table 4 of IS: 383-1970.

c) **Target Mean Strength of Concrete:**

$f_t = f_{ck} + ks$

$f_t = 35 + 1.65 * 5$

$= 43.25\ N/mm^2$

Where $f_t =$ target mean compressive strength at 28 days

$f_{ck} =$ 35, characteristic compressive strength at 28 days

S = 5, Standard deviations (from table 8 of IS456-2000)

K = 1.65 (Tolerance factor)

d) **Selection of Water-Cement Ratio:**

From figure 47 of SP: 23-1982, the water-cement ratio required for the target mean strength of 43.25 N/mm^2 is 0.34 This is lower than the maximum value of 0.65 prescribed for 'Mild' exposure (from table 23 of SP: 23-1982)

e) **Selection of Water and Sand Content:**

From table 42, for 20 mm nominal max size aggregate and sand confirming to grading zone II, water content/m^3 of concrete is equal to 186 kg and sand content as percentage of total aggregate by absolute volume is equal to 35 percent. For change in values in water-cement ratio, compacting factor, the following adjustment is required:

Change in Condition (from table 44 of SP:23)	Adjustment Required in	
	Water content %	**% Sand in Total Aggregate**
For Decrease in Water-Cement Ratio by (0.60 – 0.41 i.e. 0.25)	0	-5.2
For Increase in Compacting Factor (0.85-0.8) that is, 0.05	+3.0	0
Total	+3.0	-5.2

Therefore required sand contents as % of total aggregate by absolute volume = 35 - 5.2= 29.8%

Required water content = 186 + 5.58 = 191.58 litre/m^3

f) **Determination of Cement Content:**

Water-cement ratio = 0.34

Water = 191.58 litre

Cement = 191.58/ 0.34 = 450 kg/ m^3

Water content=450*0.34=153 litre

This cement content is adequate for 'Mild' exposure condition (Table 23)

g) **Determination of Coarse and Fine Aggregate Content:**

From table 41, for the specified maximum size of Aggregate of 20 mm, the amount of entrapped air in the wet concrete is 2%. Taking this into account and applying equation,

$V= (W+ C/S_C + 1/P* f_a/S_{fa}) * 1/1000$ &

$V= (W+ C/S_C + 1/1\text{-}P* C_A/S_{ca}) * 1/1000$, where,

V=absolute volume of fresh concrete

=Gross volume (1 m^3) minus the volume of entrapped air,

Sc=specific gravity of cement,

W= mass of water (kg) per m^3 of concrete,

C=mass of cement (kg) per m^3 of concrete,

p=ratio of fine aggregate to total aggregate by absolute volume,

f_a, C_a = total masses of fine aggregate and coarse aggregate, (kg) per m3 of concrete respectively, and

S_{fa} , s_{ca}= specific gravities of saturated surface dry fine aggregate and coarse aggregate respectively.

0.98 m3= (153 +450/3.10 +1/0.298* fa /2.46)*1/1000, and

0.98 m^3= (153 +450/3.10 +1/0.702* C_A /2.60)*1/1000, and

fa = 500 kg/ m^3

$C_a = 1244$ kg/ m^3

The mix proportion then becomes:

Water	**Cement**	**Fine Aggregate**	**Coarse Aggregate**
153	450	500	1244
0.34	1	1.11	2.76

h) **Actual Quantities Required for the Mix per Bag of Cement:**

The mix is, 0.34:1:1.11:2.76(by mass). For 50 kg of cement the quantity of material are worked out as below:

1) Cement = 50 kg

2) Sand = 55.5 kg

3) Coarse aggregate = 138 kg

4) Water:

X) For water cement ration of 0.34 water = 17.0 litres.

XI) Extra water to be added for absorption in case of coarse aggregate at (0.8% -0.4%) by mass = 0.55 litres.

XII) Extra water to be added for absorption in sand at (1.68%-0.8%) by mass = 0.49 litres.

XIII) Actual water to be added = 17.0 + 0.55+ 0.49 = 18.04 litres.

5) Actual quantity of sand required after allowing for mass of pre moisture = 55.5 - 0.49 = 55.01 kg.

6) Actual Quantity of Coarse Aggregate Required = 138 – 0.55 = 137.45 kg

Therefore, the actual quantities of different constituents required for the mix are:

Water = 18.0 litres

Cement = 50 kg

Sand = 55 kg

Coarse Aggregate = 137.45 kg

5.0 **Concreting operations:**

5.1 **Mixing of Concrete:**

The concrete mixer was initially made wet. Aggregates were placed in the mixer, followed by cement. After mixing the dry concrete ingredients, HRWR was added to the mix water, which was then placed in the mixer. After mixing well, the slump was measured, and three cube cast.

5.2 **Dosage of HRWR:**

Grade of concrete	Dosage(ml/kg cement)
M20	10 ml/kg cement
M25	15 ml/kg cement
M30	20 ml/kg cement
M35	20 ml/kg cement

Workability was again measured at regular time intervals of 15 minutes, till the slump reduced to 30-40 mm. at this stage redosage of superplasticizer @ 5 ml/kg cement was done. Again workability was measured at regular 15 min intervals, till slump reduced to 30-40 mm. At this stage a second redosage @ 5 ml/kg cement was done. Again workability was measured at regular 15 minutes intervals.

5.3 **Measurement of Workability:**

Workability of concrete was measured by slump cone. Concrete is filled in the slump cone in three layers, and each layer is tamped with 25 blows by tamping rod for compacting. After filling with concrete, the upper part is flattened and slump cone is taken out, then slump is measured.

5.4 **Redosage of HRWR:**

Dosage of HRWR is put again in the concrete after when the slump reduces to less than 40 mm, for increasing workability. Then we measure slump with slump cone.

First redosage is 5 ml/kg cement for all cements used, and second redosage is also same.

5.5 **Casting of Cube Moulds:**

a) Tightened three cubes of 10 cm size and oil them

b) Make 40 Kg mix for 43 grade cement

c) Measure slump

d) Cast three cubes of 10 cm size

e) Measure slump every 15 minutes

f) When slump is less than 40 mm, add redosage and mix well.

g) Measure slump and cast three cubes

h) Continue to measure slump every 15 minutes

i) When slump is less than 40 mm, add redosage again and mix well.

j) Measure slump and cast three cubes.

k) Continue to measure slump every 15 minutes.

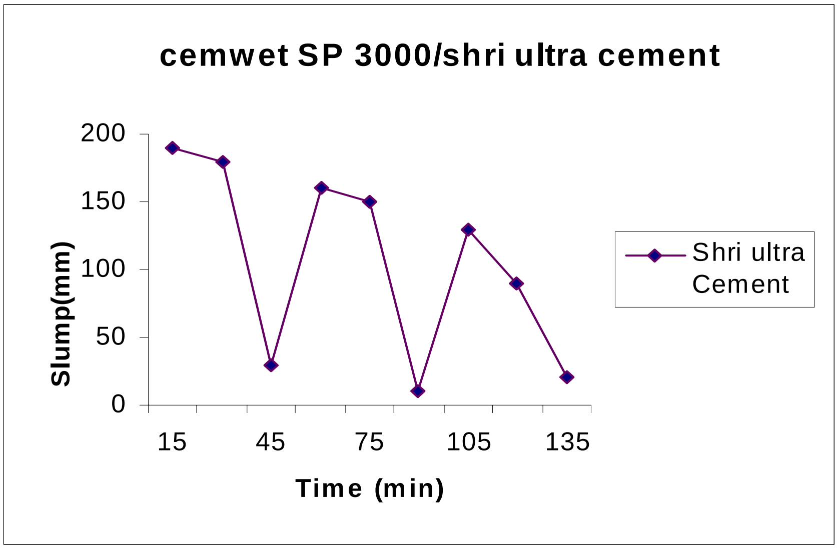


Figure 1: Variation of workability with time for M20 concrete

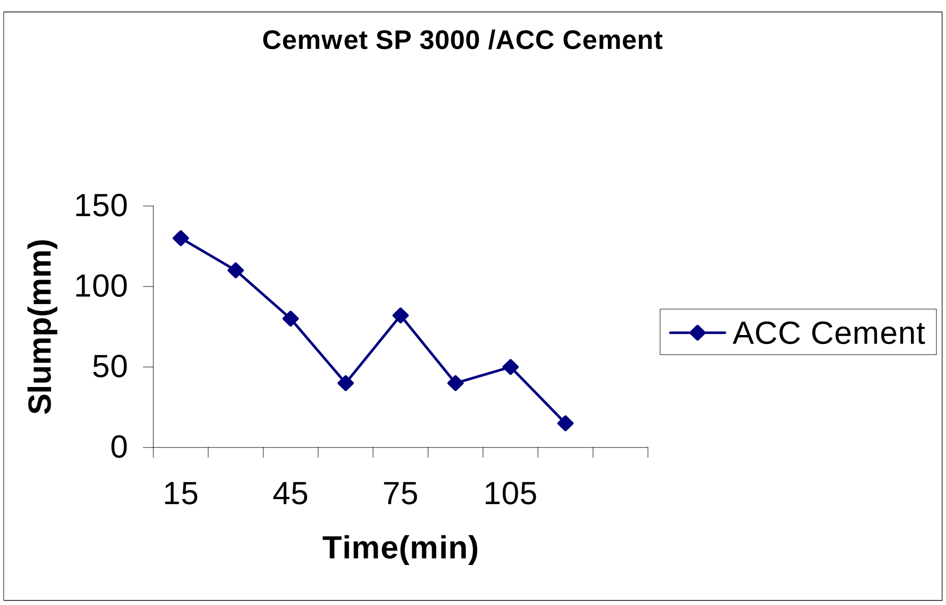


Figure 2: Variation of workability with time for M20 concrete

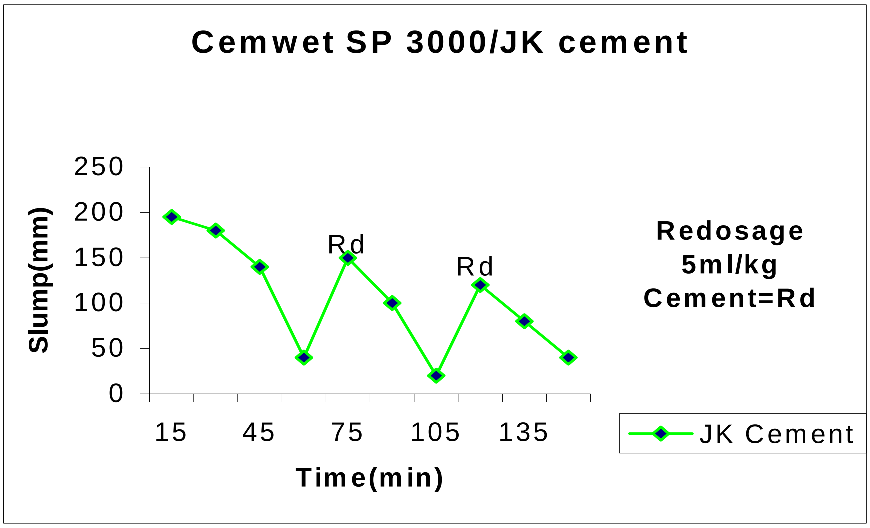


Figure 3: Variation of workability with time for M20 concrete

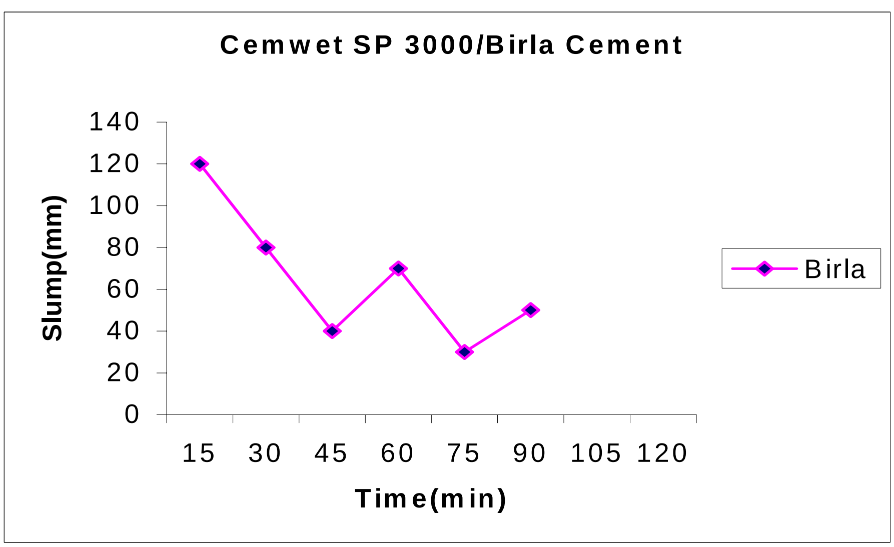


Figure 4: Variation of workability with time for M20 concrete

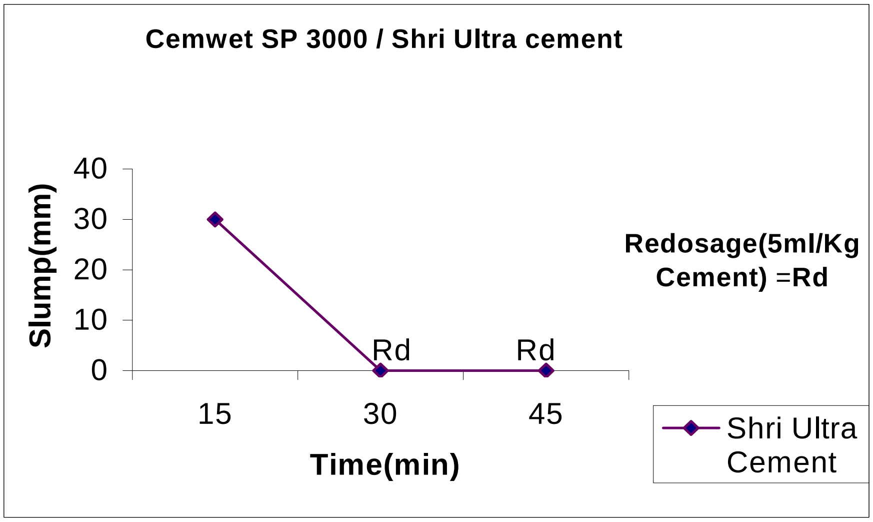


Figure 5: Variation of workability with time for M25 concrete

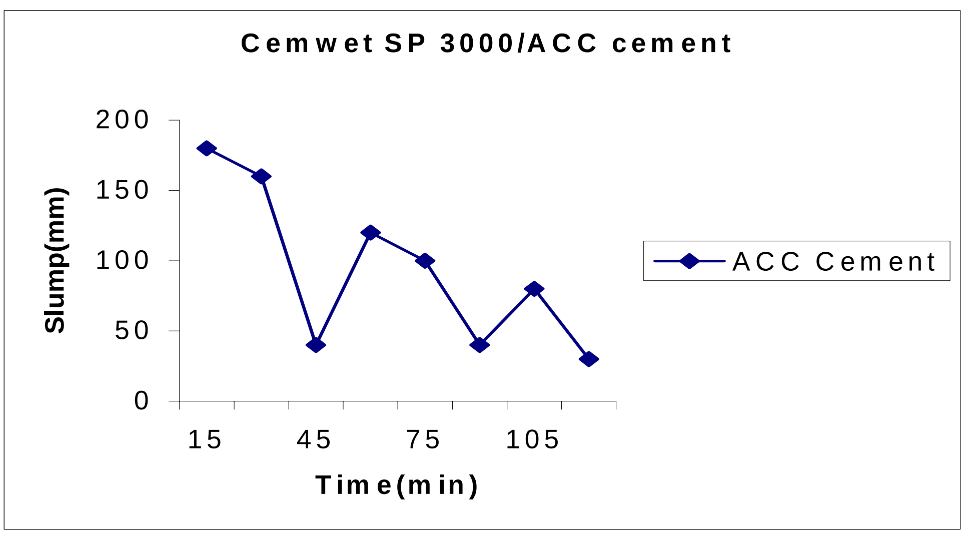


Figure 6: Variation of workability with time for M25 concrete

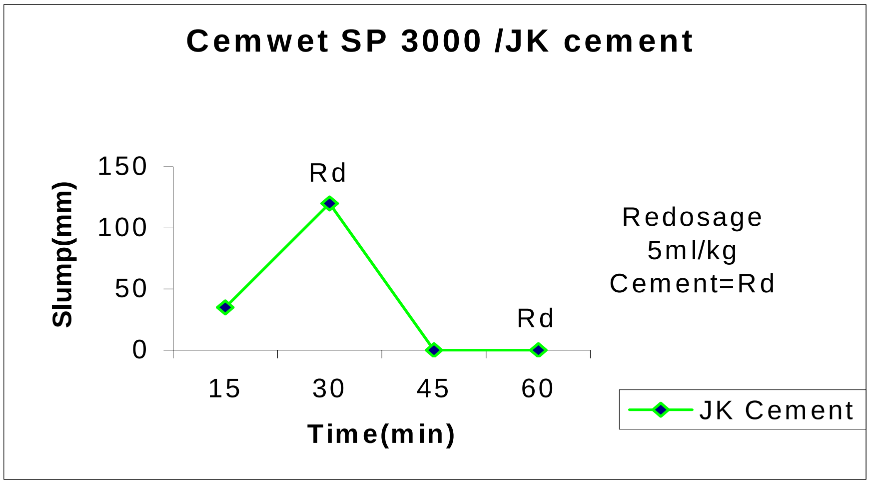


Figure 7: Variation of workability with time for M25 concrete

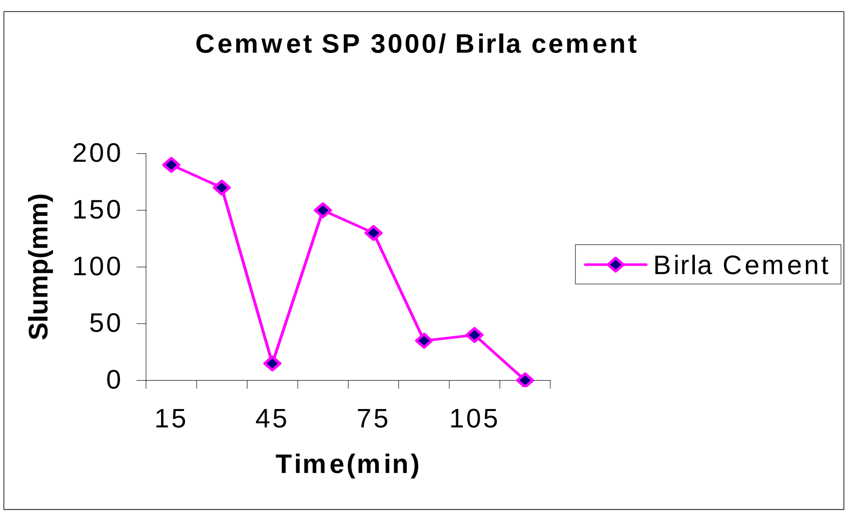


Figure 8: Variation of workability with time for M25 concrete

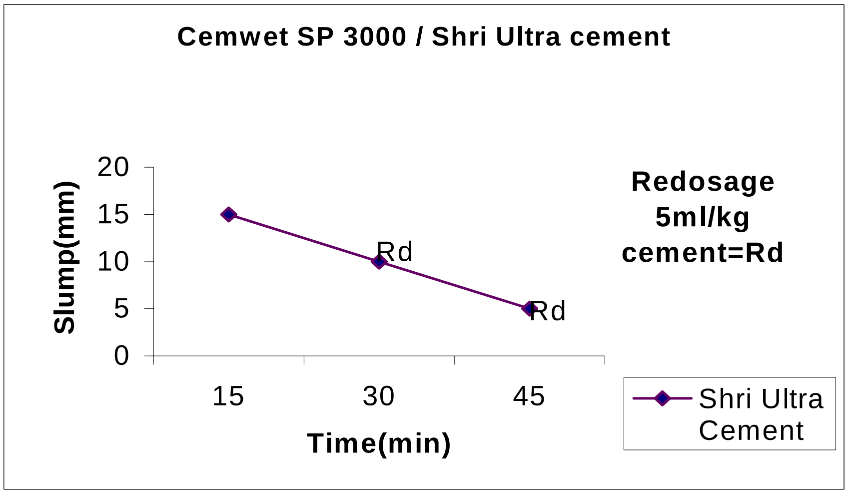


Figure 9: Variation of workability with time for M30 concrete

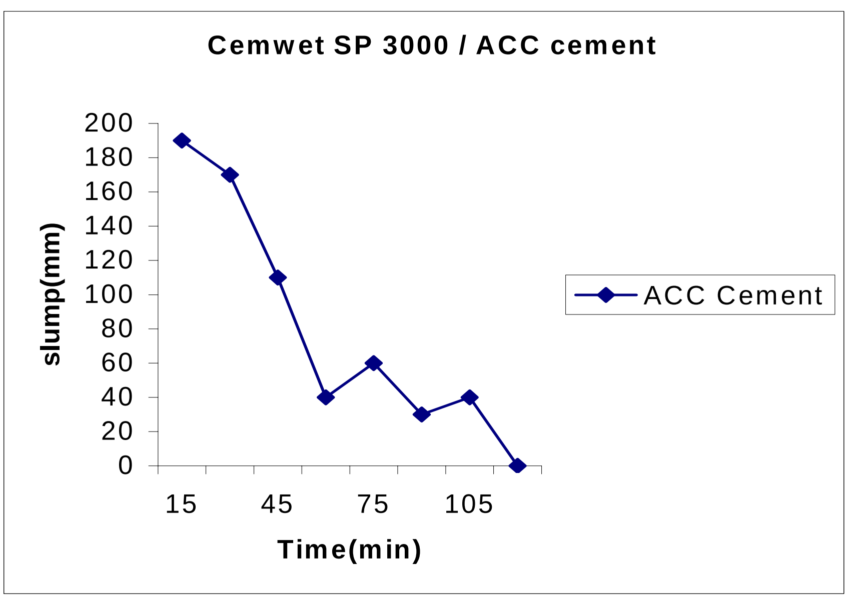


Figure 10: Variation of workability with time for M30 concrete

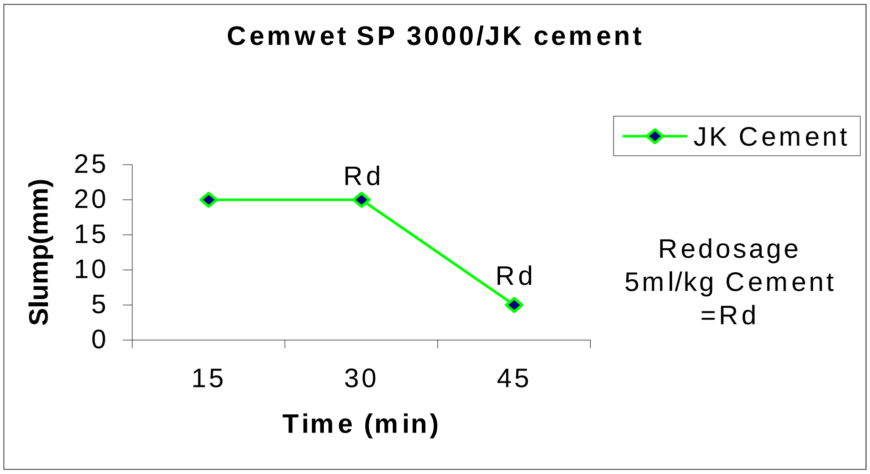


Figure 11: Variation of workability with time for M30 concrete

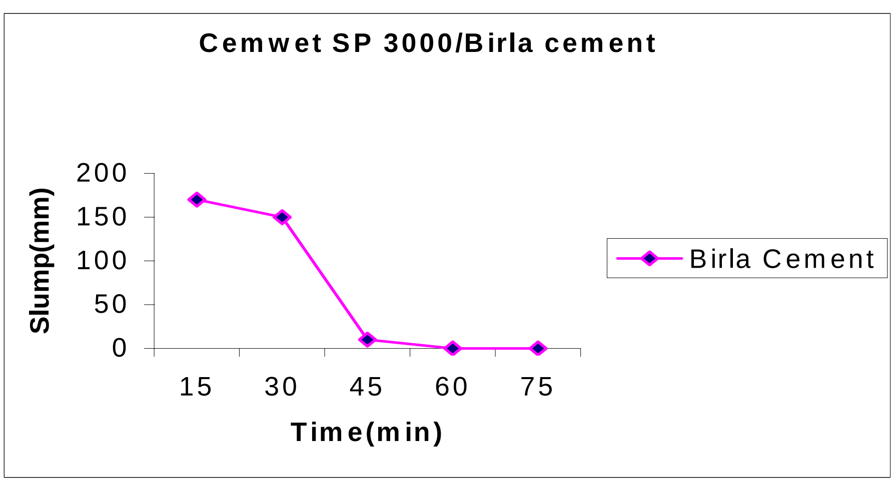


Figure12: Variation of workability with time for M30 concrete

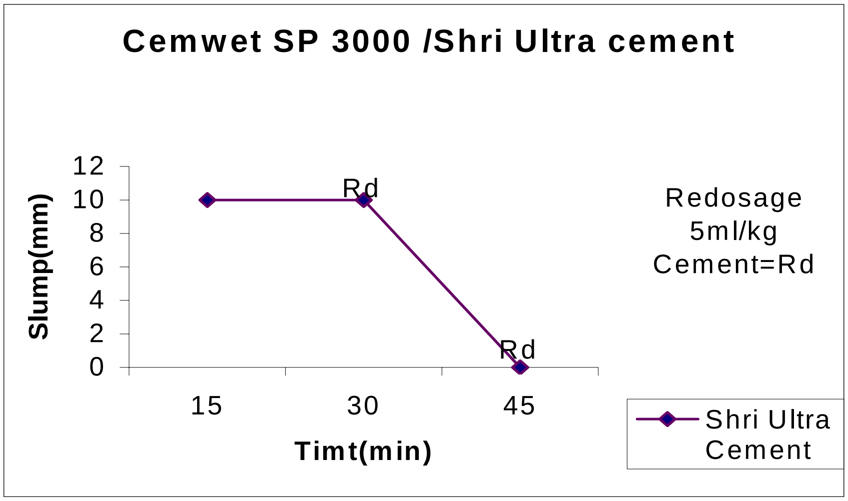


Figure13: Variation of workability with time for M35 concrete

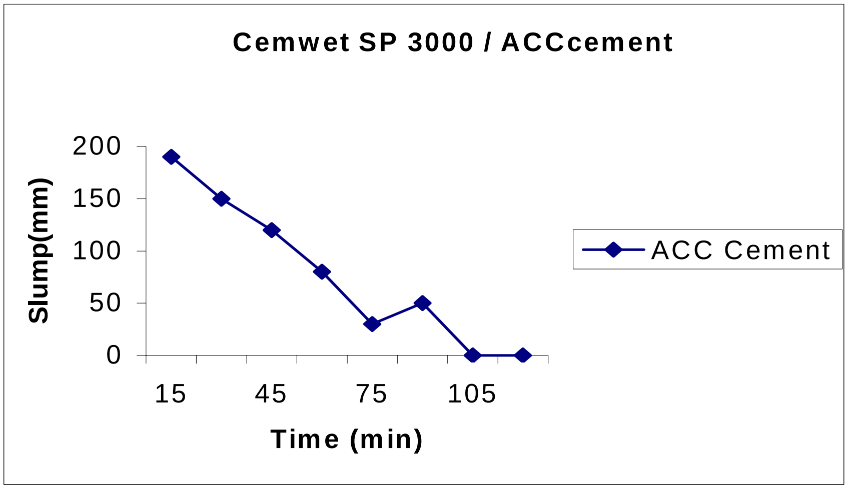


Figure14: Variation of workability with time for M35 concrete

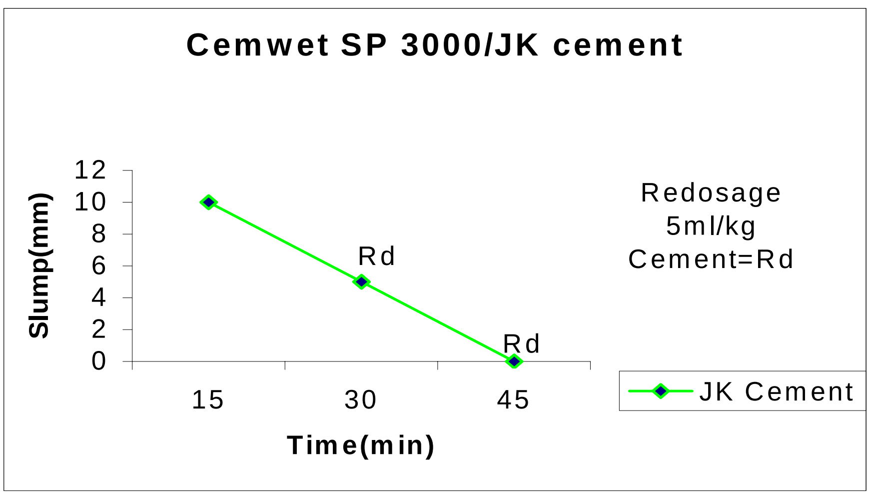


Figure15: Variation of workability with time for M35 concrete

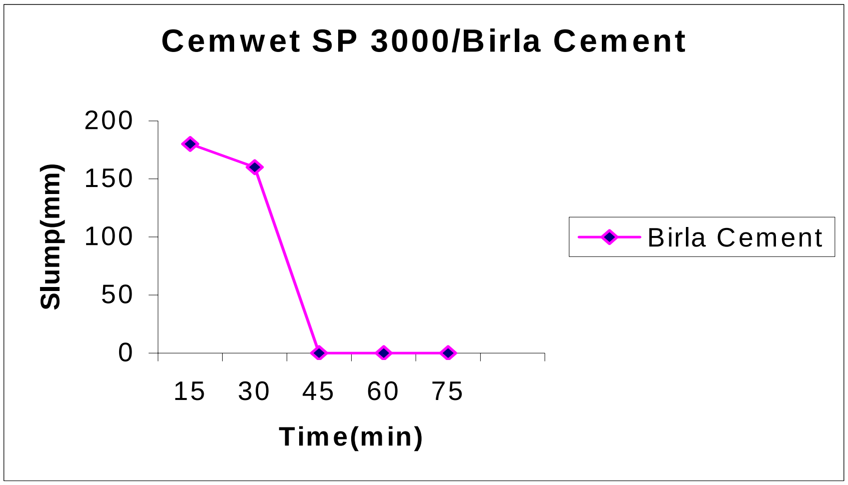


Figure16: Variation of workability with time for M35 concrete

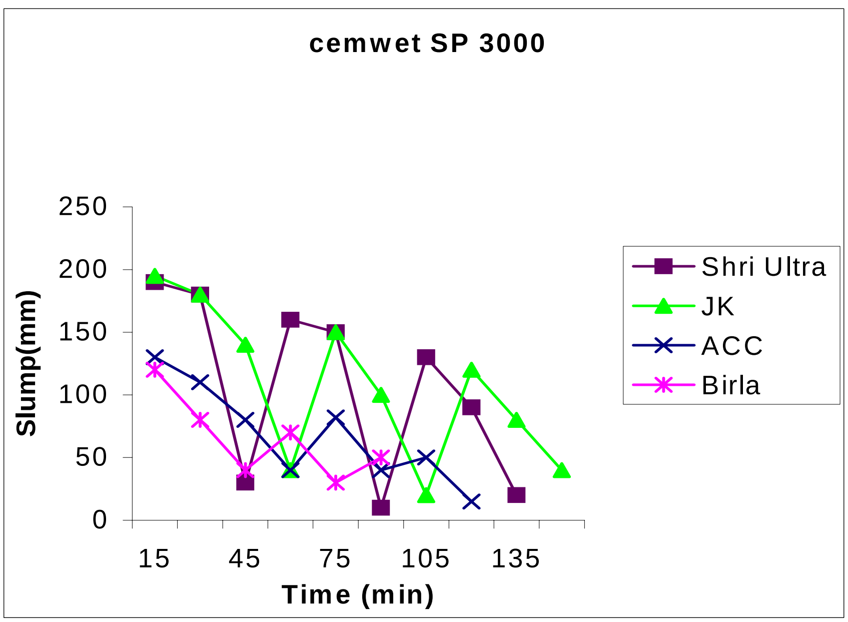


Figure 17: Variation of workability with time for M20 concrete

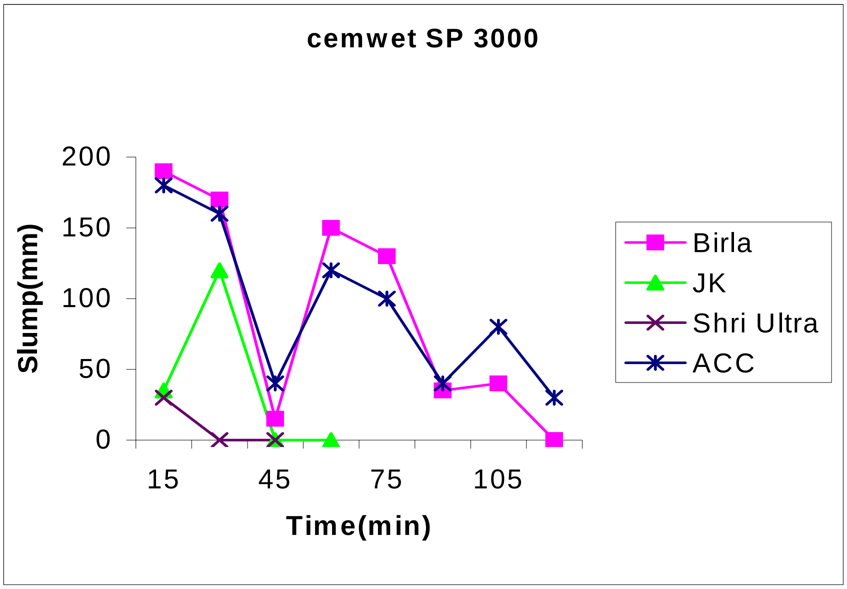


Figure 18: Variation of workability with time for M25 concrete

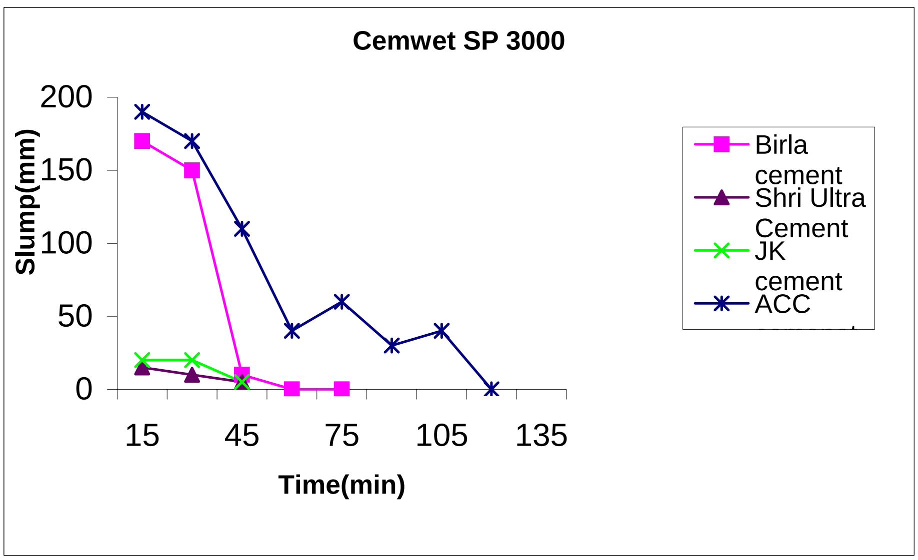


Figure 19: Variation of workability with time for M30 concrete

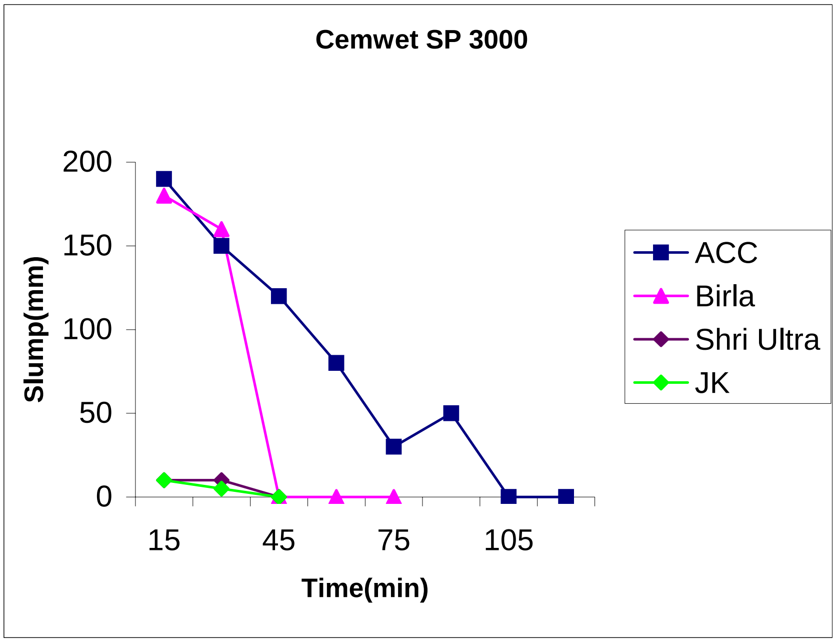


Figure 20: Variation of workability with time for M35 concrete

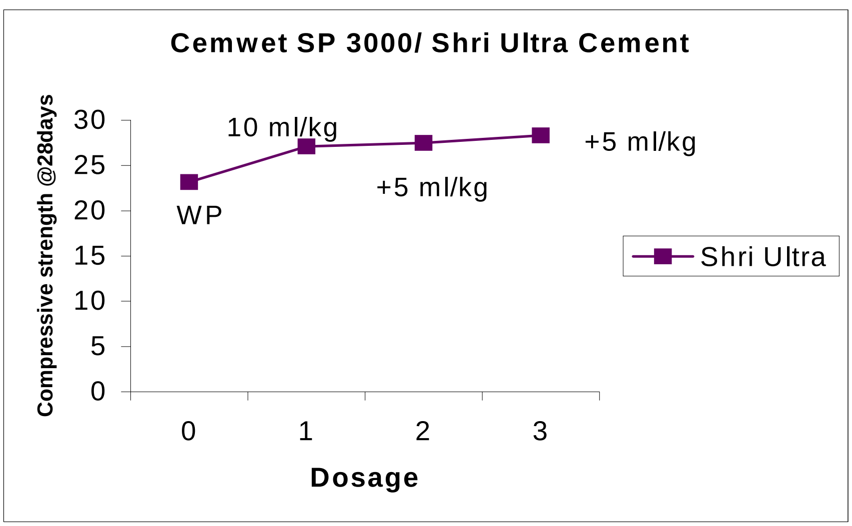


Figure 21: Variation of strength with time for M35 concrete

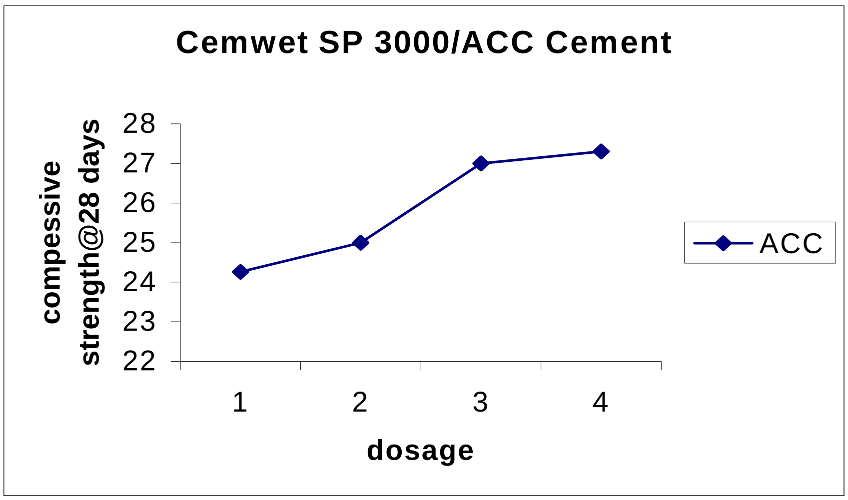


Figure 22: Variation of strength with dosage for M20 concrete

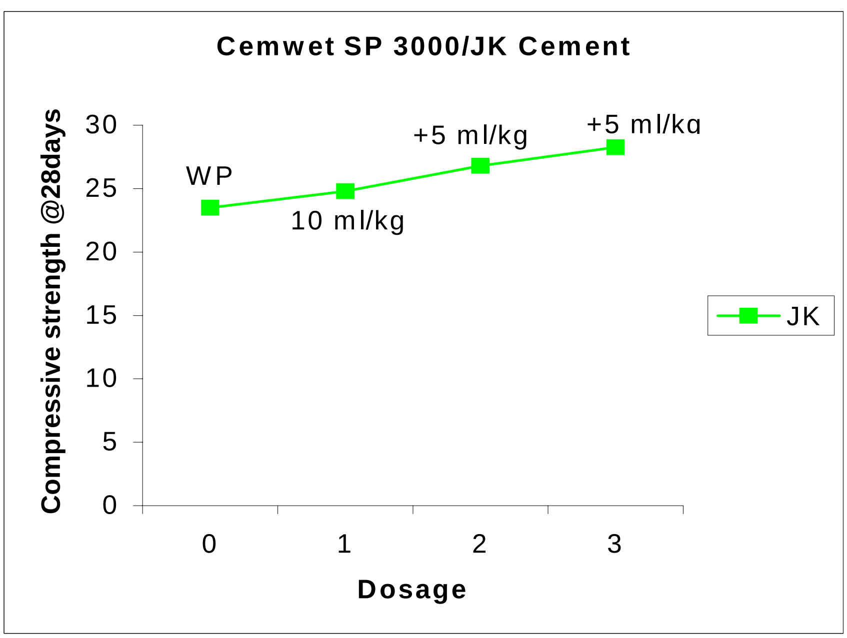


Figure 23: Variation of strength with dosage for M20 concrete

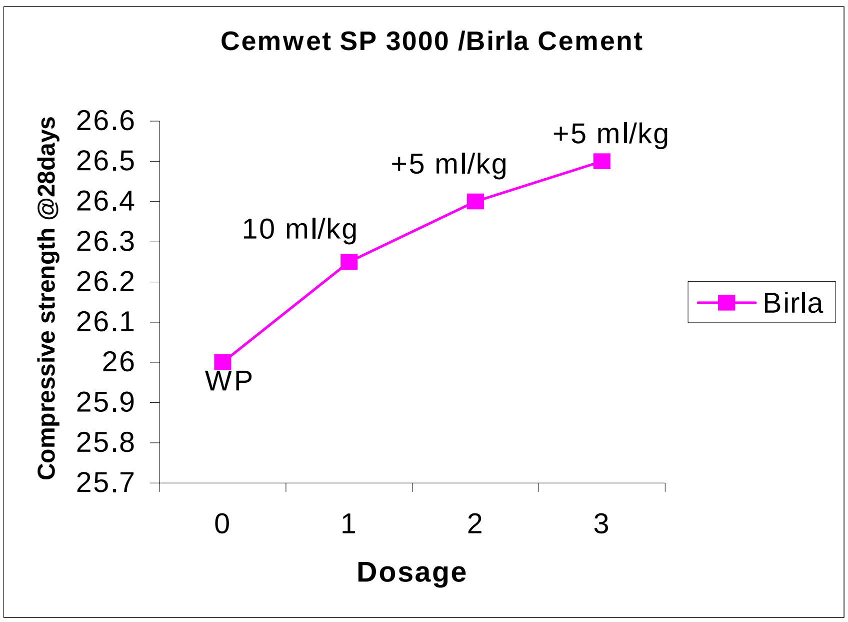


Figure 24: Variation of strength with dosage for M20 concrete

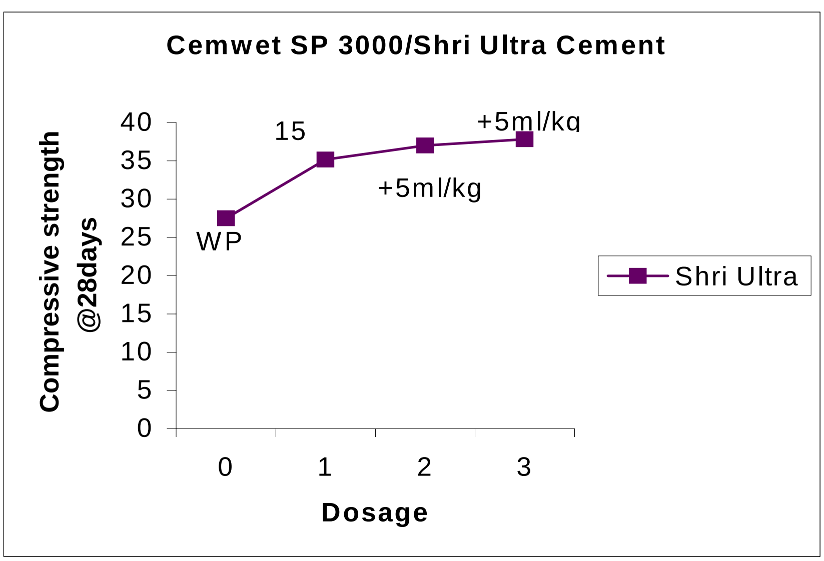


Figure 25: Variation of strength with dosage for M25 concrete

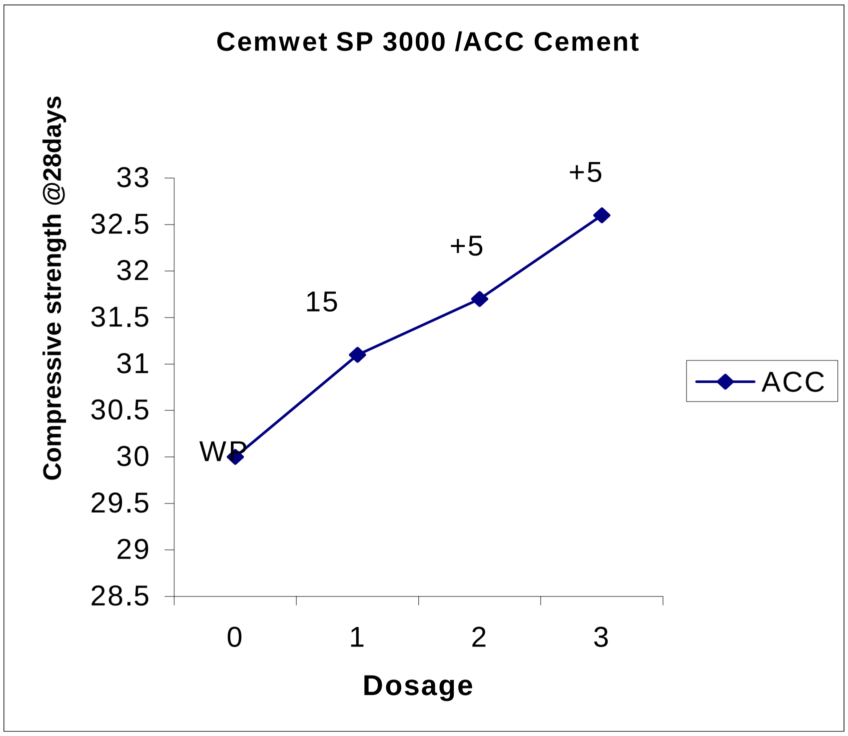


Figure 26: Variation of strength with dosage for M25 concrete

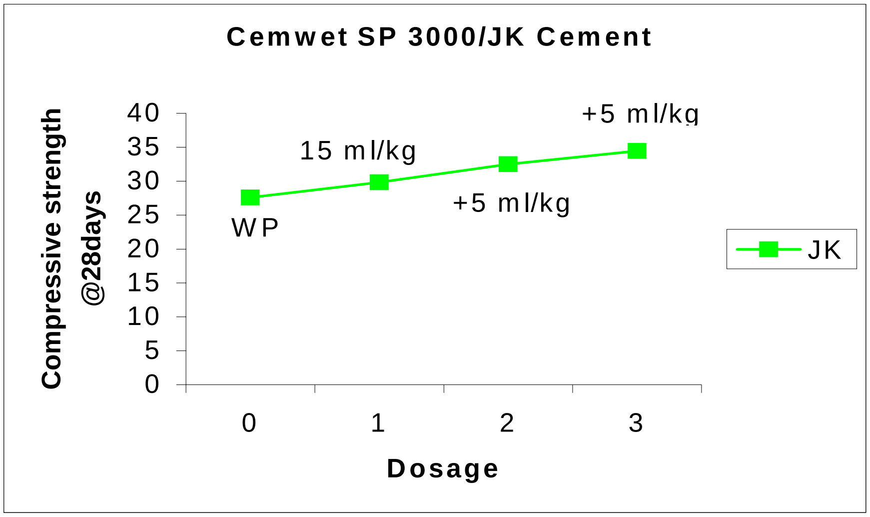


Figure 27: Variation of strength with dosage for M25 concrete

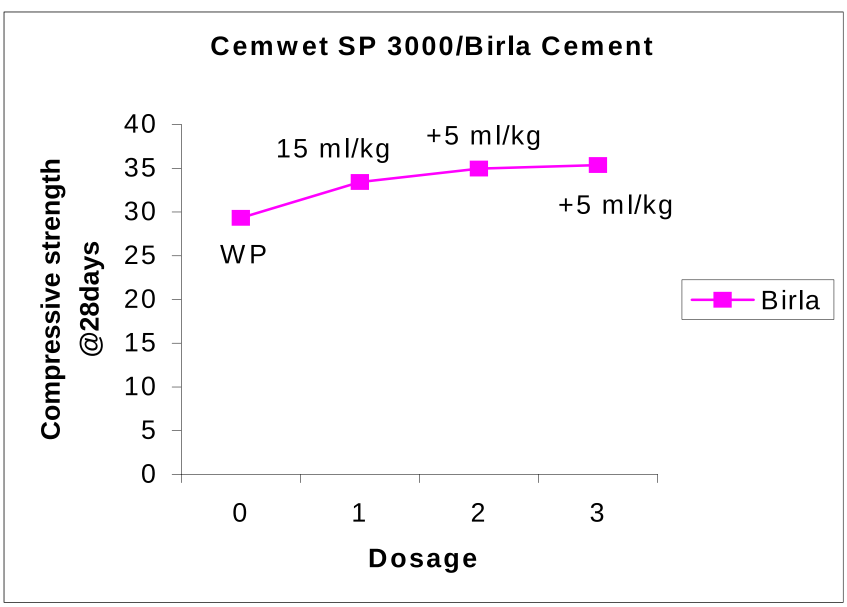


Figure 28: Variation of strength with dosage for M25 concrete

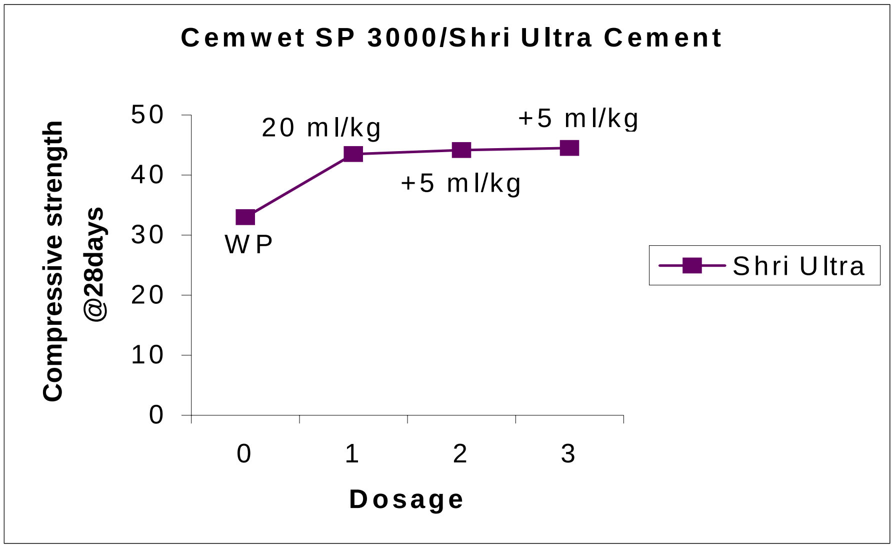


Figure 29: Variation of strength with dosage for M30 concrete

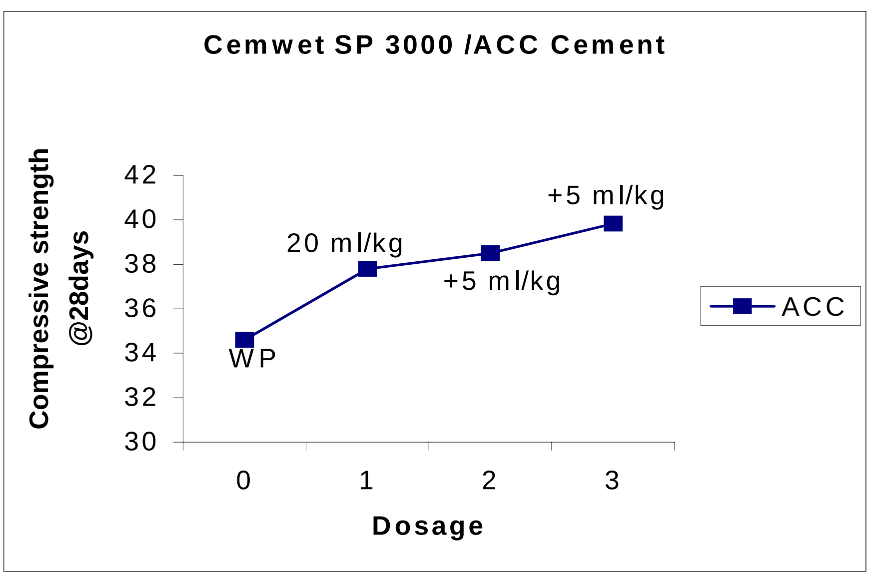


Figure 30: Variation of strength with dosage for M30 concrete

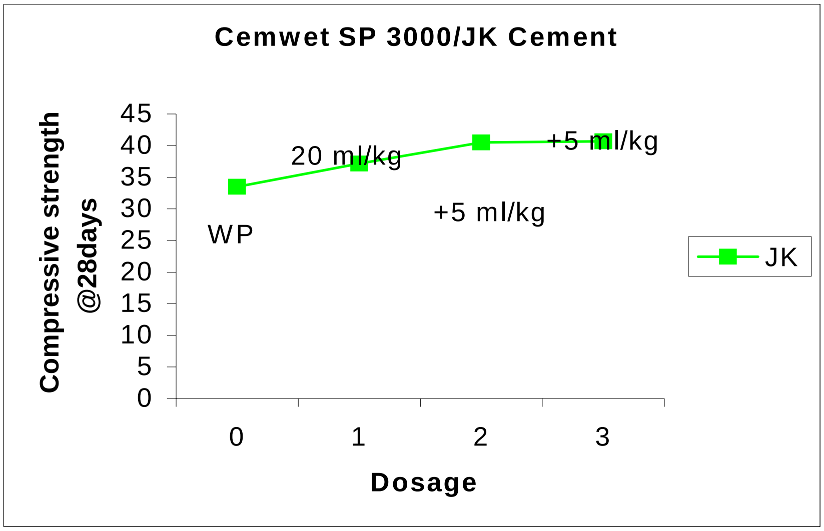


Figure 31: Variation of strength with dosage for M30 concrete

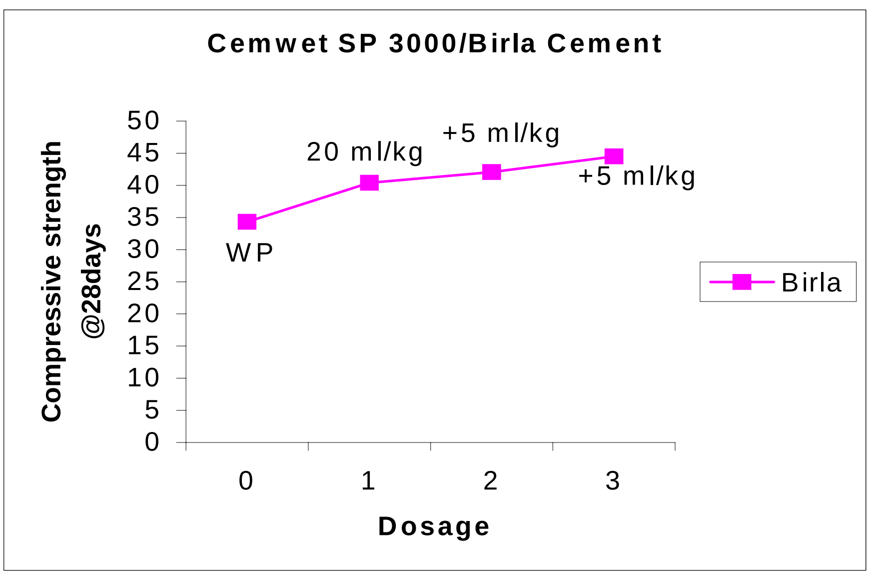


Figure 32: Variation of strength with dosage for M30 concrete

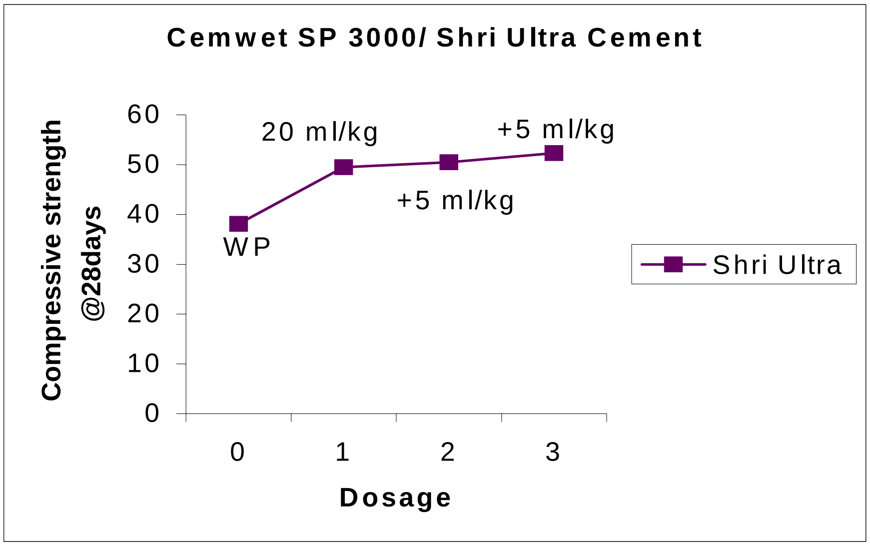


Figure33: Variation of strength with dosage for M35 concrete

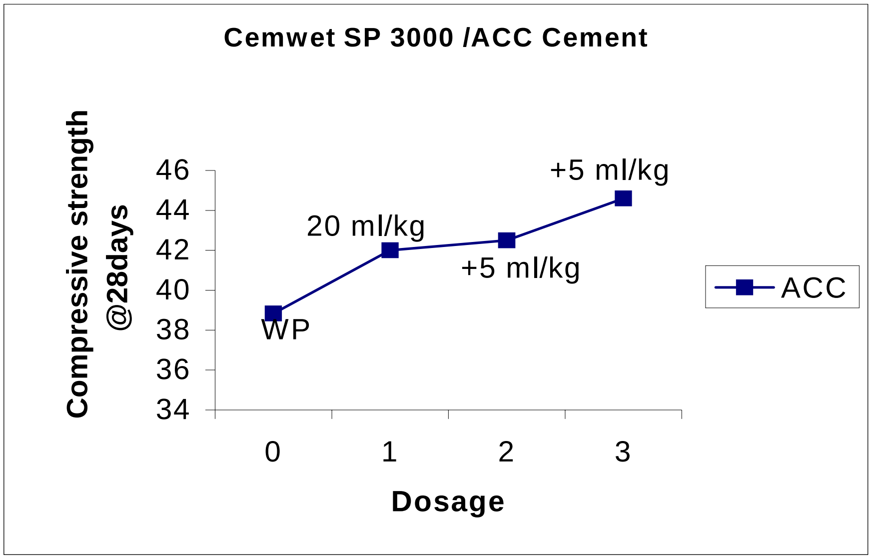


Figure 34: Variation of strength with dosage for M35 concrete

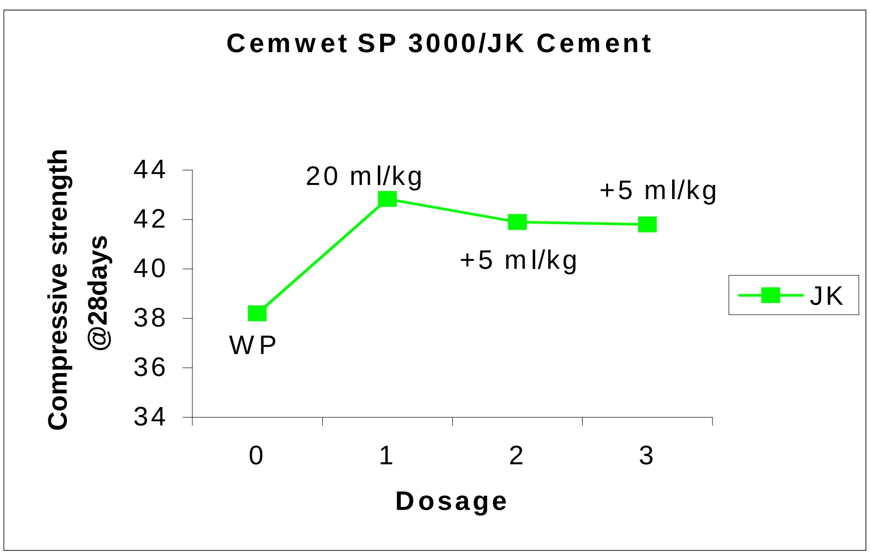


Figure 35: Variation of strength with dosage for M35 concrete

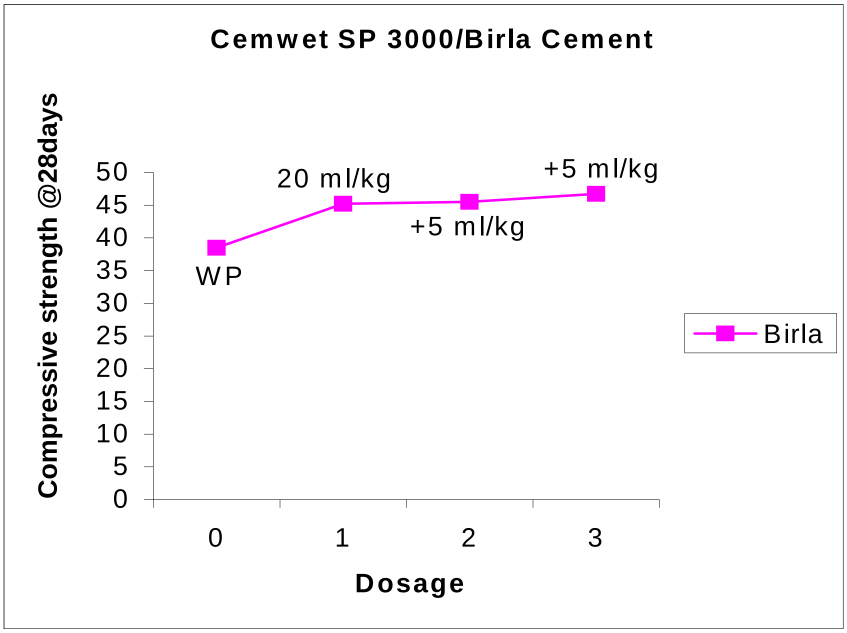


Figure36: Variation of strength with dosage for M35 concrete

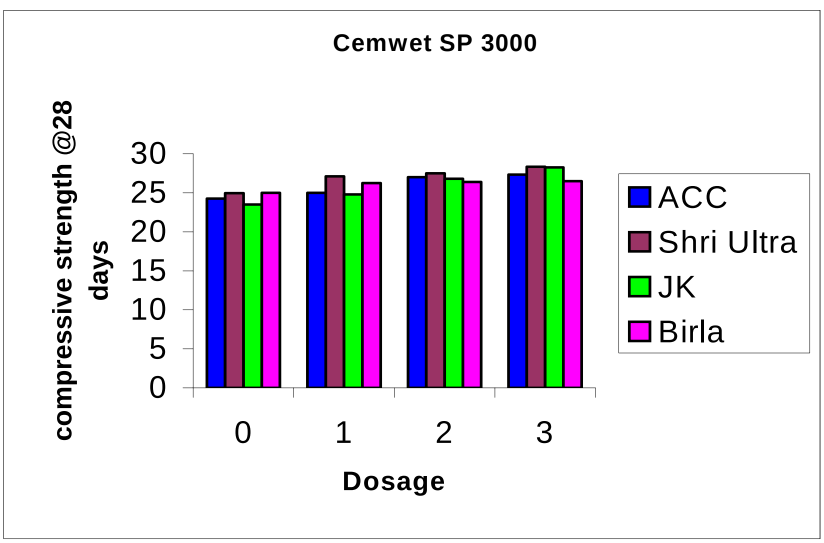


Figure 37: Variation of strength with dosage for M20 concrete

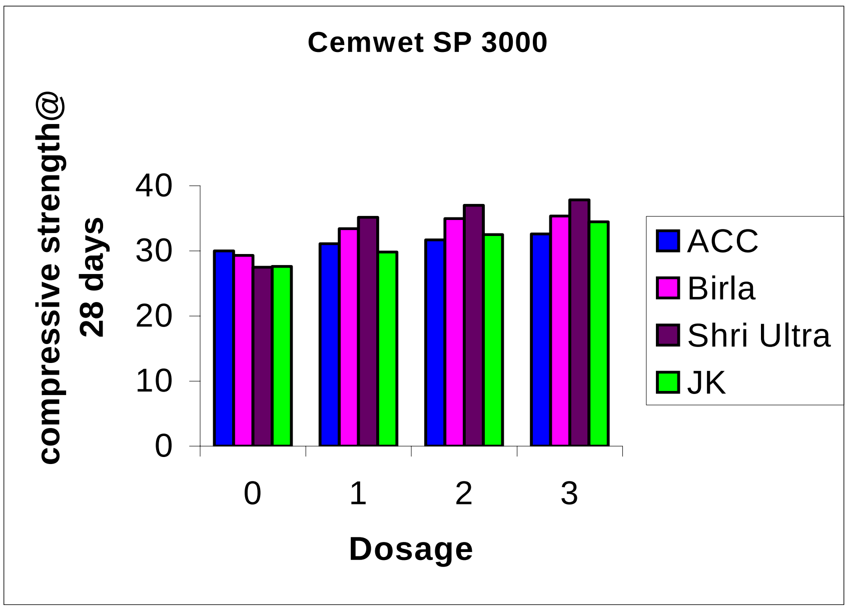


Figure 38: Variation of Strength with dosage for M25 concrete

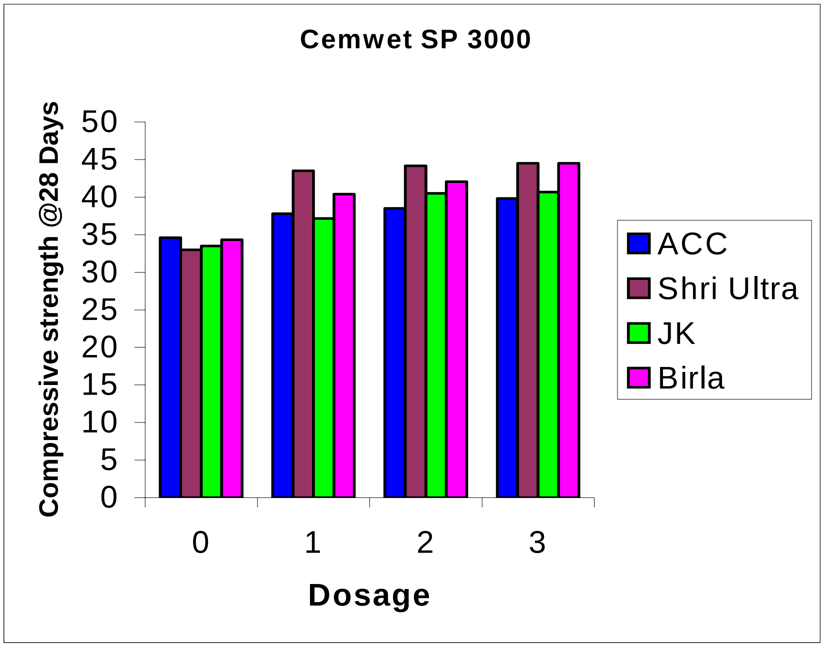


Figure 39: Variation of Strength with dosage for M30 concrete

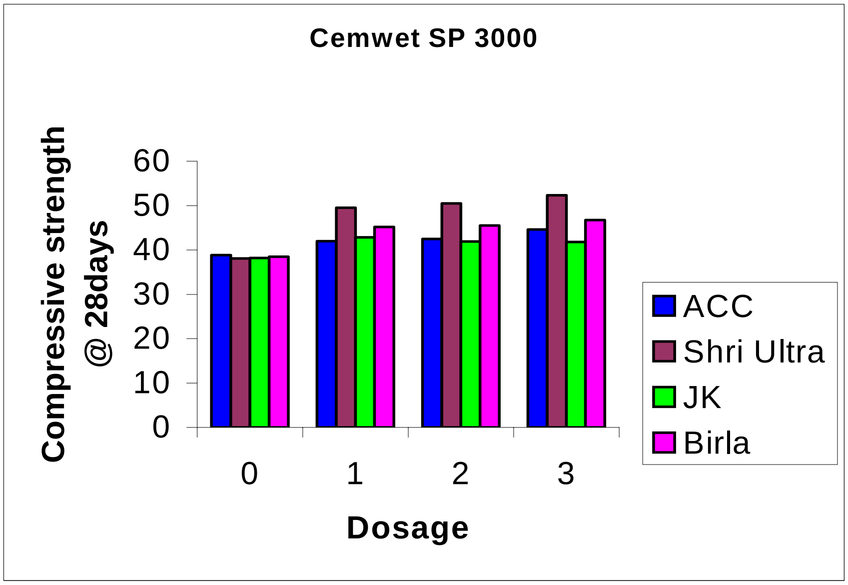


Figure 40: Variation of Strength with dosage for M35 concrete

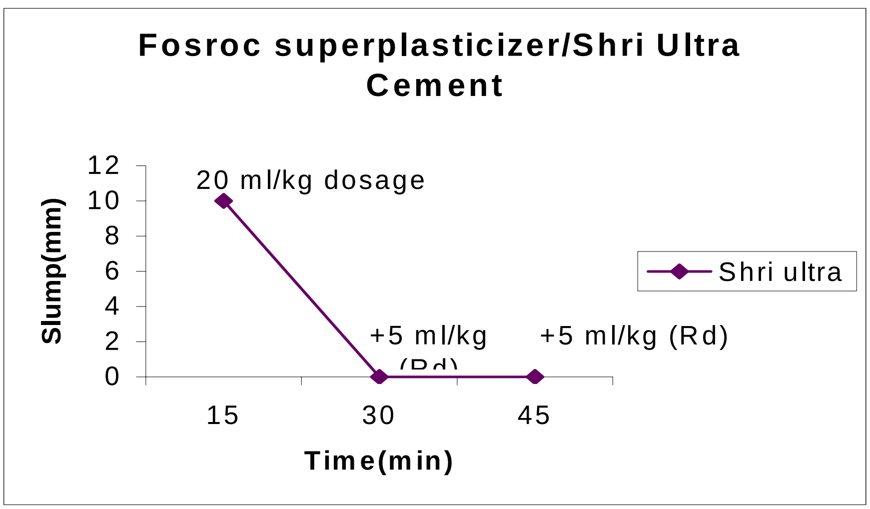


Figure 41: Variation of workability with time for M35 concrete

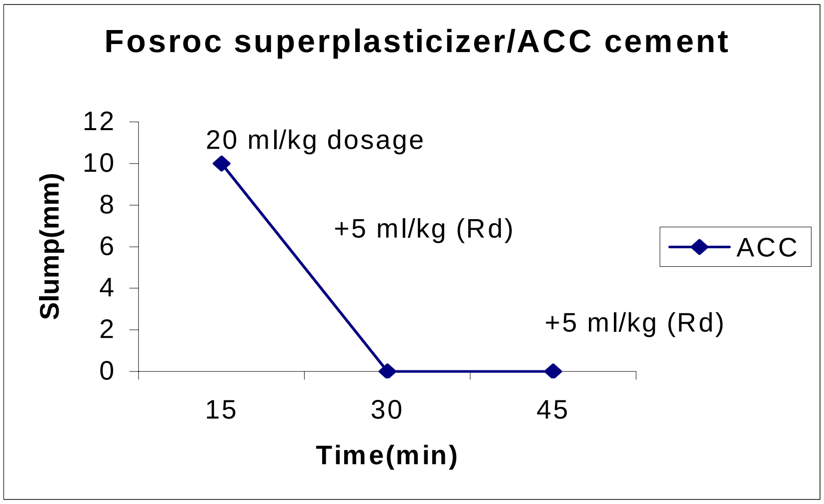


Figure42: Variation of workability with time for M35 concrete

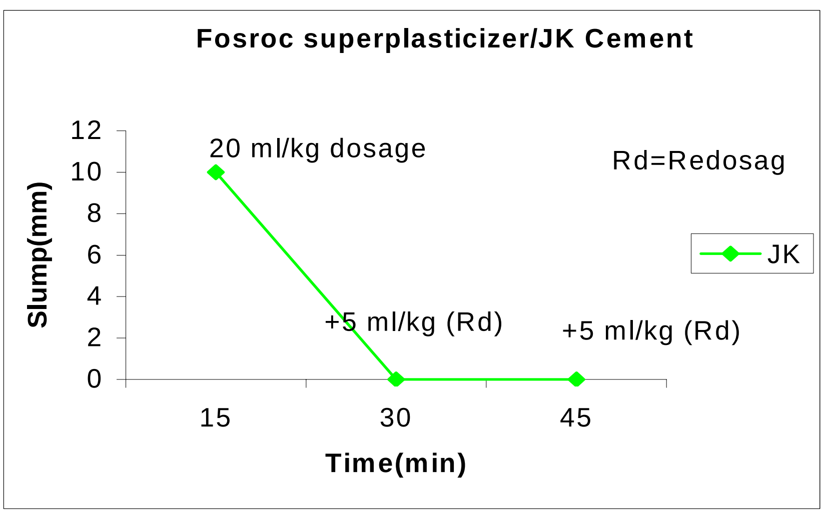


Figure43: Variation of workability with time for M35 concrete

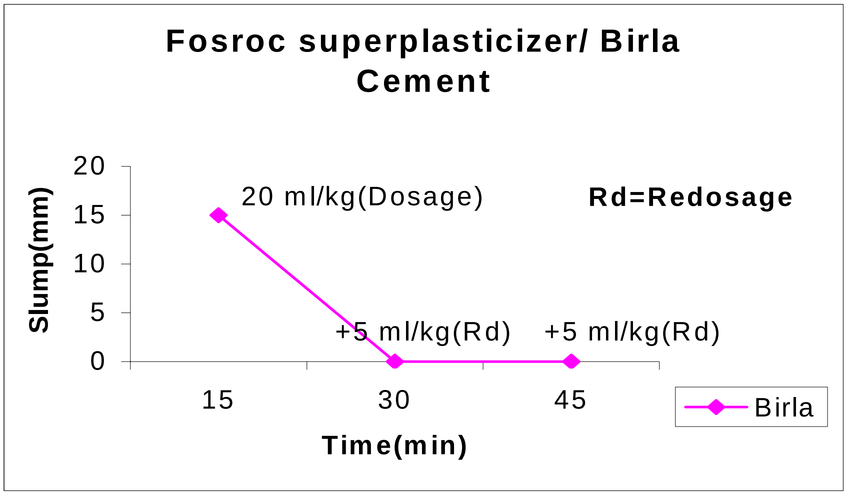


Figure44: Variation of workability with time for M35 concrete

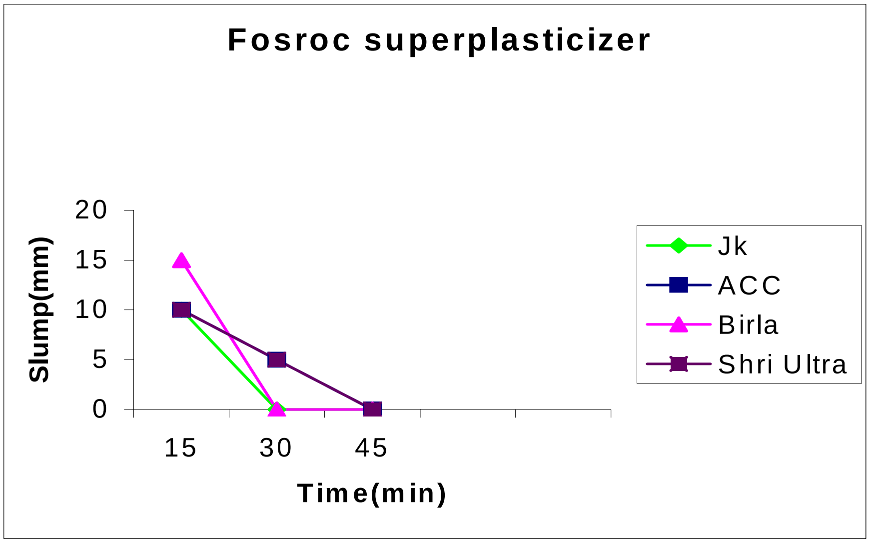


Figure45: Variation of workability with time for M35 concrete

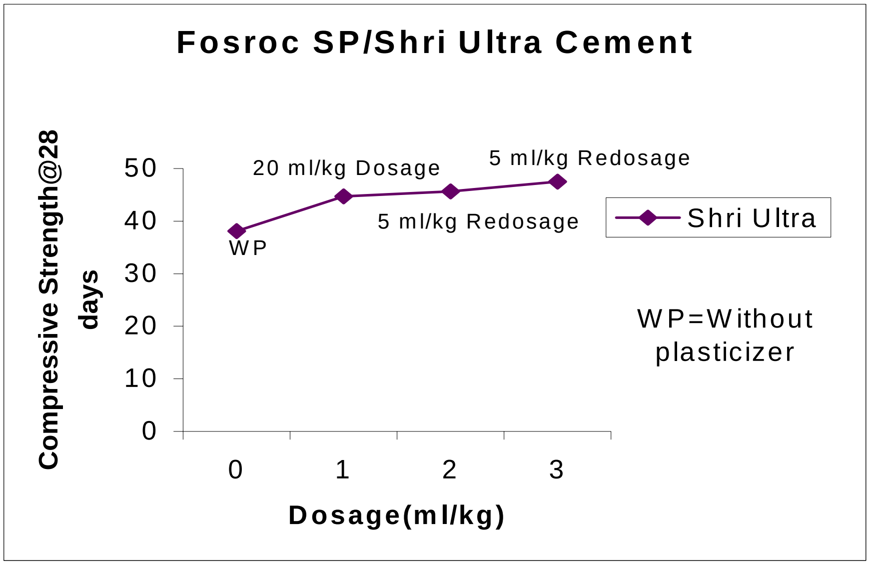


Figure 46: Variation of strength with dosage for M35 concrete

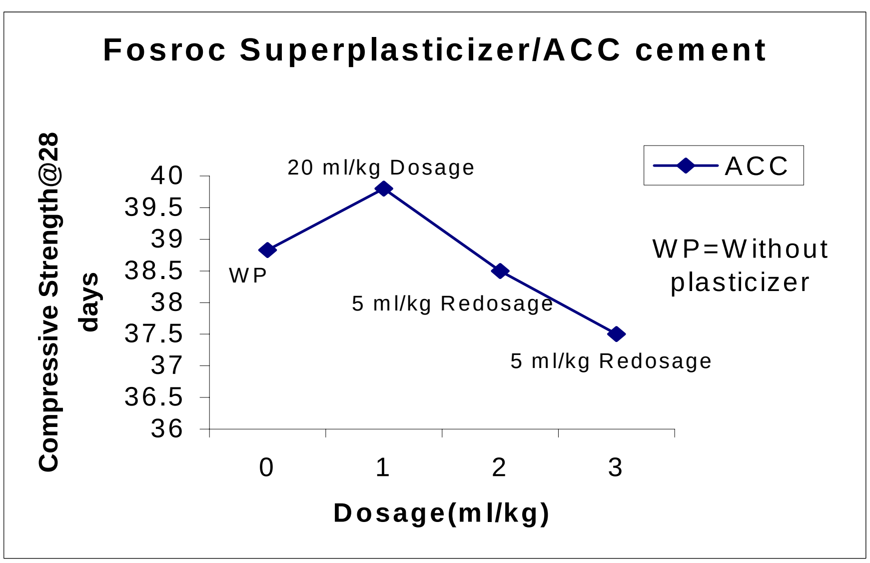


Figure 47: Variation of strength with dosage for M35 concrete

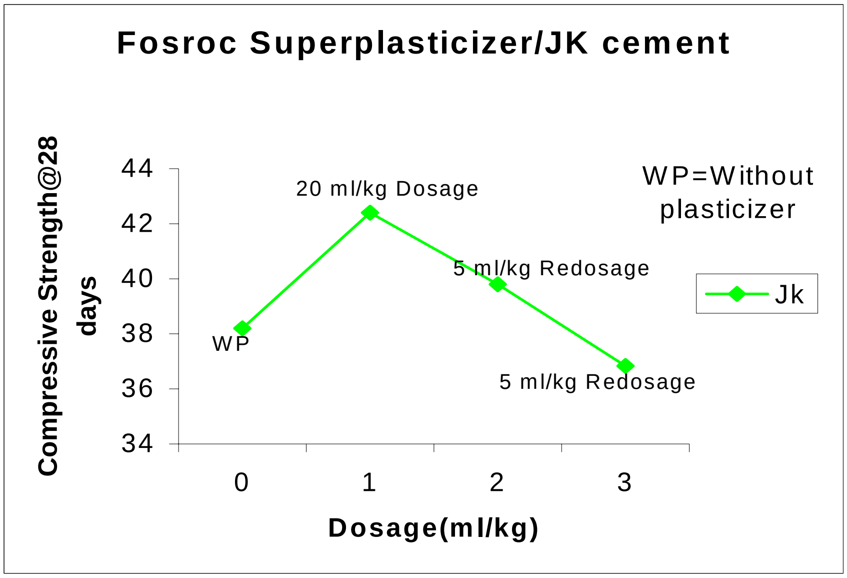


Figure 48: Variation of strength with dosage for M35 concrete

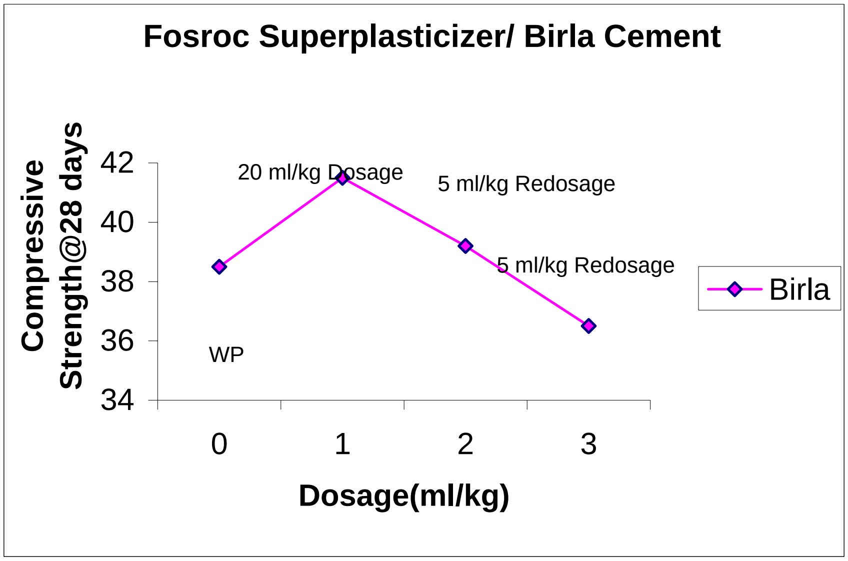


Figure 49: Variation of strength with dosage for M35 concrete

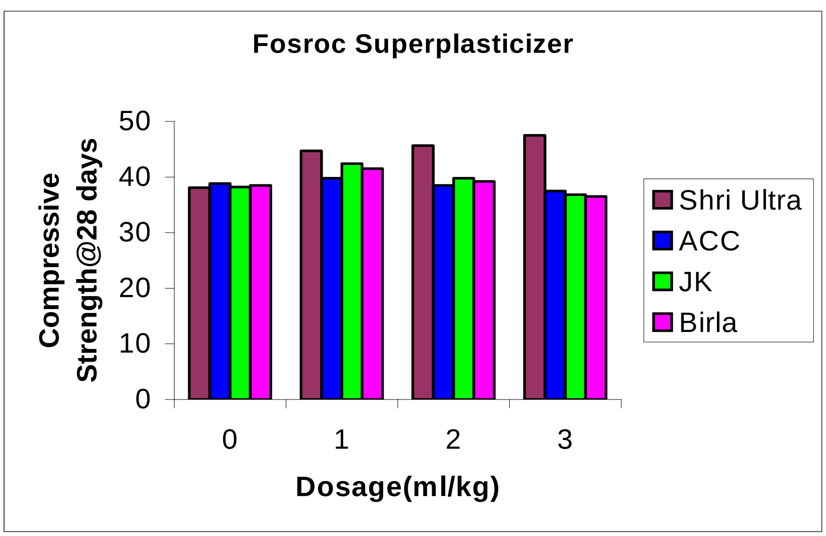


Figure 50: Variation of strength with dosage for M35 concrete

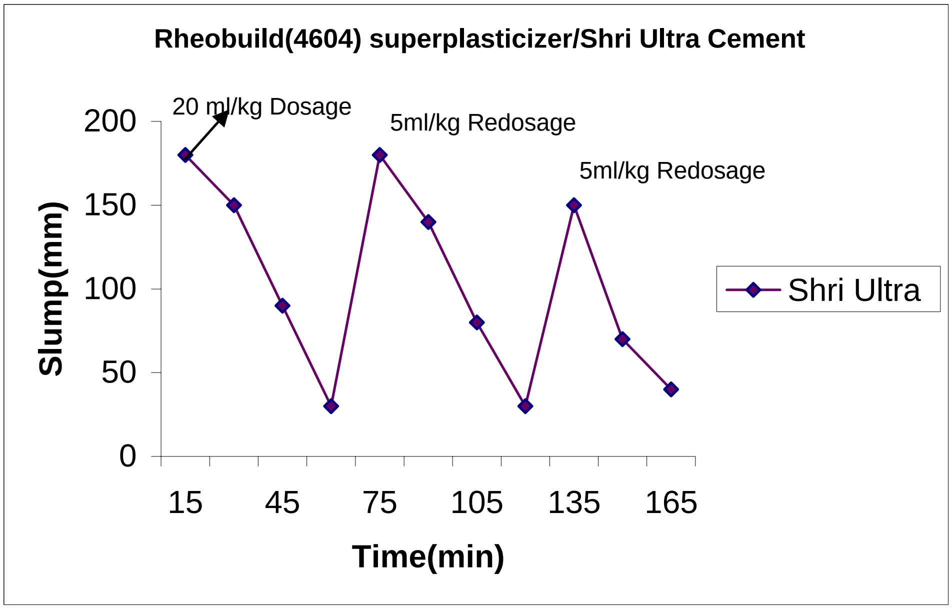


Figure51: Variation of workability with time for M30 concrete

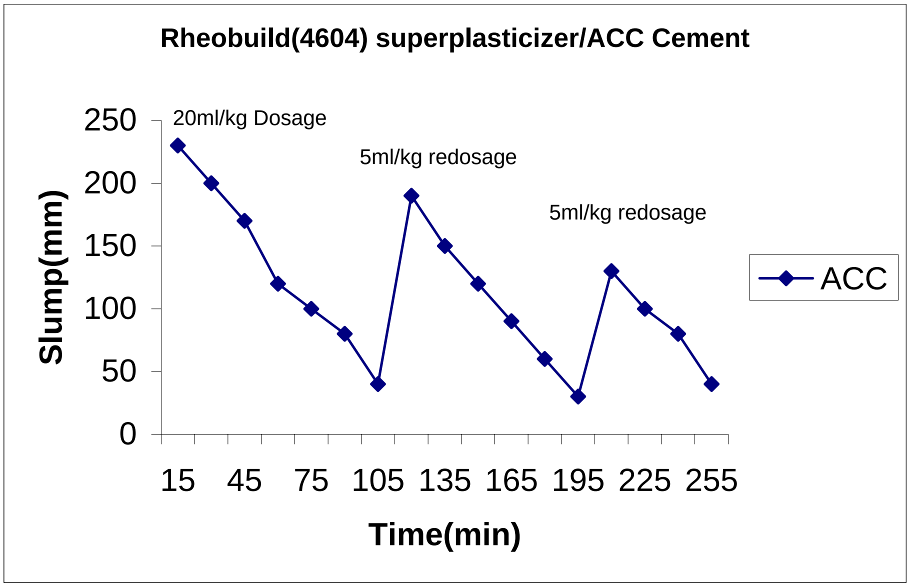


Figure52: Variation of workability with time for M30 concrete

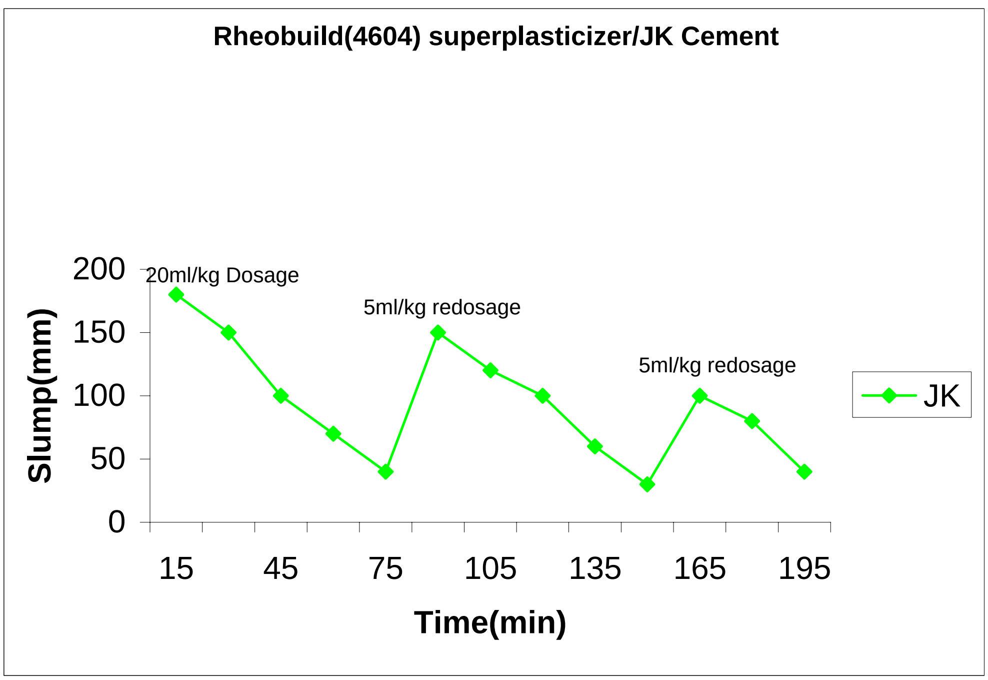


Figure53: Variation of workability with time for M30 concrete

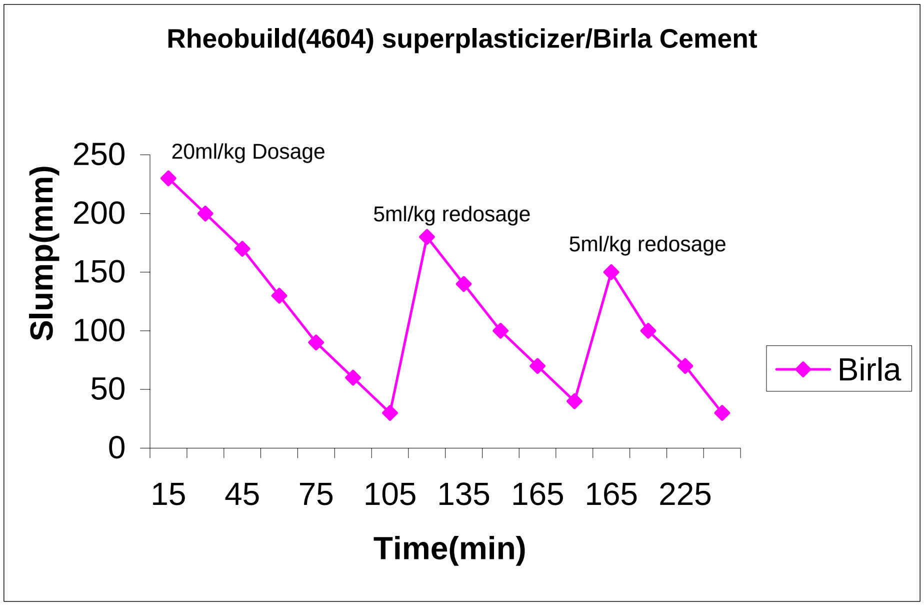


Figure 54: Variation of workability with time for M30 concrete

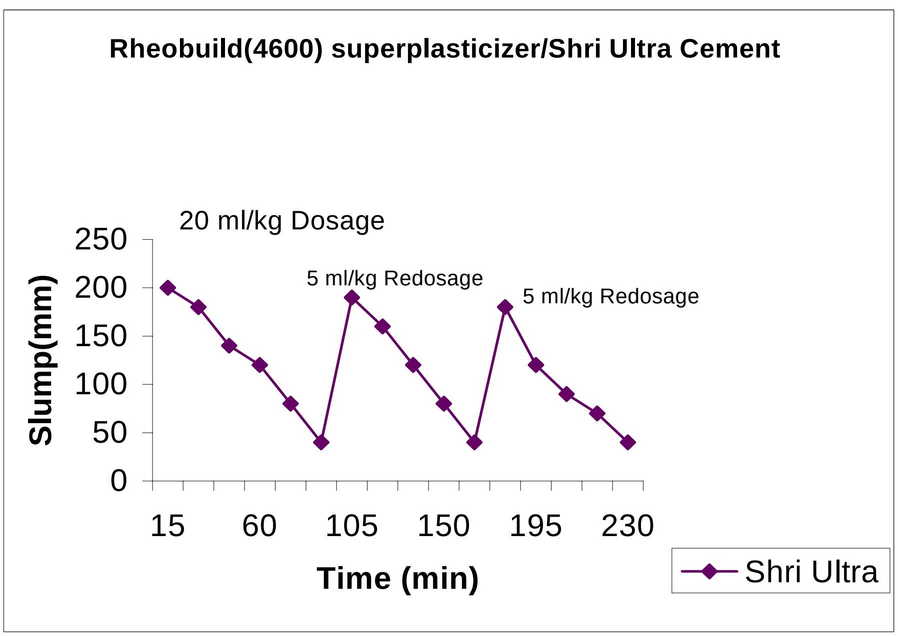


Figure 55: Variation of workability with time for M30 concrete

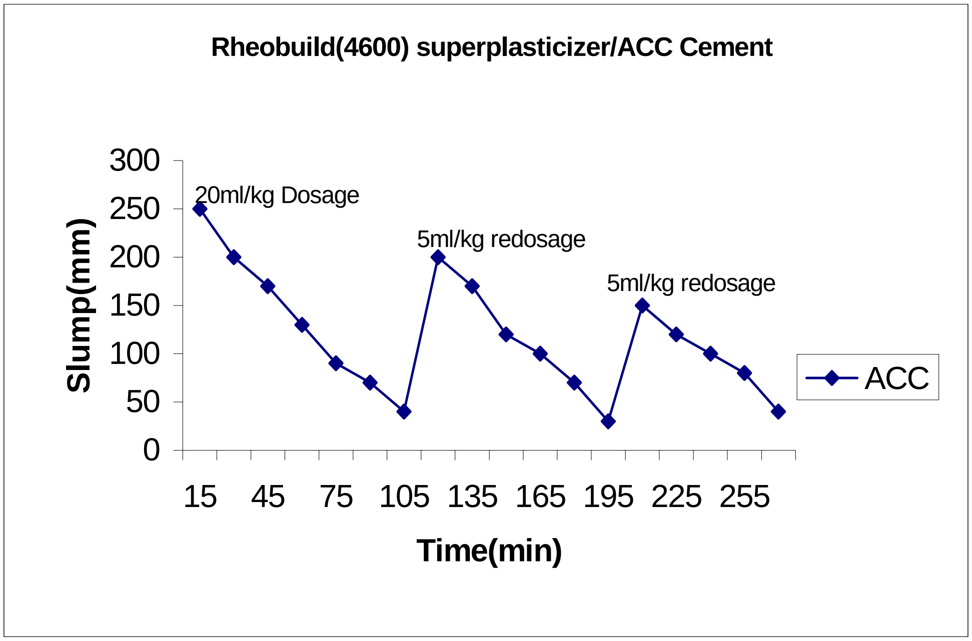


Figure 56: Variation of workability with time for M30 concrete

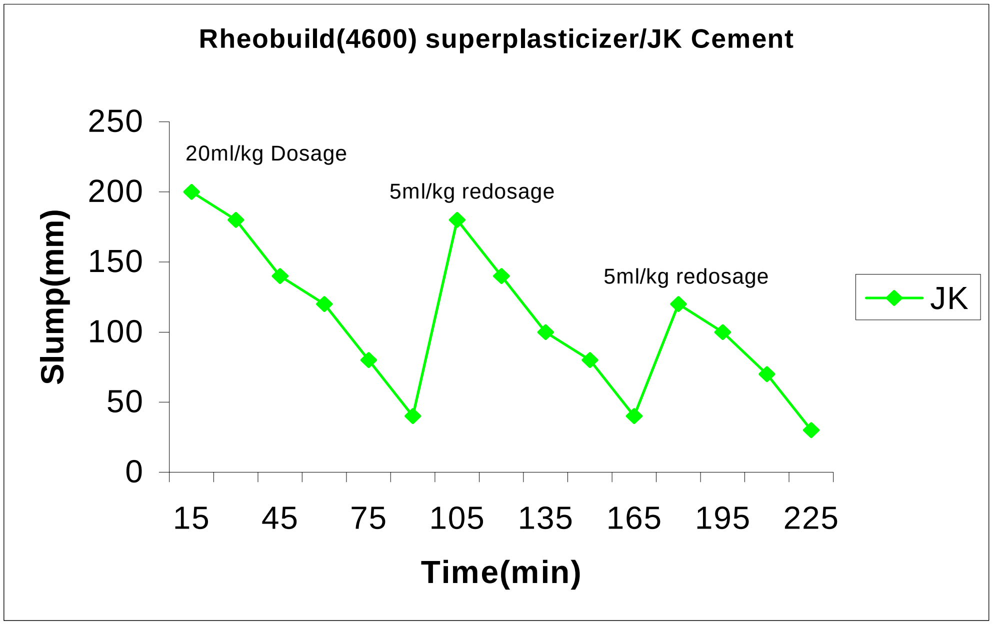


Figure 57: Variation of workability with time for M30 concrete

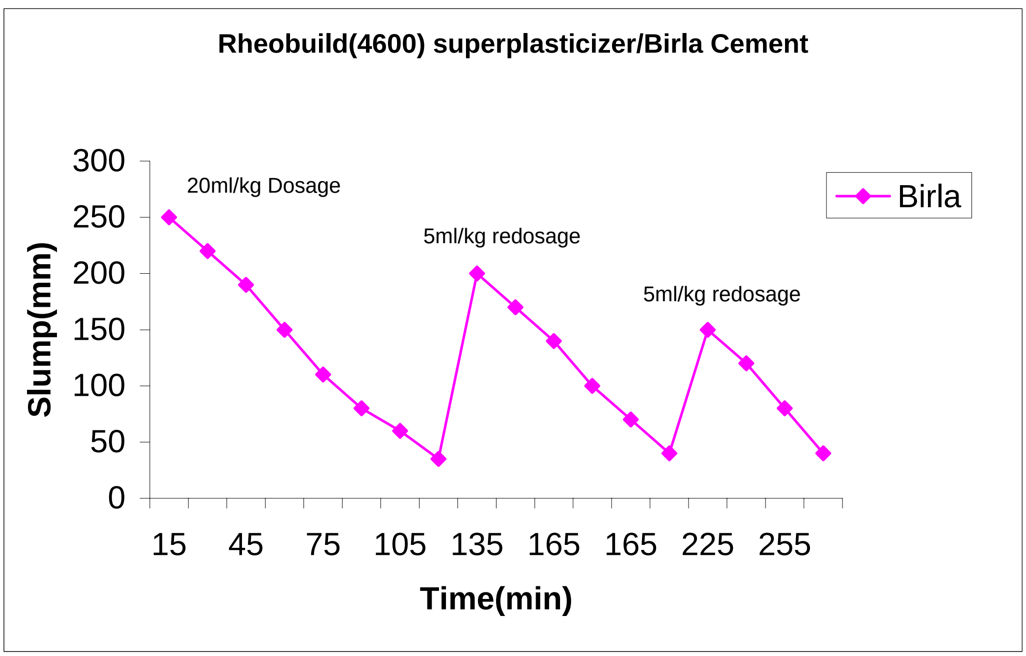


Figure 58: Variation of workability with time for M30 concrete

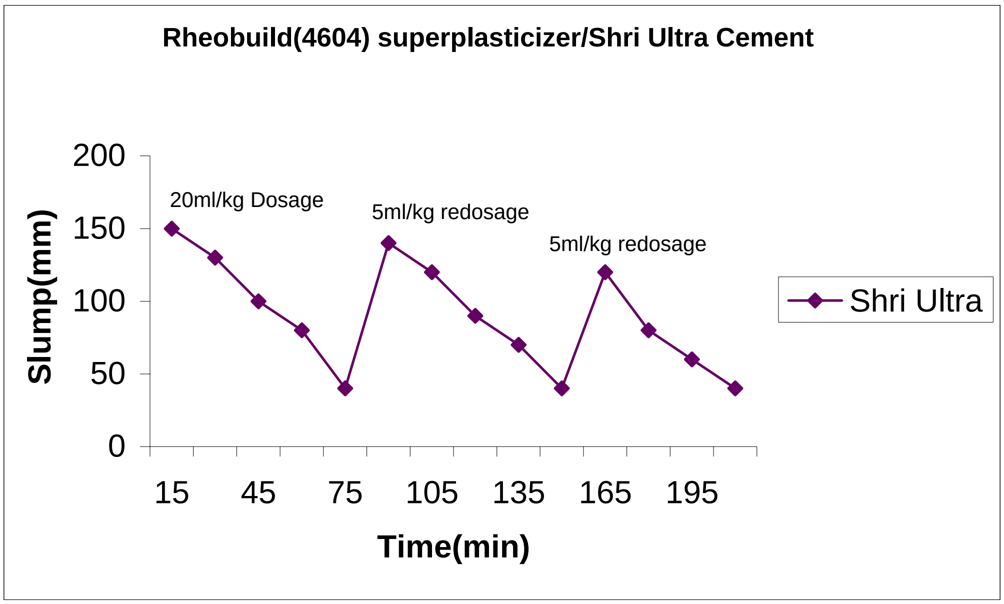


Figure 59: Variation of workability with time for M35 concrete

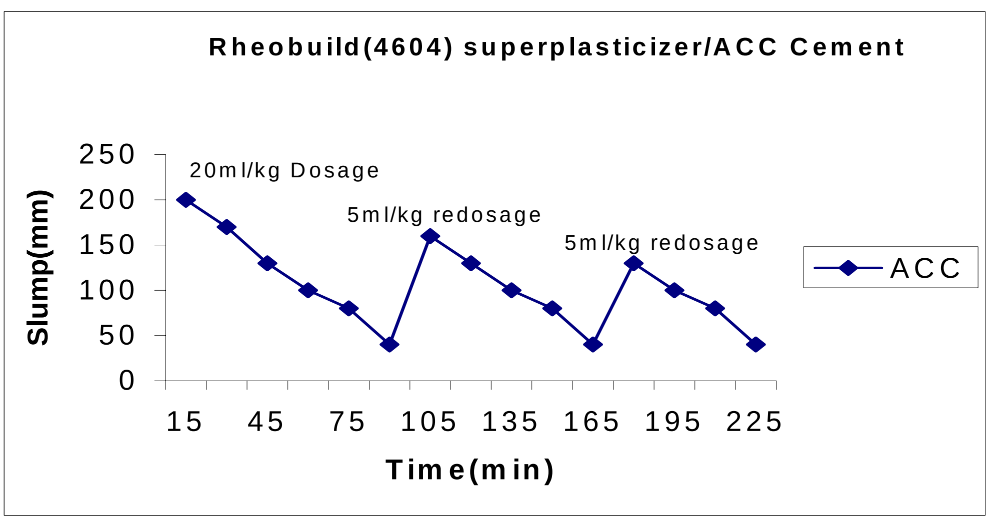


Figure60: Variation of workability with time for M35 concrete

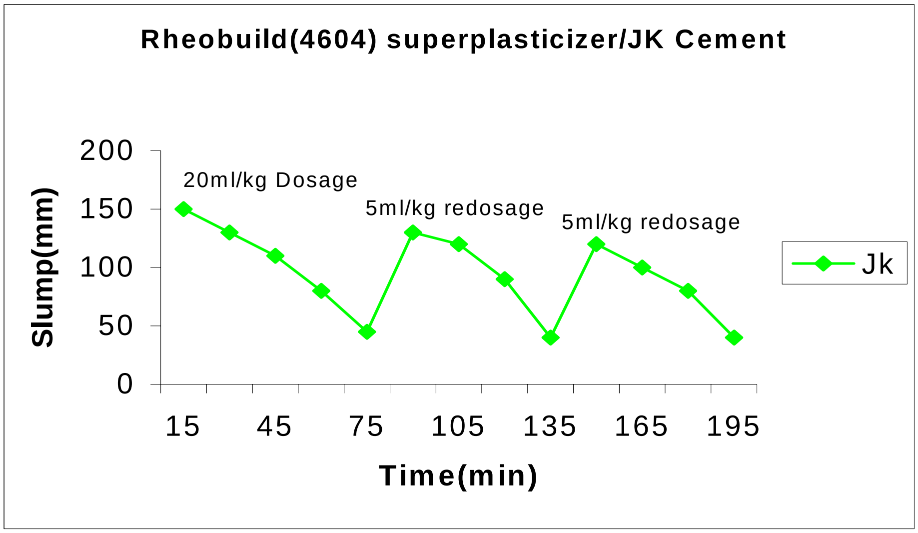


Figure 61: Variation of workability with time for M35 concrete

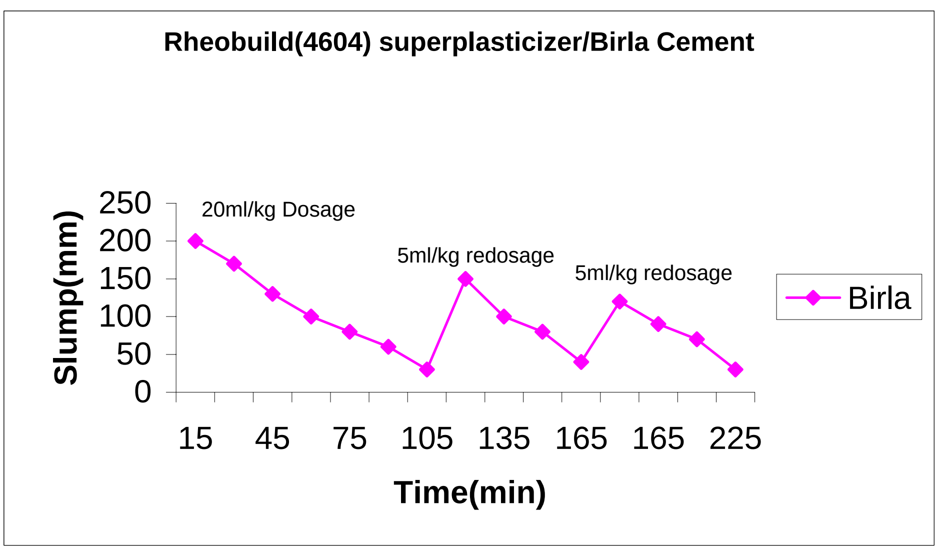


Figure 62: Variation of workability with time for M35 concrete

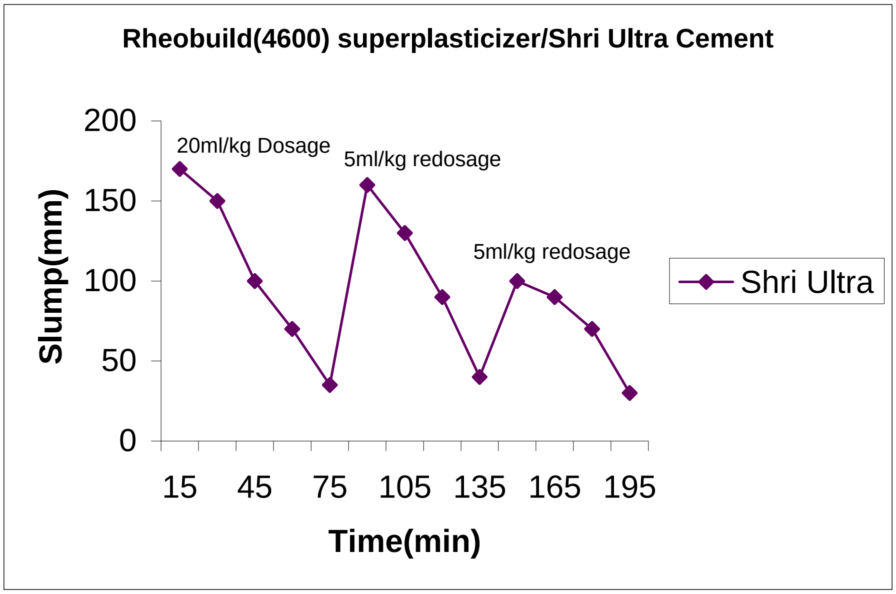


Figure 63: Variation of workability with time for M35 concrete

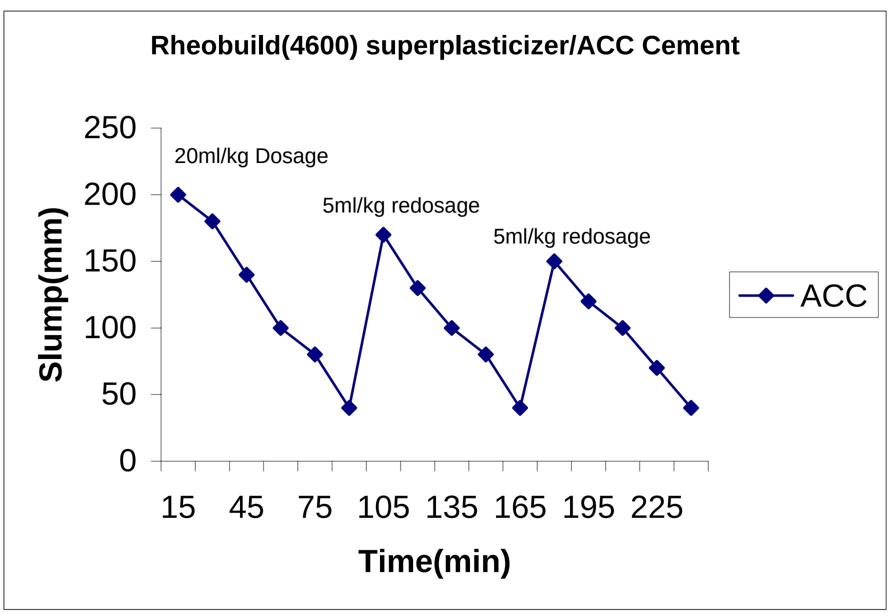


Figure 64: Variation of workability with time for M35 concrete

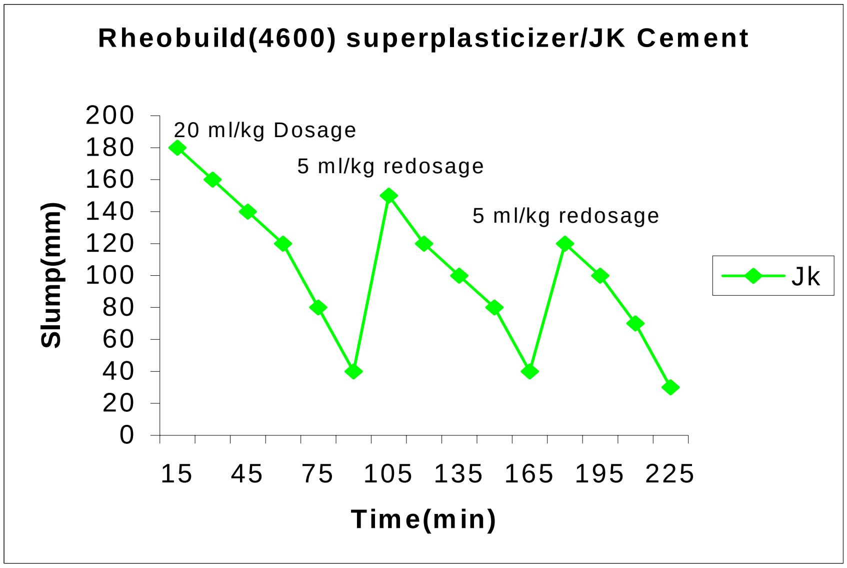


Figure 65: Variation of workability with time for M35 concrete

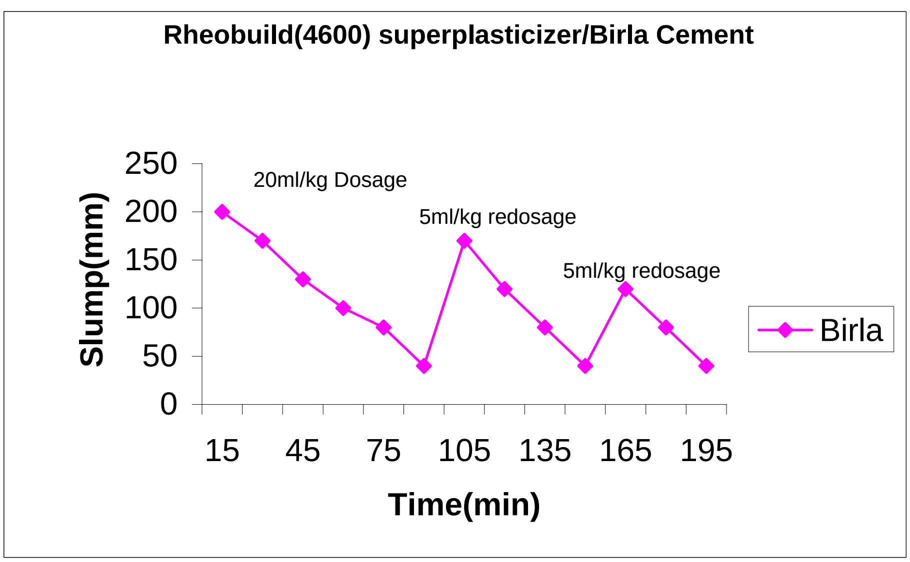


Figure 66: Variation of workability with time for M35 concrete

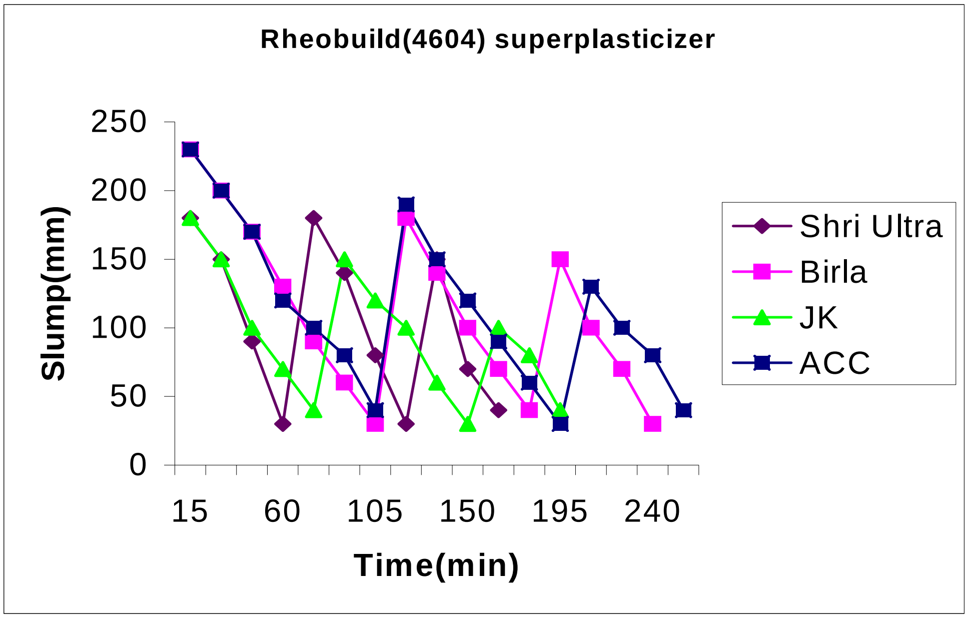


Figure 67: Variation of workability with time for M30 concrete

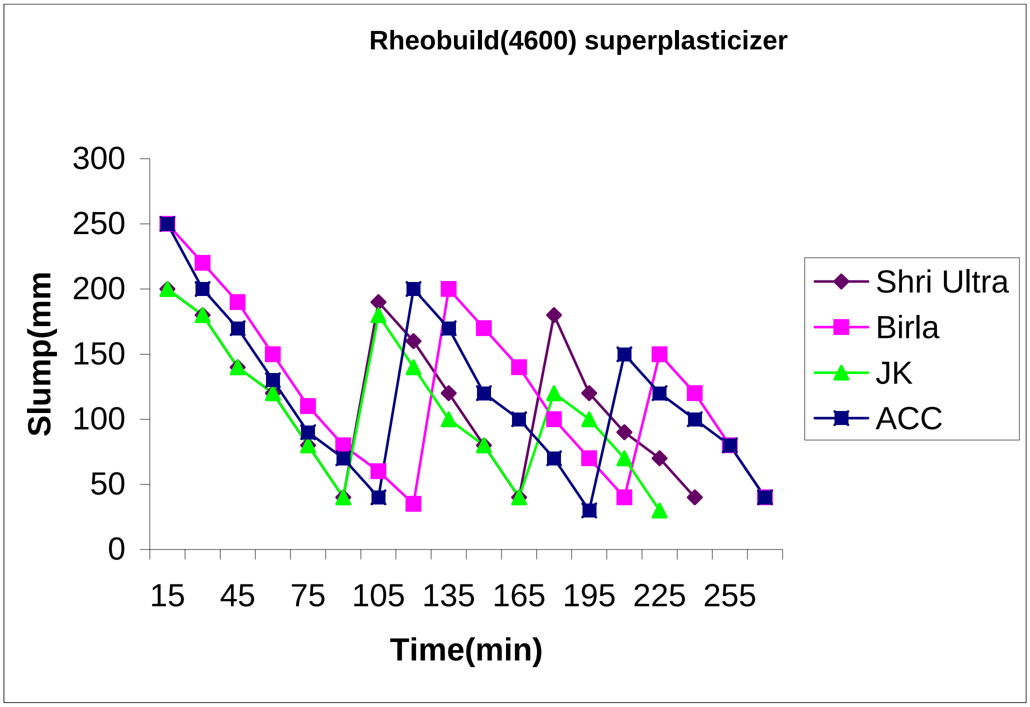


Figure 68: Variation of workability with time for M30 concrete

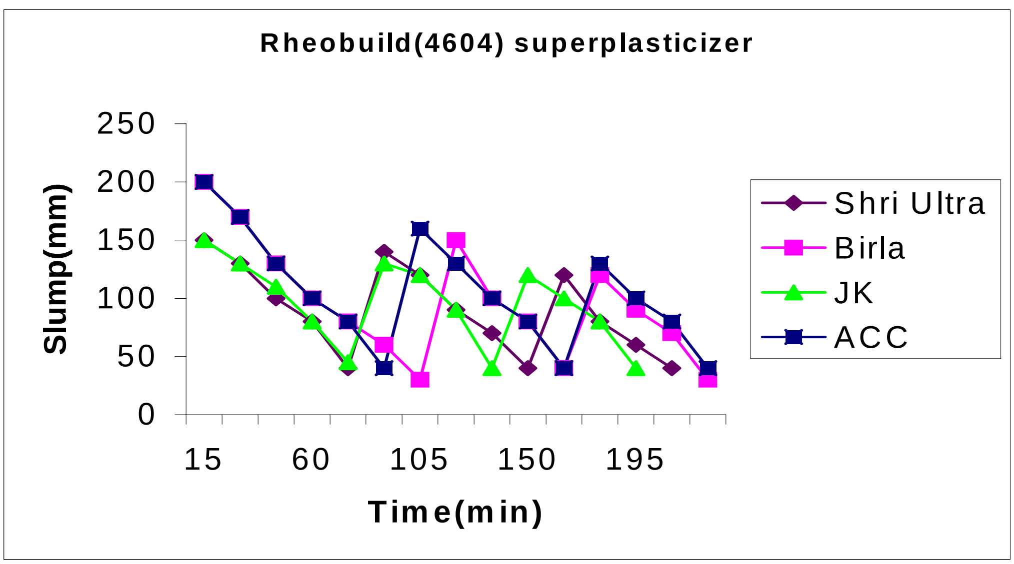


Figure 69: Variation of workability with time for M35 concrete

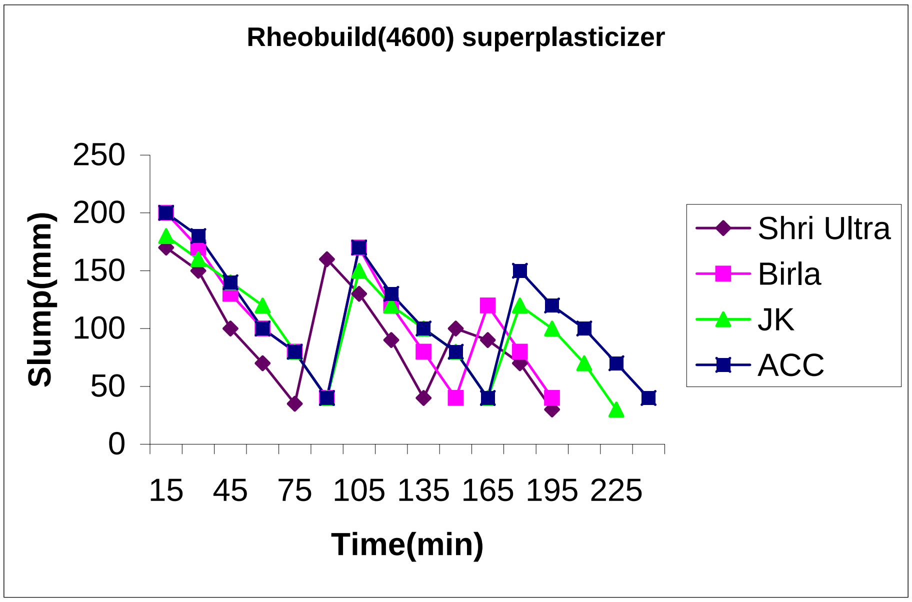


Figure70: Variation of workability with time for M35 concrete

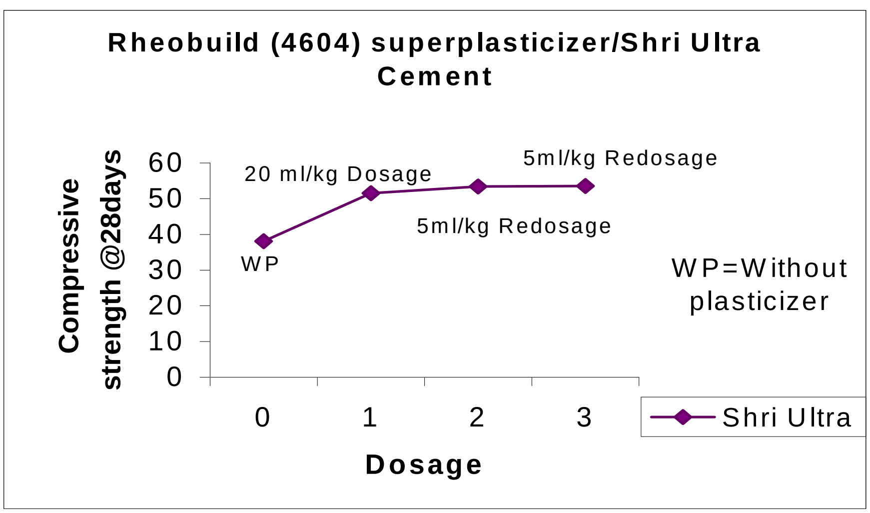


Figure 71: Variation of strength with dosage for M35 concrete

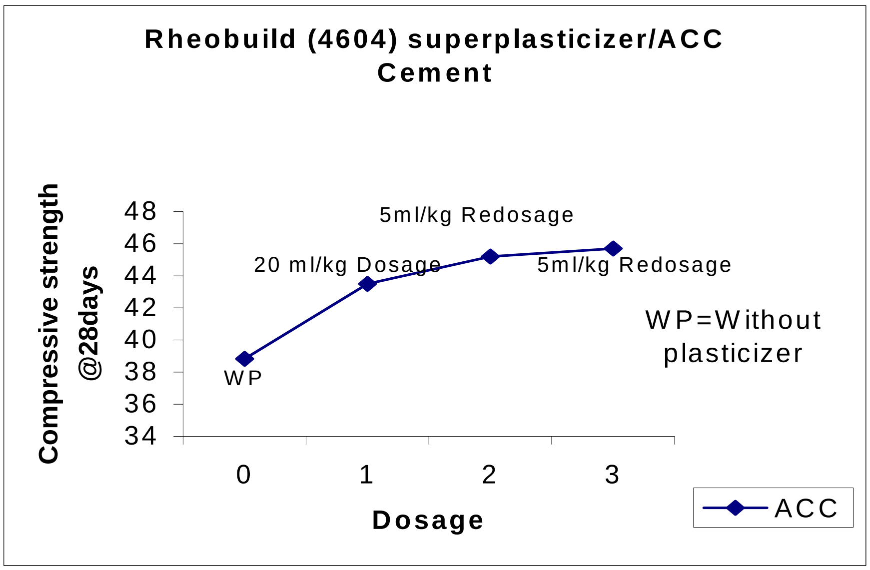


Figure 72: Variation of strength with dosage for M35 concrete

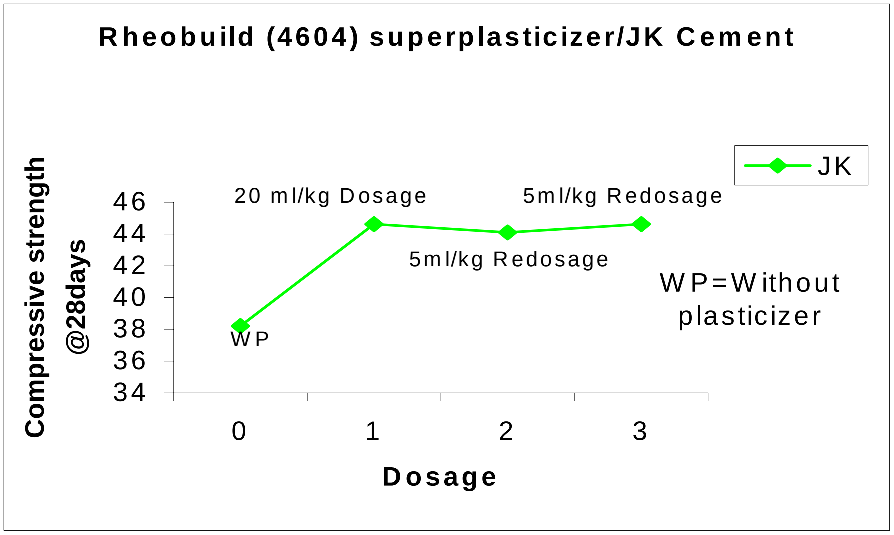


Figure 73: Variation of strength with dosage for M35 concrete

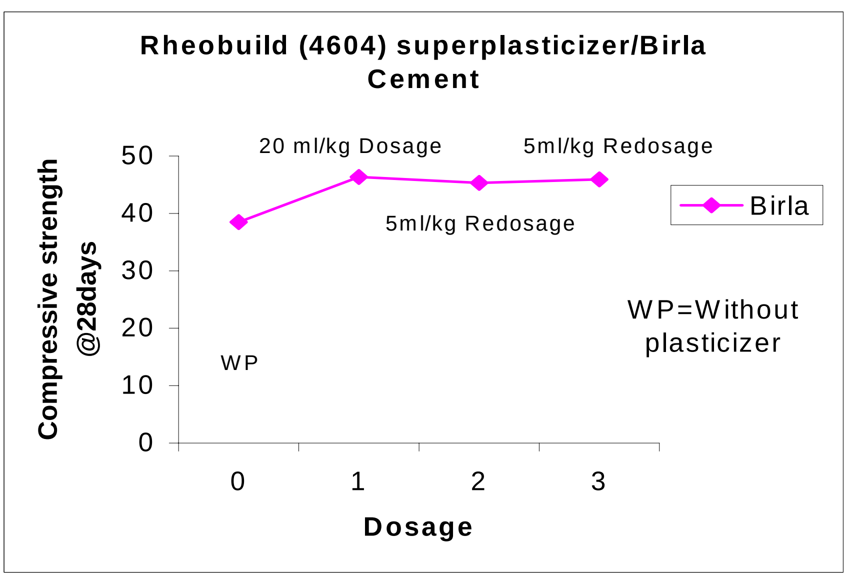


Figure 74: Variation of strength with dosage for M35 concrete

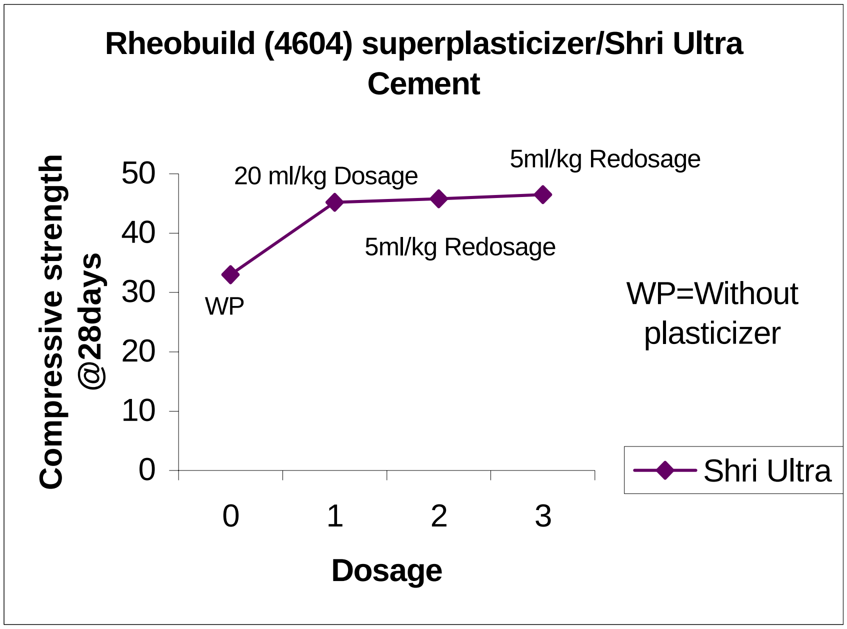


Figure 75: Variation of strength with dosage for M30 concrete

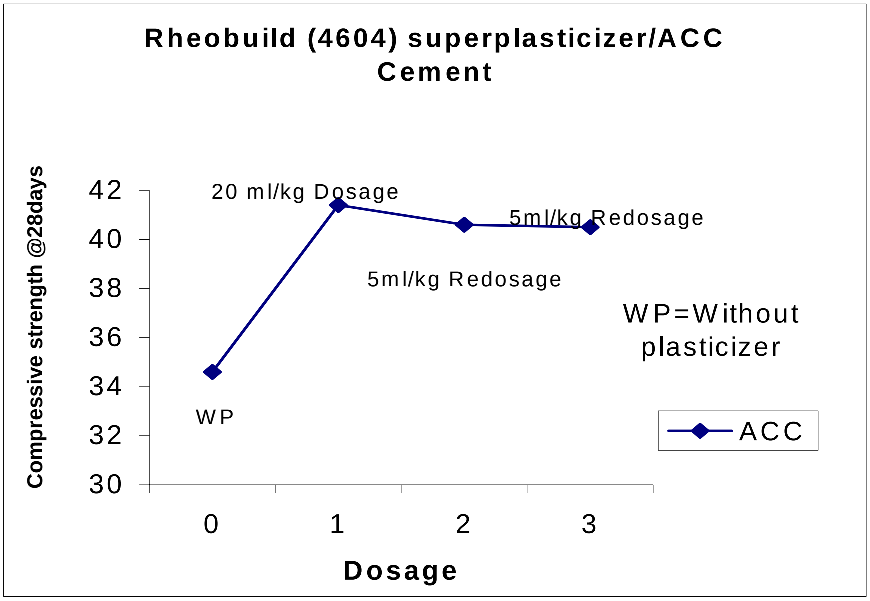


Figure 76: Variation of strength with dosage for M30 concrete

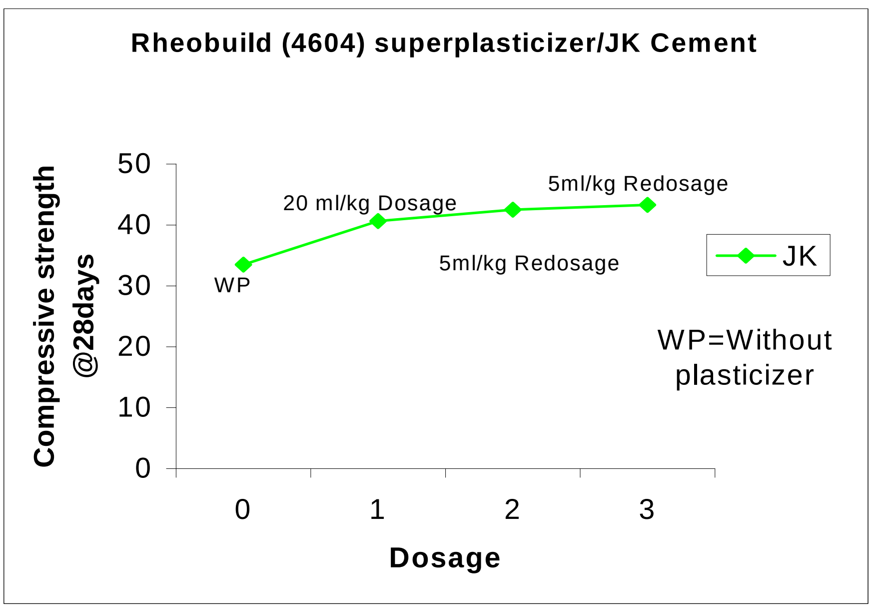


Figure 77: Variation of strength with dosage for M30 concrete

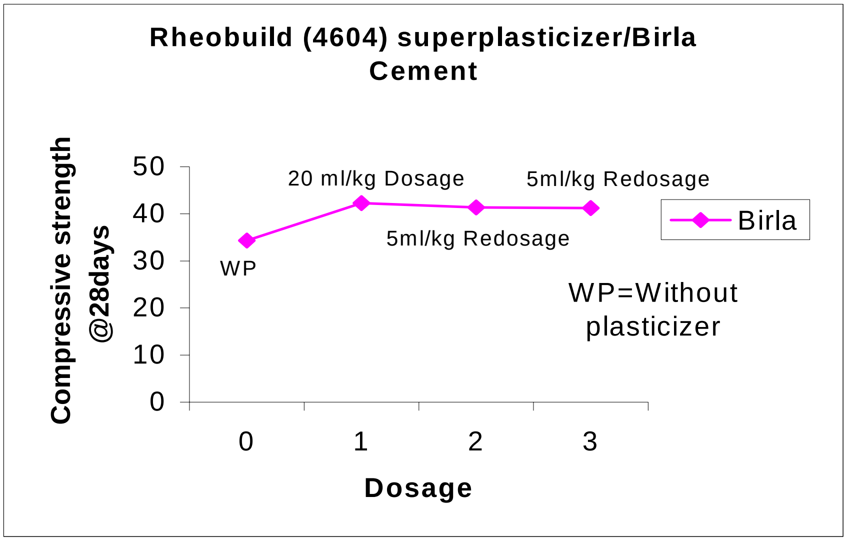


Figure 78: Variation of strength with dosage for M30 concrete

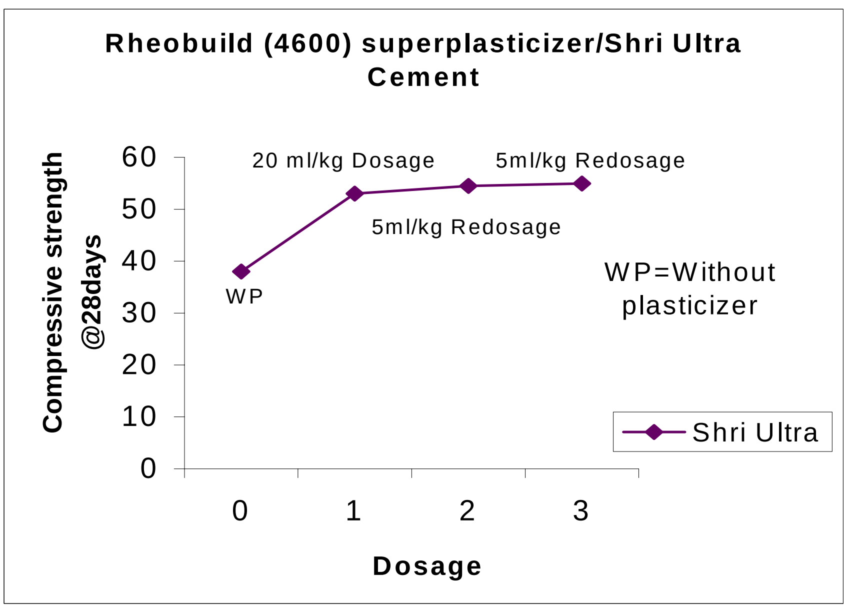


Figure 79: Variation of strength with dosage for M35 concrete

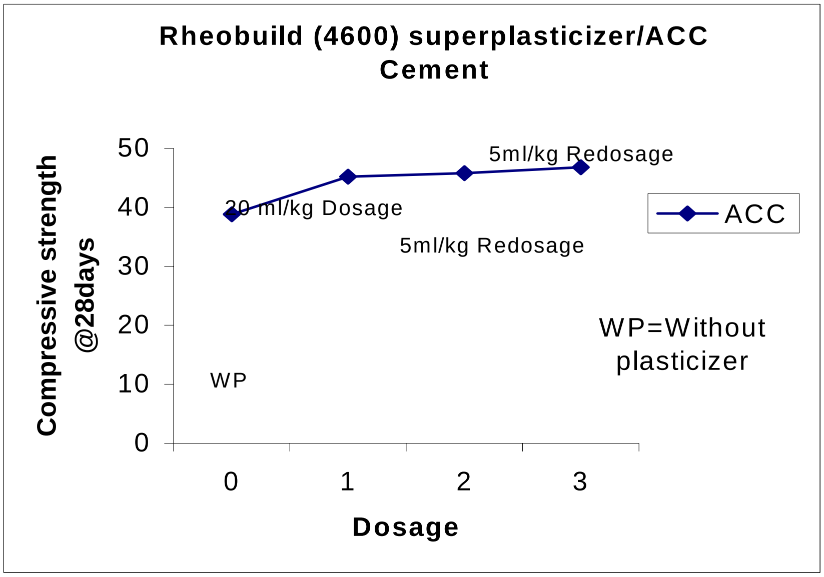


Figure 80: Variation of strength with dosage for M35 concrete

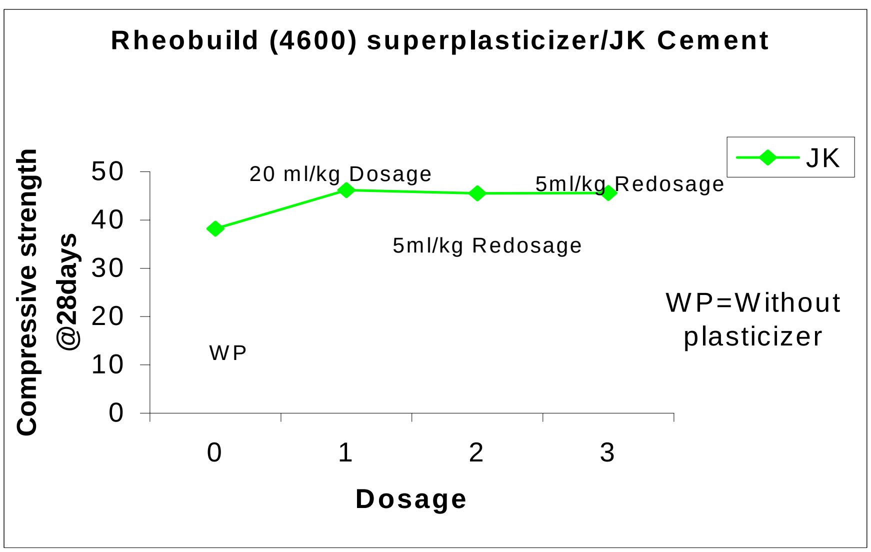


Figure 81: Variation of strength with dosage for M35 concrete

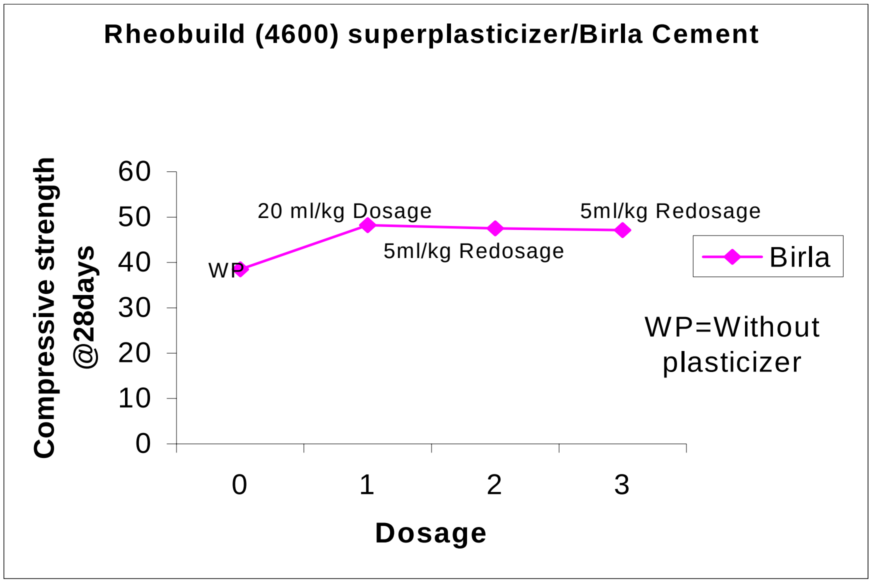


Figure 82: Variation of strength with dosage for M35 concrete

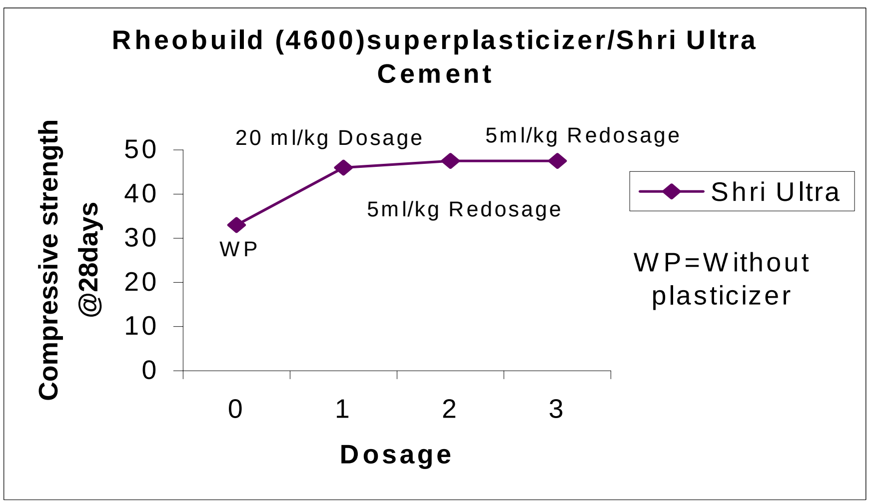


Figure 83: Variation of strength with dosage for M30 concrete

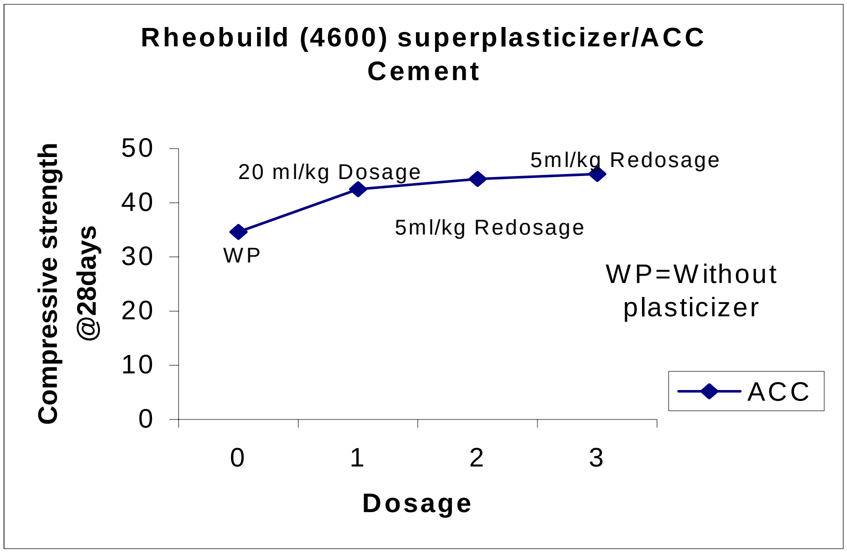


Figure 84: Variation of strength with dosage for M30 concrete

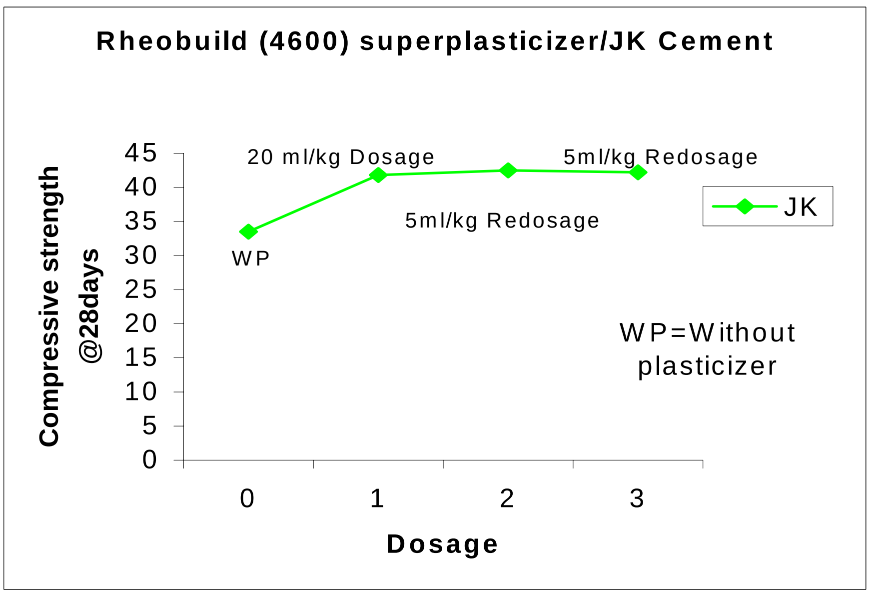


Figure 85: Variation of strength with dosage for M30 concrete

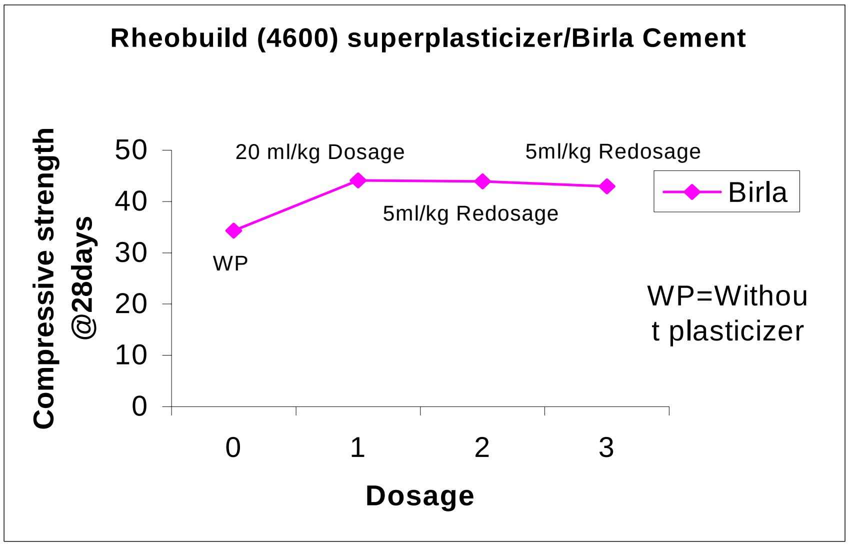


Figure 86: Variation of strength with dosage for M30 concrete

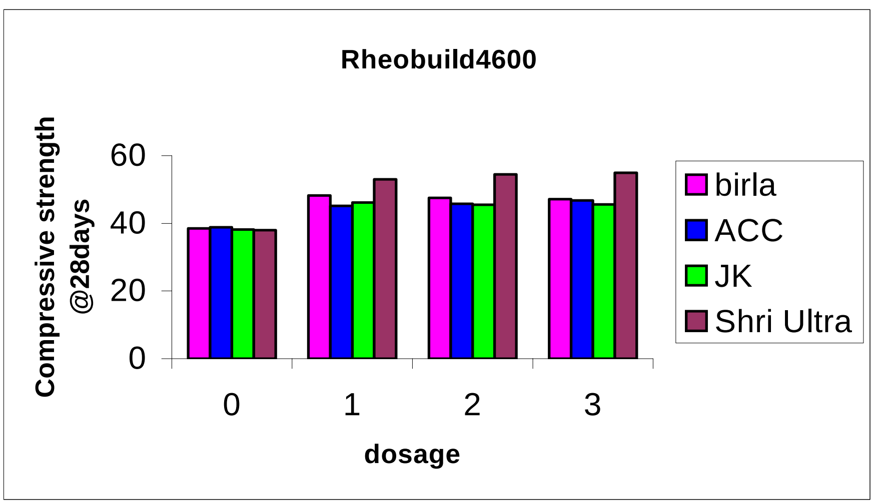


Figure 87: Variation of strength with dosage for M35concrete

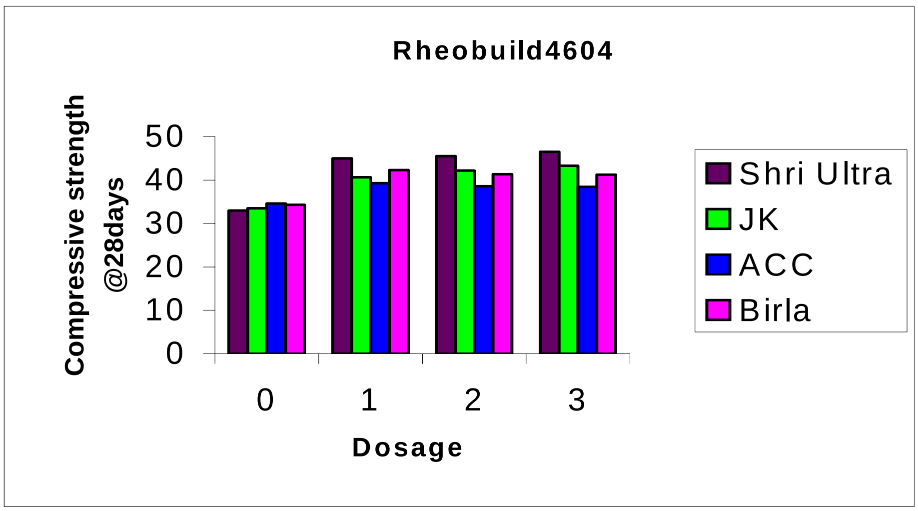


Figure 88: Variation of strength with dosage for M30 concrete

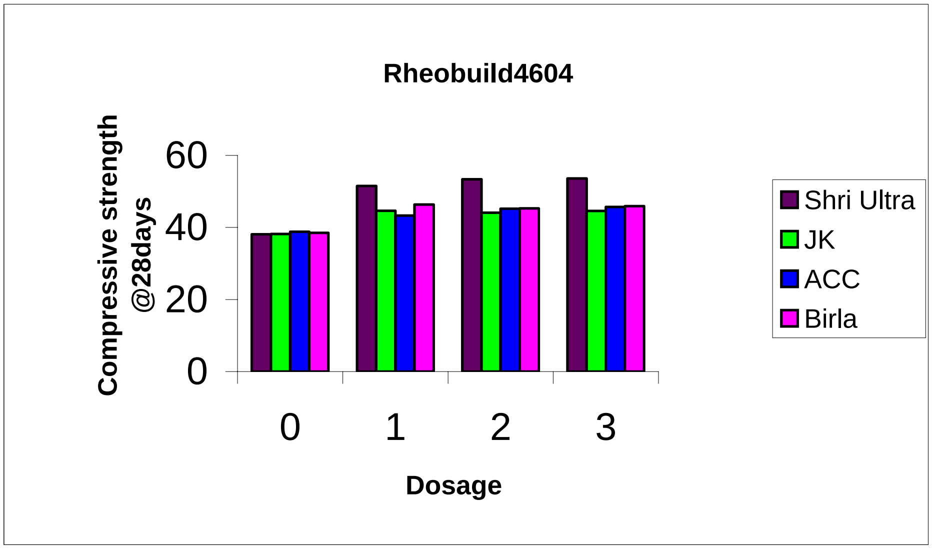


Figure 89: Variation of strength with dosage for M35 concrete

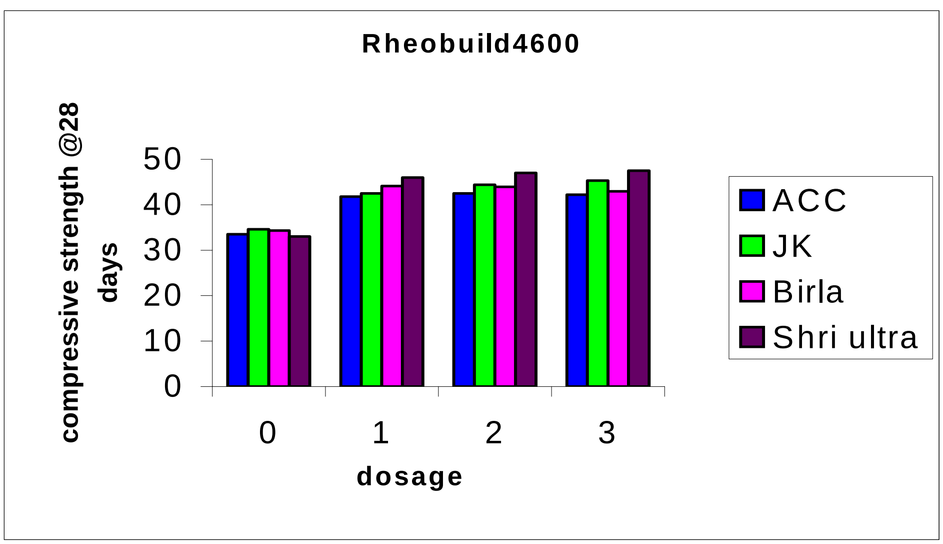


Figure 90: Variation of strength with dosage for M30 concrete

Table-1: Variation of compressive strength with dosage

Grade of concrete	For Cemwet SP 3000 ACC cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M20	24.2	25	27	27.3
M25	30	31.1	31.7	32.6
M30	34.6	37.8	38.5	39.8
M35	38.8	42	42.5	44.6

Table-2: Variation of compressive strength with dosage

Grade of concrete	For Cemwet SP 3000 JK cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M20	23.5	24.8	26.8	28.3
M25	27.6	29.8	32.5	34.5
M30	33.5	37.1	40.5	40.7
M35	38.2	42.8	41.9	41.8

Table-3: Variation of compressive strength with dosage

Grade of concrete	For Cemwet SP 3000/Birla Cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M20	25	26.9	27.6	29.1
M25	29.3	33.4	34.9	35.4
M30	34.3	40.4	42.1	44.5
M35	38.5	45.2	45.5	46.7

Table-4: Variation of compressive strength with dosage

Grade of concrete	For Cemwet SP 3000 Shri Ultra Cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M20	23.2	27.1	27.5	28.3
M25	27.5	35.2	37	37.8
M30	33	43.5	44.2	44.5
M35	38.1	49.5	50.5	52.3

Table-5: Variation of compressive strength with dosage

Grade of concrete	For Fosroc Superplasticizer /ACC Cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M35	38.8	39.8	38.5	37.5

Table-6: Variation of compressive strength with dosage

Grade of concrete	For Fosroc Superplasticizer/ JK Cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M35	38.2	42.4	39.8	36.8

Table-7: Variation of compressive strength with dosage

Grade of concrete	For Fosroc Superplasticizer/ Birla Cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M35	38.5	41.5	39.2	36.5

Table-8: Variation of compressive strength with dosage

Grade of concrete	For Fosroc Superplasticizer Shri Ultra Cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M35	38.1	44.7	45.7	47.5

Table-9: Variation of compressive strength with dosage

Grade of concrete	For Rheobuild 4604 ACC Cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M30	34.6	41.4	40.6	40.5
M35	38.8	43.5	45.2	45.7

Table-10: Variation of compressive strength with dosage

Grade of concrete	For Rheobuild 4600 ACC Cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M30	34.6	42.5	44.4	45.3
M35	38.8	45.2	45.8	46.8

Table-11: Variation of compressive strength with dosage

Grade of concrete	For Rheobuild 4604 JK Cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M30	33.5	40.7	42.2	43.3
M35	38.2	44.6	44.1	44.6

Table-12: Variation of compressive strength with dosage

Grade of concrete	For Rheobuild 4600 JK Cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M30	33.5	41.8	42.5	42.2
M35	38.2	46.2	45.5	45.6

Table-13: Variation of compressive strength with dosage

Grade of concrete	For Rheobuild 4604 Birla Cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M30	34.3	42.3	41.4	41.2
M35	38.5	46.4	45.3	45.9

Table-14: Variation of compressive strength with dosage

Grade of concrete	For Rheobuild 4600 Birla Cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M30	34.3	44.1	43.9	43
M35	38.5	48.2	47.5	47.1

Table-15: Variation of compressive strength with dosage

Grade of concrete	For Rheobuild 4604 Shri Ultra Cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M30	33	45.2	45.8	46.5
M35	38.1	51.5	53.4	53.6

Table-16: Variation of compressive strength with dosage

Grade of concrete	For Rheobuild 4600 Shri Ultra Cement			
	No HRWR	Dosage HRWR	First Redosage	Second Redosage
M30	33	46.2	47.5	47.4
M35	38.1	52.8	54.5	54.9

Table 17: Cement content of different graded concrete

Grade of Concrete	Cement Content (kg / m^3)
M20	418
M25	450
M30	450
M35	450

CEMWET SP 3000

Table 18: Slump Retainment Time (min.)

Grade of Conc.	ACC	Birla	JK	Shri Ultra
M20	120	90	150	120
M25	120	105	30	30
M30	105	45	30	15
M35	90	30	15	15

FOSROC

Table 19: Slump Retainment Time (min)

Grade of Concrete	ACC	Birla	JK	Shri Ultra
M35	15	15	15	15

RHEOBUILD 4604

Table 20: Slump Retainment Time (min)

Grade of Concrete	ACC	Birla	JK	Shri Ultra
M30	255	240	195	165
M35	225	225	195	210

RHEOBUILD 4600

Table 21: Slump retainment time (min)

Grade of Concrete	ACC	Birla	JK	Shri Ultra
M30	270	270	225	240
M35	240	195	225	195

CEMWET SP 3000

Table 22: Maximum compressive strength achieved in N/mm^2

Grade of Concrete	ACC	Birla	JK	Shri Ultra
M20	27.3	26.5	28.2	28.3
M25	32.6	35.3	34.5	37.8
M30	39.8	44.5	40.7	44.5
M35	44.6	46.7	42.8	**52.3**

FOSROC

Table 23: Maximum compressive strength achieved in N/mm^2

Grade of Concrete	ACC	Birla	JK	Shri Ultra
M35	37.5	40.1	42.4	47.5

RHEOBUILD 4604

Table 24: Maximum compressive strength achieved in N/mm^2

Grade of Concrete	ACC	Birla	JK	Shri Ultra
M30	41.4	42.3	43.3	46.5
M35	45.7	46.4	44.6	**53.5**

RHEOBUILD 4600

Table 25: Maximum compressive strength achieved in N/mm^2

Grade of Concrete	ACC	Birla	JK	Shri Ultra
M30	45.3	43.9	42.5	47.5
M35	46.8	48.24	46.2	**54.9**

1) Without the use of HRWR, the workability of all the mixes is found to be zero slump for all the four cements used.

2) Without the use of HRWR, the compressive strength of all the four mixes, i.e., M20, M25, M30, and M35 is found to be acceptable at 28 days for all the four cements used.

3) The compatibility of various cements, as tested with Cemwet SP3000 HRWR, for various dosages, showed that the best workability is achieved for:

   10 ml/kg cement dosage with JK cement and Shri Ultra cement.

   15 ml/kg cement dosage with ACC cement and Birla cement.

   The workability achieved at these dosages was between 150 to 200 mm slump.

4) A dosage of 20 ml/kg cement used for Fosroc Conplast SP 430SRV HRWR resulted in very low workability, between 10 to 15 mm slump, for all cements used. This shows that 20 ml/kg Cement is not the optimum dosage for this HRWR.

5) A dosage of 20 ml/kg cement used for Rheobuild 4600 and 4604 HRWR resulted in very good workability, between 150 to 200 mm slump, for all cements used.

6) Upon using two redosages of Cemwet SP3000 HRWR with the optimum dosage as given in (3) above, the slump retention time could be increased to 120 minutes or more for all the cements used.

7) Upon using two redosages of Fosroc Conplast SP 430SRV HRWR with an initial dosage of 20 ml/kg cement, the slump of 10 to 15 mm could be retained for 15 minutes only.

8) Upon using two redosages of Rheobuild 4600 and 4604 HRWR with an initial dosage of 20 ml/kg Cement, the slump retention time could be increased as much as 200 minutes to 270 minutes for all the cements used.

9) It is observed that the compressive strength of concrete increases with each redosage for the use of Cemwet SP3000, Rheobuild 4600 and Rheobuild 4604.

10) The use of Cemwet SP3000 HRWR with ACC Cement results in upto 15% increase in compressive strength as a result of two redosages. When JK Cement is used, this increase is upto 25%. For Birla Cement, the increase is upto 29%. When Shri Ultra Cement is used, this increase is upto 37%.

11) The use of Rheobuild 4600 HRWR with ACC Cement results in upto 31% increase in compressive strength as a result of two redosages. When JK Cement is used, this increase is upto 26%. For Birla Cement, the increase is upto 28%. When Shri Ultra Cement is used, this increase is upto 44%.

12) The use of Rheobuild 4604 HRWR with ACC Cement results in upto 17% increase in compressive strength as a result of two redosages. When JK Cement is used, this increase is upto 29%. For Birla Cement, the increase is upto 23%. When Shri Ultra Cement is used, this increase is upto 41%.

13) The mixes made with Shri Ultra Cement were found to be always cohesive, whereas, other mixes tended to bleed.

14) Thus it is concluded that the optimum dosage of HRWR for any Cement can be determined through a compatibility study conducted in the laboratory.

15) Redosages of HRWR result in increased compressive strength as well as increased slump retention for the optimum initial dosage of HRWR.

16) Redosages of HRWR with more than optimum initial dosage of HRWR result in maximum increased compressive strength.

Scope of further study:

1) Use of redosage of HRWR with flyash concrete.

2) Effect of exposure to acidic environment on redosage concrete.

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