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EFFECT OF WATER-REDUCING
ADMIXTURES ON PROPERTIES OF CONCRETE

BY

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PART I

L I T E R A T U R E S U R V E Y
ON EFFECT OF WATER REDUCING ADMIXTURES .

INTRODUCTION

The aim of this study is to introduce water reducing admixtures and investigate their effect on Turkish Cement. The first part is a literature survey of the effect of water-reducing admixtures on properties of concrete. We pay special attention on air-entrainment effect because some of the water reducing admixture introduce air in the concrete.

In the second part of the report, laboratory experiment is performed at Robert college laboratory to determine the useful effects of water reduction. (see page 32)

CHAPTER I

ADMIXTURES FOR CONCRETE

I - Introduction:

An admixture is defined in ASTM Designation C 125 as "A material other than water, aggregate and portland cement that is used as an ingredient of concrete and is added to the batch immediately before or during its mixing". If added to the portland cement at the cement such materials are defined as additives.

Usually an admixture is used to modify the properties of the concrete in such a way as to make it more suitable for the work at hand. Under certain conditions, use of a suitable admixture may impart desirable characteristics which cannot be secured as economically by other methods.

According to American Concrete Institute Committee 212 (1),
"Some of the more important modifications of properties of concrete which have been the objective of the use of admixtures are:

- 1) Improvement of workability
- 2) Acceleration of the rate of strength development at early ages.
- 3) Retardation of initial stiffening or too rapid set.
- 4) Retardation or reduction of heat evolution.
- 5) Reduction in bleeding.
- 6) Increase in durability or in the resistance to special conditions of exposure.
- 7) Control of alkali-aggregate expansion.
- 8) Decrease in capillary flow of water.
- 9) Decrease in the permeability.
- 10) Production of cellular concrete.
- 11) In grout mixtures, the improvement of penetration and pumpability and the reduction of segregation.
- 12) Prevention of settlement or creation of slight expansion in concrete and mortar used for filling blockouts or other openings in concrete structures.
- 13) Increase in bond to steel reinforcement.

In considering the effects of admixtures on concrete, the committee is pointed out that: (1)

" I) At times a change in type of cement or amount of cement used, or a modification of aggregate grading or mix proportions may offer economical approach to the objectives desired.

2) Many admixtures affect more than one property of concrete.

3) The effects of some admixture are significantly modified by such factors as wetness and richness of mix, by aggregate grading and by the character and length of mixing.

4) The specific effects of some admixtures vary with the type and with the brand of cement used."

II - Classification :

Admixtures are divided into eleven groups depending upon the materials constituting the admixture or the characteristic effects of their use. (1) These groups are:

- I) accelerators
- 2) retarders
- 3) air-entraining agents.
- 4) gas foaming agents.
- 5) cementitious materials.
- 6) pozzolans.
- 7) alkali-aggregate expansion inhibitors.
- 8) damp-proofing and permeability agents.
- 9) workability agents.
- 10) grouting agents.
- II) miscellaneous
 - a) Fungicidal compounds
 - b) Coloring compounds.

CHAPTER II

WATER AND CEMENT

In 1919, hundred years after portland cement was first used for construction purposes, Duff Abrams, studied the effect of water in various concrete mixes and discovered a direct, almost straight line relationship between water content and concrete strength. According to Abrams for every percentage point decrease in the amount of water used, there is a corresponding improvement in strength provided the mix is workable and placeable(2).

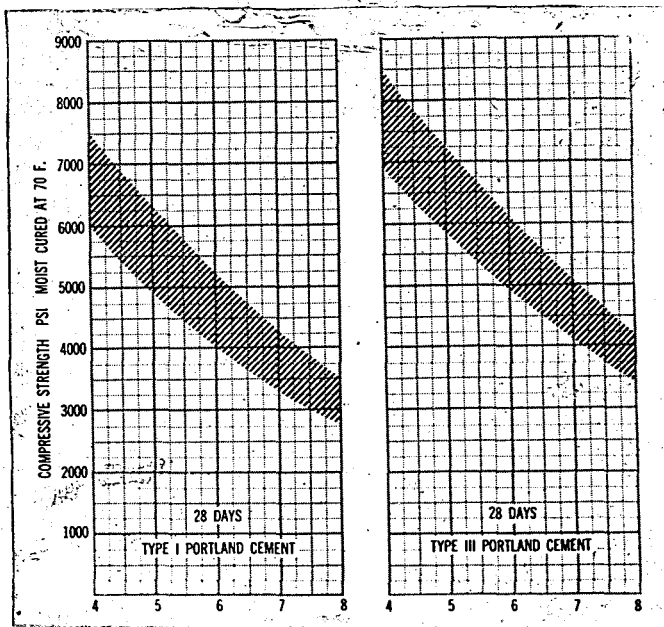


Fig: I Effect of water on compressive strength.

Before discussing the effects of water reduction, it will be helpful to consider the fundamental structure of concrete as it is understood today. The chemical reaction known as hydration begins as soon as water and cement are mixed. This action converts cement particles to cement gel, which hardens the plastic paste and thus hardens the concrete. Under the electron microscope the interaction of cement grains and water appears to produce extremely small crystals in the form of rod-like fibrous particles(4)(5). These fibers interlace into a discontinuous mass with bundles joined irregularly. and at random into a kind of XXXX felting. It has been found that

increasing the water/cement ratio does not alter the fibrous pattern. Instead, extra water in the mix forms submicroscopic spaces, called "capillary pores" in the paste itself during the setting and hardening process. The chemical conversion of each cement particle requires a

specific amount of water and any unusual water present remains as excess. It is conjectured that some excess water is stored in the open spaces between the fibers and in the relatively large open areas between the fiber bundles. Water which cannot be accommodated in these ways is forced by gravitational pressure to the surface through water channels and capillary pores. There it appears as bleeding water with fine particles of cement and sand in suspension and upon drying produces a mortar like surface. Drying or curing of the entire mass eventually occurs, perhaps by a combination of osmosis and adsorption with capillary transmission. The residual capillary pores and channels, however, leave the hardened concrete weakened to the extent that they break up the continuity of the gel.



Structure of hardened cement paste

Fig: 2a having water/cement ratio of 0.50 by weight, 20 per cent porosity.

Fig: 2b having water/cement ratio of 0.30 by weight, 7 per cent porosity. (6)

In addition, the residual porosity offers a means for the admission of ground water, the deposition of soluble salts after drying, and the resulting destructiveness of crystal growth within the concrete, usually manifested by flaking.

Gel formation in hardened paste made with an original water cement ratio of 0.50 by weight, as seen under the electron microscope is shown schematically in Fig: 2b The mass of interlaced gel fibers

is seen to be invaded by relatively large voids(white spaces) which had served as storage tanks for the eXcess water of the fresh mortar. Porosity is of the order of 20 per cent. In fig: 2a is seen the gel structure of a hardened paste made with an original water cement ratio of 0.30 by weight, taken at the same magnification. The porosity now is of the order of only 7 per cent. The emperical knowledge that a low water/cement ratio makes better concrete is thus shown to be scientifically sound.

In any concrete miX, the total amount of water present can be divided into two categories "water of hydration" and "water of convenience". Water of hydration is the amount needed to promote the basic chemical reaction between cement and water. Water in eXcess of this amount, added to make the miX fluid and easier to place is water of convenience.

Any of the five standard types of cement recognized by the ASTM requires about 3 gal. of water per sack of cement for chemical hydration, a 0.27 water/ cement ratio by weigth. Another 1 gal. per sack is required to saturate the gel spaces, the total of 4 gal. per sack giving a 0.35 water/cement ratio by weight. Any additional water serves no usefùl purpose structurally and in fact, as has been shown, reduces strength and other desirable properties.

However, eXcess water does serve to make the miX more fluid and therefore easier to transport and place. But this fluidity is purchased at a dangerously high price... at the cost of such factors as increased segregation, bleeding, channeling, permeability and shrinkage, and reduced strength and durability.

CHAPTER III

AIR ENTRAINMENT

I.-Introduction

Air entrainment in concrete may be defined as the introduction of air in controlled amounts and in the form of properly-sized well-dispersed air bubbles. This air is introduced, through the whipping action of the concrete mixer, but the size, quantity distribution and stability of the bubbles are controlled by the addition of an air entraining agent.

The principal effects of entrained air on the physical properties of concrete are follows:

- 1) The water requirement of concrete is reduced and part of the free water is thereby eliminated.
- 2) The distribution of minute spheroids of air throughout the paste tends to decrease its porosity by reducing the capillary and water channel structure of the matrix.
- 3) Workability is increased.
- 4) Durability against freezing and thawing is markedly improved.
- 5) Some strength reduction occurs.

II.-How air cause decrease of water:

The water reducing property of intentionally entrained air is primarily due to the substitution of air for water. These very fine bubbles of air may be looked upon as fine aggregate distributed throughout the paste portion of the concrete. They add greatly to the workability of the plastic concrete by aiding the internal arrangement of the rigid particles and in this way relieve a portion of the cement paste from the function of being a lubricant. The net result of this action is a decrease in the amount of water required to place the concrete.

The air entraining agents do not put air into a mix, the air must be already there by virtue of inclusion with the cement and aggregates or by the folding in action of the mechanical mixer. The air-entraining agent distributes this film around each bubble

to stabilize its size and life and establishes a degree of adhesion between the cement grains and the air bubbles.

III.-Mechanism by which entrained air improves the durability:

Mechanism by which entrained air improves the durability of concrete is very complex and the following explanation is a very simplified version. Entrained air bubbles may be looked upon as reservoirs which provide room for the expansive action that takes place when water changes from liquid to the solid state (freezing) within hardened concrete. This expansive action results in an increase in volume of about nine per cent and creates an expansive force sufficient- if unrelieved to rupture even the strongest concrete. (5) (7)

However, with air entrained concrete, as ice forms at increasing depths from the surface, the excess water is forced ahead of it through the capillaries and channels and into the air voids. When the concrete thaws, the water is drawn back out of these voids and into the capillaries and channels. The concrete is thus again prepared to withstand subsequent cycles of freezing and thawing.

IV.-Strength:

Intentionally entrained air may be looked upon as additional fine aggregate, but it should be realized that these spheroids of air do not contribute to the strength of concrete. Air entrainment is therefore limited to the amount necessary for adequate frost protection and the accompanying decrease in strength is accepted as a penalty.

V.-Average air contents:

In general, the air content of concrete should be controlled to amounts between 3 per cent and 5 per cent by volume of the concrete because: If less than

a) If less than 3 per cent is entrained the full benefits in workability and durability may not be obtained.

b) If more than 5 percent is entrained, strength is apt to be impaired while durability is enhanced only a negligible amount. In floor slabs which are to be finished by mechanical steel troweling, the maximum air content should not exceed 4 per cent since otherwise striking and dragging may occur. In lean mixes, say 5 sacks per yard

or less, a top limit in air content of 6 per cent is frequently not only permissible but desirable in order to obtain maximum water cuts.(5)

TABLE I

Air contents required for frost resistant concrete made with different
MaX size aggregates(8)

MaX size of coarse aggregate inches	Air content in percent
3/8	8
1/2	7
3/4	6
1	5
1 1/2	4.5
2	4
3	3.5
6	3

VI:-Factors which affect the air content of concrete:

I, -MiX proportions:

a) Ratio of fine to coarse aggregate.

The air content increases when the percentage of sand is increased (from 3 percent air with 30 percent sand to 4 percent air with 40 percent sand).(5)

b) Gradation of sand:

The majority of the entrained air is produced by the sand passing the 30 mesh screen and retained on the 70 mesh screen Sand passing the 100 mesh screen fills the voids between the active size sand and reduces their effectiveness. About 2 per cent passing the 100 mesh screen is average. Higher percentages passing 100 mesh will require more air entraining admixture to obtain desired air content.(12)(13)

c) -Coarse aggregate

One-Fourth inch and larger aggregate has very little effect

on air content. However, dirty, coarse aggregate or rock dust will act the same as minus 100 sand and make it more difficult to entrain air(7)

d) Other admixtures.

All of the natural or artificial pozzolantic materials (such as fly ash, lime dust, shales, diatomaceous earth, etc.) reduce the air content and require more air entraining admixture (as much as 2 to 3 times normal amounts). This is due to the fineness of the material, usually from minus 100 mesh to 300 mesh. In the case of fly ash, high carbon content also makes it more difficult to entrain air. (14)

2. Temperature of the Concrete:

Air content decreases as the temperature of the concrete increases.

With Vinsol Resin, a 40 C increase in temperature results in a loss of air which is usually less than 10 per cent of the total air content. Other approved Air Entraining Agents lose as much as 40 per cent of the total air content (with 40 increase in temperature). (5)

3. Mixing Time: (15)

The air content reaches its maximum at approximately 2 min. with a stationary mixer and at about 5 min. when mixed in transit (approximately 50 revolutions of the mixing drum).

Insufficient or excessive mixing both result in a loss of air.

4. Slump of Concrete:

The air content increases proportionally as the slump of the concrete increases. Increase in air content by volume is approximately 1/2 per cent for each 1 inch increase in slump. (5)

5. Vibration

a) Internal A loss of approximately 10 to 15 per cent of total air content is average, however with prolonged vibration, losses up to 40 per cent may result. The higher the slump greater the loss of air due to vibration.

b) External A loss of approximately 8 to 10 percent of the total air content is average. Prolonged vibration may result in losses up to 30 per cent. (14)

6. Other factors: (14)

a) Artificial Heating or Cooling of Concrete:

Field results indicate that it requires an increase of from 25

percent to 50 per cent in the amount of air entraining admixture when the concrete temperature is raised by means of heating the water and/or aggregates.

b.-Hard Water

Field results seem to indicate that hard water (caused by the presence of any one or combination of minerals) tend to reduce air contents and require more air entraining admixture to obtain desired air content. Since the hardness of the water is dependent upon the quantity and kind of minerals, there is no authoritative information as to the amount of loss of air that occurs.

c.-Brand of Cement and type of cement:

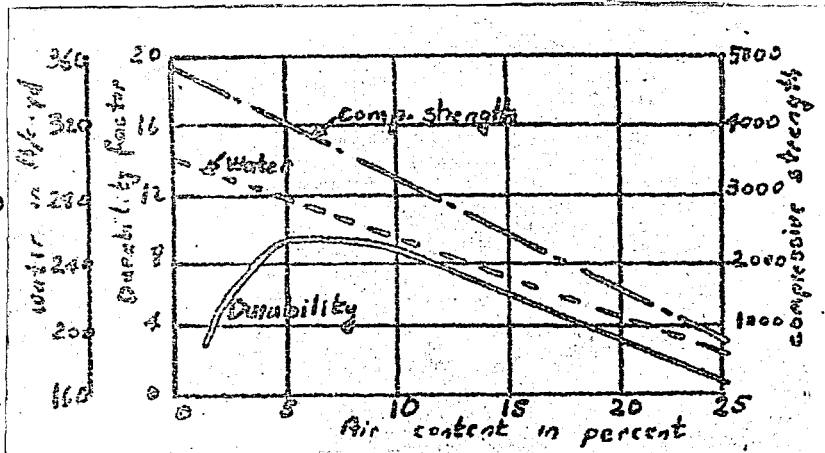
The finer the grind of cement the more Air Entraining Admixture required to obtain the desired air content. Standard portland cements or Type I cement therefore require less Air Entraining Admixture than does the modified or type II cement. Hi-Early strength or type III cement requires even more admixture.

VII.-Conclusion about the air -entrainment:

Water reduction, increase in durability, improvement in workability are important advantages of air -entrainment will depend upon amount of air present in the concrete. With air entrainment the slump picture is apt to be misleading because air entrained concrete actually gives greater workability and better placeability although its slump may be exactly the same as that for a non air entrained concrete. (low water content). (5)

It is possible to reduce water by adding more air but the water reducing potential of entrained air is limited by its adverse effect on the compressive strength of concrete.

Fig: 3
Effects of air content on durability and compressive strength and water (10)



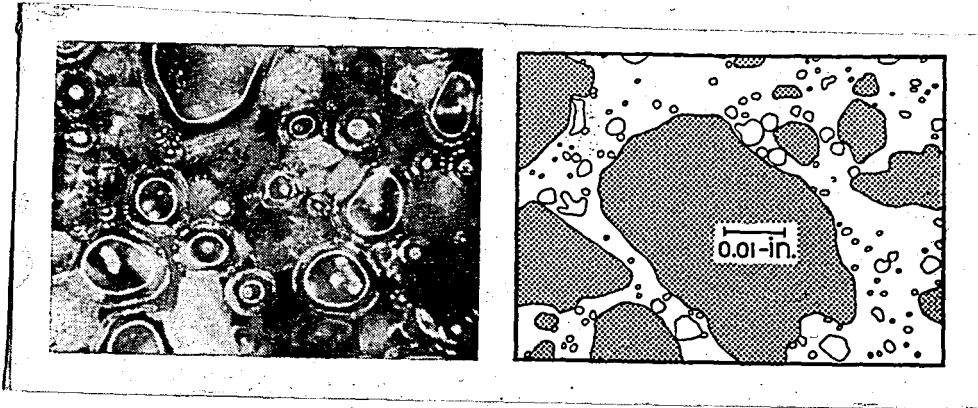


Fig: 4
Air bubbles under the microscope

For a given water/cement ratio, strengths for air entrained concrete are approximately 5 per cent lower than non air entrained concrete for each 1 per cent entrained air over and above 3.5 per cent (11) It should be born in mind that this reduction applies only when water cement ratio is the same in each case. When cement content and consistency are maintained constant, this reduction in strength is partially or entirely offset by reduction in mixing water requirement.

CHAPTER IV

EFFECT OF WATER-REDUCING ADMIXTURES ON THE PROPERTIES OF PLASTIC CONCRETE /

I.-Water reduction:

Less water is required in a concrete mixture for a specified workability when a water reducer is added. The use of these admixtures will permit reduction in the water/cement ratio if the cement content is maintained constant. The benefits derived from reduction in water cement ratio may thus be expected to result from the use of these admixtures if all other conditions are equal. In many cases the benefits are much greater than would be expected from a simple reduction in water-cement ratio. Benefits can often be expected from their use even if the water content is not reduced.

Water reduction is desirable in any concrete mixture, provided the concrete can be properly compacted. Better concrete with increased compressive strength and less drying shrinkage may result from the use of water-reducers when slump and air content are maintained constant. Water reduction is particularly desirable if aggregates have a high water requirement or if concrete slump must be greater than 3 in for placing.

Recommended proportions of water reducers will permit a reduction in mixing water of 5 to 16 per cent for a given slump. The actual water reduction is influenced by several factors including type and brand of cement, air entraining capacity of the admixture, and richness of mix. Water reduction can be obtained with air entrainment alone, but additional water reduction is possible when a water reducer or set retarder is added to the air-entrained concrete.

Increased water reduction is possible with air-entraining water reducers when the dosage, and consequently the air content are increased. (16)

II.-Effect of Type and Brand of cement

Water reduction can be obtained with all hydraulic cements, including aluminous cement and portland blast furnace slag cement. Different types or brands of cement may not show the same water

reduction with a given water reducing admixtures. A few cements may not show the anticipated water reduction when tested in concrete with recommended proportions of water reducers. (15)

Portland cement composition has a significant influence on the effectiveness of water reduction. Water reducing admixture is more efficient in improving the compressive strengths of concretes containing the cements of moderate alkali content than those containing the high alkali cements.* (17)

III.-Effect of Aggregate:

Significant water reduction can be obtained in concrete using angular, rounded, lightweight, and heavyweight aggregate.

A few aggregates will have a different effect on water reduction and strength development ordinarily expected from the admixture concrete. Sand and gravel from source B in Table II permitted approximately 50 per cent as much water reduction as sand and gravel from source A when used in concrete with the same cement and recommended amounts of a class 2 admixture (derivatives of lignosulfonic acid). In addition, the admixture concrete containing aggregates from source B did not produce the expected increase in compressive strength.

TABLE II

Effect of two aggregates on water reduction of a product of class 2 (16)

AGGREGATE	SOURCE A		SOURCE B	
	plain	admixture	plain	admixture
specific gr. of sand	2.62	2.62	2.64	2.64
Specific gr. of gravel	2.62	2.62	2.68	2.68
fineness Mod. of sand	2.42	2.42	2.49	2.49
Dry rodded unit weight of gravel lb/cu ft.	104.5	104.5	96.7	96.7
Slump in	4.5	3	4	3.5
Cement content sack/cu yd	5.51	4.69	5.48	4.64
Water-cement ratio gal/sack	6.19	5.91	6.56	6.97
Air content per cent	1.4	4.4	2.0	4.5
Water reduction per cent		18.7		10.0

effect of water reducing admixtures and set-retarding admixtures as influenced by portland cement composition".

By Milos Polivka and Alexander Klein

IV:-Effect of cement content:

Water reducing admixtures have been used in concrete containing 3 to 9 sacks of cement per cu yd. Admixtures that entrain air show high water reduction with low cement contents and less water reduction as the cement content is increased. They also show higher air-entraining capacity for lean mixes than for richer mixes. (I6)

V:- Effect of fly ash: Water reducers may be used in concrete in which fly ash is used as an addition or a replacement for part of the cement. Total water reduction is influenced by the type and amount of fly ash.

VI.-Retardation:

Subcommittee III-n Methods of Testing Setting Time of Concrete of ASTM committee C-9 on Concrete and Concrete Aggregates has prepared a tentative method of test for time of setting of concrete mixtures by Proctor penetration resistance needles (ASTM method C 403T)

Retardation of the setting time of concrete is often desirable when temperature increases to avoid loss in slump and greater water demand. Retardation is beneficial when concrete must be transported or pumped long distances. Danger of cold joints in large concrete sections is reduced if a retarder is incorporated in the concrete.

Admixtures prepared from lignosulfonic acids and their derivatives, and hydroxylated carboxylic acids and their derivatives. Have also set retarding effects. Manufacturers of water reducers eliminate the set retarding effect of their admixture by adding catalysts.

VII.-Air Entrainment:

Some of the basic chemicals used and some of the products marketed as water reducers or set retarders cause entrainment of air in concrete in addition to influencing water requirements or setting time of concrete, or both. Air entrainment also increases plasticity and is partly responsible for the water reduction possible with these materials. Water reducing admixtures may be used in plain or air entrained concrete. If the concrete is to be exposed to freezing and thawing and the admixture does not entrain sufficient air for frost resistance, a regular air entraining agent must be added to secure the required air content.

Water-reducing admixtures have little effect on air content of low-slump (1 to 2 in) concrete, provided the water content is reduced to maintain the same slump in the admixture concrete. If they are added to an air-entrained concrete mixture having 3 to 6 in. of slump the air content will usually increase unless the quantity of the air-entraining agent is reduced.

VIII.-Bleeding:

Water-reducing admixtures that entrain air will reduce bleeding and settlement of plastic concrete compared to plain concrete having the same mix proportions and slump. Bleeding can be reduced by air entrainment alone, but greater reduction in bleeding at the same air content can be obtained if the concrete contains a water-reducing admixture. Reduced bleeding in admixture concrete is attributed to the reduction in water requirement in addition to the air entraining effects.

Rapid bleeding reduces the total amount of water in the plastic concrete and may be partially responsible for the increased strengths obtained with concrete containing admixtures that promote bleeding.

Plastic cracking in concrete occurs when the rate of evaporation exceeds the rate at which water rises to the surface. Admixtures that increase bleeding without increasing laitance formation can be helpful in reducing surface drying during hot or windy weather.

IX Unit weight:

Unit weight of concrete can be increased by the use of water reducers provided air content is not increased.

X.-Compaction:

Compaction has been defined as the elimination of unintended voids containing entrapped air or water (19). It is brought about by the movement of solid particles into closer contact with each other. The ease with which concrete is compacted is determined by the mobility or flow as determined by the ability of the concrete to fill out the section and the workability, or work required for full compaction.

Water reducers may improve workability over that of plain concrete.

at a given water content or water-cement ratio by decreasing the work necessary for manipulation. They may increase compaction, which is reflected in higher unit weight.

If the water content is maintained constant, slump is increased. AN increase in slump may be particularly important where concrete with very low water content is used. In some cases the addition of an admixture will increase strength in addition to increasing slump, which may be partially caused by more thorough compaction.

XI.-Uniformity:

The water-cement paste which binds the aggregates together is the most important ingredient in a concrete mix. It has been well established that strength, permeability, and abrasion resistance of concrete are governed to a large extent by the water -cement ratio, provided all other things are equal.

In order to produce concrete of uniform quality it is important that a uniform water-cement be maintained. Uniform water-cement ratio is maintained by controlling the water content of the mixture.

Temperature variation is one of the chief factors contributing to variation in unit water content. As the temperature at which concrete is mixed and placed rises, more water is required to maintain the same slump. As the temperature rises, the increased proportion of water reducers having retarding property largely offsets the increased water demand, resulting uniform slump water-cement ratio and unit water content.

CHAPTER V

THE EFFECT OF WATER REDUCING ADMIXTURES ON THE PROPERTIES OF HARDENED CONCRETE/

I.-Compressive strength:

Compressive strength is the most generally accepted criterion of good concrete, and although such acceptance can be misleading, it is nevertheless true that compressive strength and other quality characteristics are related.

The strength of a concrete will generally increase with the proportion of cement in the mix until the strength of the cement paste or aggregate, whichever is the weaker, is reached. This relationship is, of course, based upon the premise of similar materials and consistencies being used.

Just as important as the cement content is the water content of a mix. Strength is inversely proportional to the water-cement ratio and workability requirements necessitate two to three times the water required for chemical hydration of the cement, it does seem logical to seek a means of reducing the water content while maintaining equal or improved workability.

The effect of water reduction on compressive strength is in the direction of greater strength when such water reduction is supplementary to that derived from air entrainment alone. (18)

II.-Flexural strength:

Resistance to flexure and bending is of major importance in the case of slabs and beams. However, interpretations of flexural test results require a great deal of consideration because of the high degree of sensitivity encountered in the treatment and testing of specimens and because of inherently different aggregate properties. (20)

With a given set of materials, the relationship between compressive strength and flexural strength can be established in the laboratory. Compressive strength specimens are easier to fabricate the testing procedures less complicated, and the results more readily interpreted than those dealing with flexural strength. In view of these

practical factors, after establishment of the compressive flexural strength relationship, satisfactory control of flexural strength can be obtained. However, with different materials and properties, compressive strength tests are merely an indication of the flexural strength to the extent that these parameters are somewhat parallel. (2I.22)

III.-Bond Strength:

The resistance to slipping of steel reinforcing bars embedded in structural concrete is a property of considerable significance in flexural members. The character of the hardened paste, particularly with respect to dimensional stability, greatly influences the bond maintained between the paste and the steel.

The quantity of the paste can be improved by certain water-reducing admixtures. Water reduction permits lower water-cement ratios and superior volume change characteristics: settlement or shrinkage away from reinforcing members is reduced during the hardening period, thus providing more extensive adhesion and improved bond strength.

IV.-Modulus of Elasticity:

Although the modulus of elasticity is generally taken as being approximately equal to the compressive strength multiplied by 1000, it is well recognized that no definite relationship holds between these two parameters. The influence of testing techniques on results is of great significance. The moduli of aggregates also influence to a great extent the ultimate results and consequently become an important item for consideration. (I8)

Water-reducing admixtures, when properly used, aid in the development of superior elastic properties. These elastic properties are particularly dependent upon the amount and type of paste as well as upon the volume ratio of paste to aggregate. As a consequence these properties are governed to a great extent by the control exerted by the admixture over the water content and, in some instances over the cement content.

The modulus of elasticity does vary inversely as the air content

and the the water cement ratio. However, the use of water-reducing admixtures with air entrainment and proper redesign of mix to offset the strength loss due to air entrainment provides a means of maintaining strength and desirable elastic characteristics.

V. Resistance to freezing and thawing:

The greatest factor in improving the resistance of concrete to freezing and thawing cycles is the proper distribution of purposely entrained air voids.

Although the use of properly entrained air does most toward enhancing the property of weathering resistance, water-reducing admixtures supplement such enhancement.

By utilizing water reductions at improved conditions of workability a more homogenous concrete is possible, entrained air incorporated into the mix by the water -reduction or by the use of supplementary agent then imparts its share of the enhancement. Measurements of resistance to potentially disruptive cyclic freezing and thawing can be made by means of methods utilizing weight loss, volume change, strength change or change in elastic modulus.

The change in elastic modulus under the influence of freezing and thawing cycles has become accepted as indicative, if not conclusive, means of determining the durability of concrete. The dynamic modulus as determined from sonic measurements has become a very useful datum.

The increased durability of admixture treated concrete is often overlooked, with strength taking precedence: yet continuity of strength is dependent upon durability. Severe weathering conditions particularly those involving rapid changes, require concrete of high durability characteristics. Air entrainment plus the advantages of water reducing admixtures permit concrete to be made with such characteristics and improved strength.

TABLE III (18)

Portland cement I admixture type 2

cement factor 5.0 sacks per cu. yd. Natural sand and gravel slump 4 in
water/cement ratio water red. Air cont. Relative M. of Elasticity

None	gal. per sack	per cent	per cent	per cent at var. cycles
				10 20 30 40 50 60 70 80 9
	6.20		1.6	92 70 53 42
Class 2	5.30	14	5.2	98 97 93 93 92 89 88 83 8

VI.- Volume Change:

The dimensional stability of concrete is of considerable importance to the construction industry. The volume changes that normally affect concrete may be listed as follows:

I. Pre.- Hardening

- a) Settlement shrinkage
- b) Plastic shrinkage.

2. Post-Hardening

- a) Drying shrinkage influenced by cement factor and water-cement ratio

- b) Shrinkage caused by temperature change.

Proper mixing of concrete results in a uniform distribution of water, air and solids throughout the batch. This distribution begins to change immediately after placement because all of the water will not stay in the mix without agitation. The solids settle against each other and some water rises to the surface. Loss of water by the process of settlement and bleeding occurs mostly during the first hour after placement and can result in as much as a one per cent decrease in concrete volume. Water-reducing agents lessens settlement and bleeding shrinkage by causing water reduction and air entrainment.

Plastic shrinkage cracks result from rapid loss of surface moisture and can be prevented by prompt curing and by other means of protection from rapid moisture loss. Other causes of plastic shrinkage

cracks are moisture loss to dry subgrade or to dry aggregates. Water reducing admixtures have lower initial water content which tend to reduce shrinkage resulting from moisture loss.

Evaporation of mixing water is prevented during the curing period. As hydration proceeds, a calcium silicate gel forms which holds moisture in its pores during the curing period. Later, in concrete exposed to the atmosphere the gel gradually loses its moisture by evaporation this results in gel shrinkage and a loss in concrete volume. The factors affecting drying shrinkage are many. This phenomenon, one of major concern, is influenced greatly by the unit water and cement contents and the elastic properties of the aggregates. (23)

The chemical process of cement hydration generates heat. Heat of hydration escapes rapidly from structures with small cross section and large surface area. In massive structures, heat of hydration cannot escape rapidly and can cause considerable rise in concrete temperature with resultant shrinkage and cracking upon cooling. Heat of hydration can be decreased by lowering the cement content. This is possible by using water-reducing admixtures. (24)

VII.-Permeability:

The voids between the aggregate particles are not completely filled with solid cementing medium. This is partially due to the excess water required to produce workability and not needed for the hydration of the cement. Furthermore, the absolute volume of the products of hydration is less than the sum of absolute volume of the original water and cement. Since the hardened cement paste can not fill the original volume of the fresh paste voids and cracks are formed in the hardened paste. In addition the mixing of concrete entraps some air in the mass.

The absorption and permeability of concrete do enable disintegrating agencies to damage and shorten its structural life.

Permeability decrease using more cement more dense concrete or less water again more dense concrete, also discontinuous spheroids of entrained air tend to prevent the formation of continuous passageways and thereby lower the permeability of the hardened concrete.

VIII.-Abrasion resistance:

There are eXtensive data in the literature to show that abrasion resistance is proportional to the strength. The conclusion reached is that, other factors equal the abrasion resistance of concrete paralels the strength. (25)

Water reducing admixtures permit use of lower unit water contents and consequently give rise to increased strength. In keeping with the acceptance of compressive strength as a crîterion of abrasion resistance it can be said that the proper use of water-reducing admixtures is conductive to increased ab rasion resistance.

CHAPTER VI

FUNCTION AND MECHANISMS OF WATER-REDUCERS

I.-Theory for dispersion:

Interfacial tension is always present at interface between any two completely immiscible phases. It arises from a dissymmetry among forces acting upon the molecules at or near the surface.

A disperse system in which there is a measurable interfacial tension between phases is thermodynamically unstable compared to the same system in which the dispersed particles have coalesced (this means that total solid liquid interface has been reduced).

Dispersion may be facilitated by a reduction in the interfacial tension of the system. Surface active agents due to positive attraction or to an actual linkage between specific polar groups in the adsorbent and in the surface active molecule reduction of the interfacial tension occurs.

Also amphipathetic molecules may be adsorbed on the surface of the disperse phase and reduce the interfacial tension.

II.-Classic concept of dispersion:

The stability of disperse systems, the adsorption of an ion on the surface of a particle and the acquisition by the particle of a negative (or positive) potential creates an energy barrier causing an electrostatic repulsion between the particles which contributes to the degree and stability of dispersion (29). This same negative potential will orient the water dipoles around each particle and form a hydrated sheath which acts mechanically to prevent close approach between particles.

Thus there are three factors contributing to the degree of dispersion and the stability of a disperse system: (30)

- 1) a reduction of the interfacial tension
- 2) an increase in the electrokinetic potential
- 3) a protective adherent sheath of water molecules.

Zhuravlev and Tikhonov(26) have studied the effect of increasing concentrations of Ammonium Lignosulfonate on the electrokinetic potential of cement-water systems and upon the mobility of the paste. It is their conclusion that the plasticizing action of Ammonium lignosulfonate on the cement paste is due primarily to the formation of the hydrated sheath around each particle of cement.

In portland cement concrete we are dealing with suspension of particles which are unstable physically and chemically, due to hydration which begins immediately the particles are watted. It has been shown from measurements of optical densities of filtrates from dilute suspensions of portland cement in water that substances such as the lignosulfonates are adsorbed by cement particles, and it can be shown experimentally, migration of suspended cement particles acquire a negative potential.

III.- Cement-hydration:

In its normal state, portland cement is flocculated to some degree, that is particles are held together, weakly, by forces of attraction between them. Flocculation is defined as the formation of clusters of particles which are disturbed by relatively weak mechanical forces or by a change in the physical forces at the interface between the solid and the suspending medium. In portland cement concrete, in the paste, we are dealing with suspensions of particles which are unstable physically and chemically, due to hydration which commences immediately the particles are watted.

I, -In the presence of a water-reducing admixture and at the time of initial contact with water, dispersion phenomena predominate. The reduction in the forces of attraction between cement particles permits greater mobility of the particles that water freed from the restraining influence of highly flocculated system is now available to

lubricate the mix and provide a wetter consistency .As a result, the water content of a concrete mixture of given consistency may be substantially reduced.

2.-In the presence of a dispersing agent the cement flocs are not dispersed by the addition of a dispersing agent, but rather the particles are held apart once the flocs have been broken up, that is, the breaking up of the flocs is accomplished by mechanical action of a mixer and then particles are held apart by physicochemical means. The separation of the particles of cement by dispersant results in a minimum resistance to movement of the grains which, in effect, is lubrication and this lubrication decreases water requirement for any given consistency.

3.-In the presence of an air-entraining agent the air is introduced, through the whipping action of the mixer but the size quantity, distribution and stability of the bubbles are controlled by the addition of air-entraining agent. The water reducing property of intentionally entrained air is primarily due to substitution of air for water. They add greatly to the workability of the plastic concrete by aiding the internal arrangement of the rigid particles and in this way relieve a portion of the cement paste from the function of being a lubricant.

Powers has stated(4) that the attraction between cement and water is so strong that each cement grain becomes completely surrounded by water even though in dilute suspension the grains are clustered.

Scripture(27) has suggested that experience with other hydrophilic solids, such as clays, would indicate that complete wetting of the surfaces of the flocculated cement is improbable .One of the effects of dispersion would be to expose more surface area of the cement to water and possibly more complete hydration at earlier ages of the concrete. This together with more uniform distribution of the cement throughout the concrete and over the surface of the aggregate , could account for observed strength increases.

IV.-Other influences: Schmid (28) has indicated that "Hydroxylated carboxylic acids and their salts" react with the hydrates initially formed to form complex soluble salts reducing the quantity of initial hydration products and thus delaying hydration. Therefore the dispersing agent must be chemically modified or the water-reducing admixture

formulated to minimize this retarding effect if retardation is not desired, and the set-retarding admixture must be designed to control this effect beneficially.

The dispersing agent (lignosulfonate or hydroxylated typer) may be combined with a catalyst or an accelerator to offset the retarding influence of the dispersant such that the resultant water-reducing admixture will have a negligible effect upon the rate of hardening of the concrete.

Accelerator may participate in the chemical reactions which it influences and for this reason, the system is more sensitive to the concentration of the accelerator and to changes in cement composition. This type of reaction is accompanied by the evolution of heat which, in turn may speed up the rate of hydration of cement beyond that desirable, if proportions are carefully controlled. Accelerators are normally incorporated into water-reducing admixtures only to overcome the inherent retarding influence of the dispersant, but they may also be used under controlled conditions in sufficient concentration to exert a pronounced accelerating effect such that the setting time of the concrete is reduced. It is ordinarily preferable where reduced setting time is desired to consider and use the accelerator as a separate admixture for concrete.

Certain organic materials used in very small proportions materially increase the strength of concrete. Forbrich (24) terms such materials catalysts since, he states, in proportions used, it is apparent that such materials cannot have a significant effect on strength by direct combination with any part of the cement but must react to promote some reaction of the cement in which the compound takes no part.

VI.-Chemical classification of water-reducers :

According to the ASTM water-reducing and set-retarding admixtures may be classified in the following categories:

1:-Lignosulfonic acids and their salts.

2:-Modifications and derivatives of lignosulfonic acids and their salts.

3:-Hydroxylated carboxylic acids and their salts.

4:-Modifications and derivatives of hydroxylated carboxylic acids and their salts.

Some few materials offered as water-reducing admixtures may fall into another or miscellaneous category.

All of these admixtures are surface active agents some of them have dispersing effects that is, normally have a retarding influence on the rate of hydration of portland cement, some of them introduce air during its functions by this way it provide further water- reduction.

PART II

LABORATORY EXPERIMENTS

WITH

WATER REDUCING ADMIXTURE (LISSAPOL N)

INTRODUCTION

The main object for this test is to determine the useful effects of water-reduction.

Tests are combined into three groups:

1) T- 1 represents group of test which investigates the optimum amount of lissapol N in the case of turkish cements.

2) T - 2 represents group of test which investigates the maximum water reduction without loss in workability.

3) T - 3 represents group of test which investigates the maximum cement reduction without loss in strength.

Test group T-2 and T-3 subdivided into two groups as:

a) T - 2(A) and T - 3(A)

b) T - 2(B) and T - 3(B)

In (A) tests 0.04 per cent by weight of cement lissapol are used

In (B) tests 0.08 per cent by weight of cement lissapol are used.

Mix prepared with 0.08 per cent by weight of cement lissapol increases workability more than mix prepared with 0.04 L. But it introduce more air than 0.04 L. In order to see the effect of air and water reduction more precisely we worked on both groups.

CHAPTER VII

MATERIALS AND LABORATORY EQUIPMENT USED IN TESTS SERIES;

I:-Materials:

1)Cement:

type : I

Name: Aslan ve Eskihisar çimentosu

Specific gravity 3- I8 - 3,20

Compression strength at 28 days 350 kg/cm² according to cube test.

2) Concrete aggregates.

a)Fine aggregate:

Sieve No:

	<u>cumulative per cent passing</u>		
	type A	type B	combine grading
3/8	100	100	100
No 4	94.8	99.3	97.1
No:8	78.1	96.7	87.4
No 16	51.4	86.7	69.1
No 30	16.4	58.7	37.6
No 50	2.6	18.3	10.5
No 100	0.6	2.2	1.4

type A is the coarse sand

type B is the fine sand

Combine grading satisfy the requirement for fine aggregates.

ASTM C-36

Fineness Modulus F.M. 2.95 for combine grading

Specific gravity : 2.58

Absorption : 1.0 per cent

b) Coarse Aggregate:

Coarse aggregate 1 inch Max. size
grading:

Sieve	cumulative percent passing
1 in.	100
3/4	95
"	"
3/8	37
"	"
4	3
"	"

Saturated surface dry specific gravity : 2.70

Absorption 0.65 per cent

Unit dry weight 94 lb/cu ft.

Voids in Aggregate 44 per cent

It is angular crushed limestone.

3) Admixture?

Lissapol N-X is used with different quantities as mentioned
during the tests. (see appendix A)

II.-LABORATORY EQUIPMENT USED IN TESTS SERIES

- 1) Concrete -Mixer: Model CT-30 Soiltest incorporated comp. 1.5 cu ft.
MIX capacity.
- 2) Slump cone : according to ASTM C- I43
- 3) Slump rod : According to ASTM C-I43
- 4) Metal cylinder molss : According to ASTM C-I92
- 5) Cylinder capper, 6in : According to ASTM C-I92 soiltest inc. CT-53
- 6) High strength capping compound ? Soiltest inc. CT-59
- 7) Capping Compound warmer, 2 Quart : Soiltest inc. L-I07
- 8) Yield Buckets: Astm C-I92, C-I38, C-232, C-388
Soiltest inc. type CT-4I
- 9) Concrete cylinder compressometer: Soiltest inc. type CT-I70



Fig 5 CT-I70 concrete cylinder
compressometer

- 10) Concrete compression tester: ASTM C-39 Soil test inc. type
CT- 710
- II) Dunagan test set: ASTM C 6127 , ASTM C - I28 used for the
determination of the specific gravity and
adsorbition of fine and coarse aggregates.

- I2) Volumetric flasks: for specific gravity determination.
- I3) Mechanical testing screen: ASTM C-136 Soiltest inc. type CL-325
- I4) Sieves : U.S. Standard sieves 8 in. diameter.
- I5) "VB" Consistometer : shown at page 49

CHAPTER VIII

MIXING PROCEDURE AND MIX DATA

I:- Mixer charging procedure:

In preparing all mixes, the following procedure was followed:

a) Clean water was placed in the mixer. The mixer was then revolved to clean and wet the interior surface. The free water was then removed from the mixer.

b) All aggregates were then fed into the mixer and mixed until thoroughly combined.

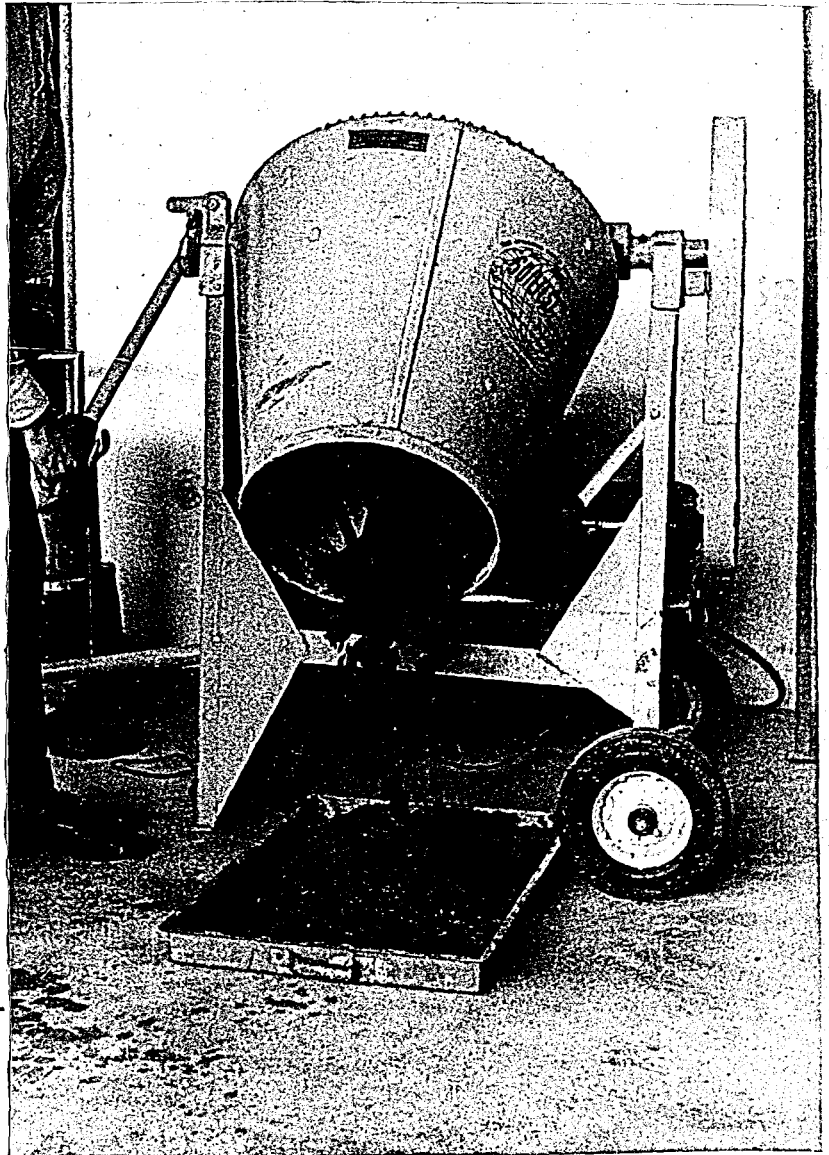
c) One half of the mix water was added and the admixture, if used introduced.

d) The mixer drum was revolved for 90 seconds and stopped long enough to add the cement.

e) The mixer was started and the remaining mixing water added.

f) The Mixer was left running for a period of two minutes after all materials had been added. The was then stopped and the freshly mixed concrete discharged.

Figure 6.-Concrete
Mixer 1.5 cu
ft mix
capacity
model CT-30



II:--CONCRETE MIX DATA:

I) Test group number T-I

Investigation about Lissapol effect on concrete

Mix identifications	T-II	T-I2	T-I3	T-I4	T-I5
Cement Ib/cu yd.	564	564	564	564	564
Water Ib/cu yd.	338	338	338	338	338
Sand Ib/cu yd.	1354	1354	1354	1354	1354
Coarse Ib/cu yd.	1736	1736	1736	1736	1736
AdmiXture percent					
by weigth og cement	-	0.02	0.04	0.06	0.08
Size of the batch	1.25	1.25	1.25	1.25	1.25cuft

Water reduction	-	-	-	-	-
Theoretical yield	4.50	4.50	4.50	4.50	4.50
Actual yield	4.56	4.58	4.68	4.73	4.80
Slump in.	1	1	3.5	5	6
Time for compaction	19	15	6	4	2
'VB' results, sec.					
Air content in percent	1.7	2	4	5.3	6.3
Bleeding in percent	5.6	3.7	2.3	3.7(1)	2.0
Unit weigth Ib/cu ft	145.2	145	141.7	140	138.8
Date of the test					
March/1963	15	21	22	27	28

(1) Platform was vibrating during this test, there fore bleeding water wasn't accurate.

2) Test group number T-2

Investigation of water reduction keeping workability constant.

part a) 0.04 per cent lissapol

Mix identification:	T-21	T-22	T-23
Cement lb/cu yd	564	564	564
Sater lb/cu yd	338	321	304
Sand lb/cu yd	1354	1370	1390
Coarse lb/cu yd	1736	1760	1790
Adm. percentage by weight of cement	0.04	0.04	0.04
Size of the batch	1.25	1.25	1.25 cu ft

Water reduction in percent	-	5	10
Theoretical yield	4.50	4.50	4.50
Actual yield	4.68	4.67	4.66
Slump in.	3.5	1	1
Time for compaction 'VB' sec.	6	14	18
Air content	4.0	3.85	3.85
Bleeding per cent	2.3	2.1	2.0
Date of tests			
March/ 1963	22		
April/ 1963		2	10

Part b) 0.08 per cent lissapol

Mix identification:	T-21	T-22	T-23	T-24
Cement lb/cu ft	564	564	564	564
Water lb/cu ft	338	321	304	288
Sand lb/cu ft	1354	1370	1390	1420
Coarse lb/cu ft	1736	1760	1790	1820
Adm. percentage				
by weight of cement	0.08	0.08	0.08	0.08
Size of the batch	1.25	1.25	1.25	1.25

Water reduction in per cent	-	5	10	15
Theoretical yield	4.50	4.50	4.50	4.50
Actual yield	4.80	4.73	4.75	4.76
Slump in.	6	4	1.25	0.7
Time for compaction 'VB' sec.	2	7	16	30
Air content	6.3	5.0	5.4	5.6
Bleeding per cent	2	2	1.8	1.4
Date of tests				
March /1963	28			
April /1963		3	4	11

3) Test group number T-3

" Investigation about cement reduction

part a) 0.04 per cent lissapol

Mix identification:	T-31	T-32	T-33	T-34	T-35
Cement lb/cu yd	564	536	508	480	452
Water lb/cu yd	304	290	276	261	244
Sand lb/cu yd	1390	1410	1440	1470	1500
Coarse lb/cu yd	1790	1820	1850	1880	1910
Adm. percent by weight of cement	0.04	0.04	0.04	0.04	0.04
Size of the batch	1.25	1.25	1.25	1.25	1.25

Cement reduction in per cent Aggregate/cement by weight	-	5	10	15	20
Date of test					
April/1963	10	26	24	24	26

Note: If we compare the water amount in those mixes the plain mix T-II they contain 10 per cent less water which is the result of test group A T-2 .

Part b) 0.08 per cent lissapol

MIX identification:	T-31	T-32	T-33	T-34	T-35	T-36
Cement lb/cu yd	564	536	508	480	452	423
Water lb/cu yd	298	285	270	255	240	225
Sand lb/cu yd	1400	1420	1450	1480	1510	1530
Coarse lb/cu yd	1800	1830	1855	1900	1940	1950
ADM.percent by						
weight of cement	0.08	0.08	0.08	0.08	0.08	0.08
Size of the batch	1.25	1.25	1.25	1.25	1.25	1.25

Cement reduction

in per cent - 5 10 15 20 25

Aggregate/cement

by weight 5.67 6.07 6.50 7.05 7.63 8.25

Date of test

April/1963 inter- 15 16 16 22 22
 polation

Time for compaction for all mixes are between 18-20sec. Slump is approximately 1 in.

Note: If we compare the water amount in those mixes with the plain mix T-II they contain 12 per cent less water which is the result of test group B T-3.

CHAPTER I X
CONCRETE TEST DATA

I-Group T-I :

Mix identification:	T-II	T-I ₂	T-I ₃	T-I ₄	T-I ₅
Age at test in days	28	28	28	28	28
Test results in psi	2940	3120	29000	2560	2590
	2980	2980	2700	2690	2560
	<u>2870</u>	<u>3190</u>	<u>2840</u>	<u>2660</u>	<u>2500</u>
average stress	2910	3090	2810	2640	2550
per cent compressive strength	100	106	97	91	88

strain	:	stress			
0.00025		640	640	710	570
0.00050		1280	1280	1330	920
0.00075		1770	1770	1770	1550
0.00100		2310	2270	2220	1880
0.00125		2450	2480	2500	2160
0.00187		2840	2900	2800	2520
0.00250		2910	3090	2810	2640

E Modulus of

elasticity

in 10⁶ psi

2.40	2.38	2.54	1.88	1.90
------	------	------	------	------

II-Group T-2

MIX identification	T-I3	A T-22	A T-23
age at test 28 days	"	"	"
test results in psi	2900	3070	3580
	2700	2980	3560
	<u>2840</u>	<u>3080</u>	<u>3480</u>
average stress	2810	3050	3540
per cent comp.str.	100	108	126
strain : stress			
0.00025	710	605	710
0.00050	1330	1240	1490
0.00075	1770	1850	1980
0.00100	2220	2230	2500
0.00125	2500	2510	2810
0.00150			3020
0.00187	2800	2870	3420
0.00250	2810	3050	3540
Modulus of elasticity			
-- in 10^6 psi	2.54	2.52	2.60
MIX identifications :	T-21 B	T-22	B T-23 B T-24
age at 28 days	"	"	"
test results in psi	2590	3000	3350 3660
	2560	3040	3560 3520
	<u>2500</u>	<u>3220</u>	<u>3370</u> <u>3580</u>
average stress	2550	3080	3420 3590
per cent comp.stress	100	120	134 140
STRAIN : Stress			
0.00025	500	675	780 780
0.00050	1060	1300	1450 1470
0.00075	1530	1880	2010 2000
0.00100	1900	2300	2400 2450
0.00125	2180	2620	2780 2900
0.00150			3140
0.00187	2500	2940	3250 3420
0.00250	2550	3080	3420 3590
Modulus of elasticity	1.9	2.5	2.72 2.74

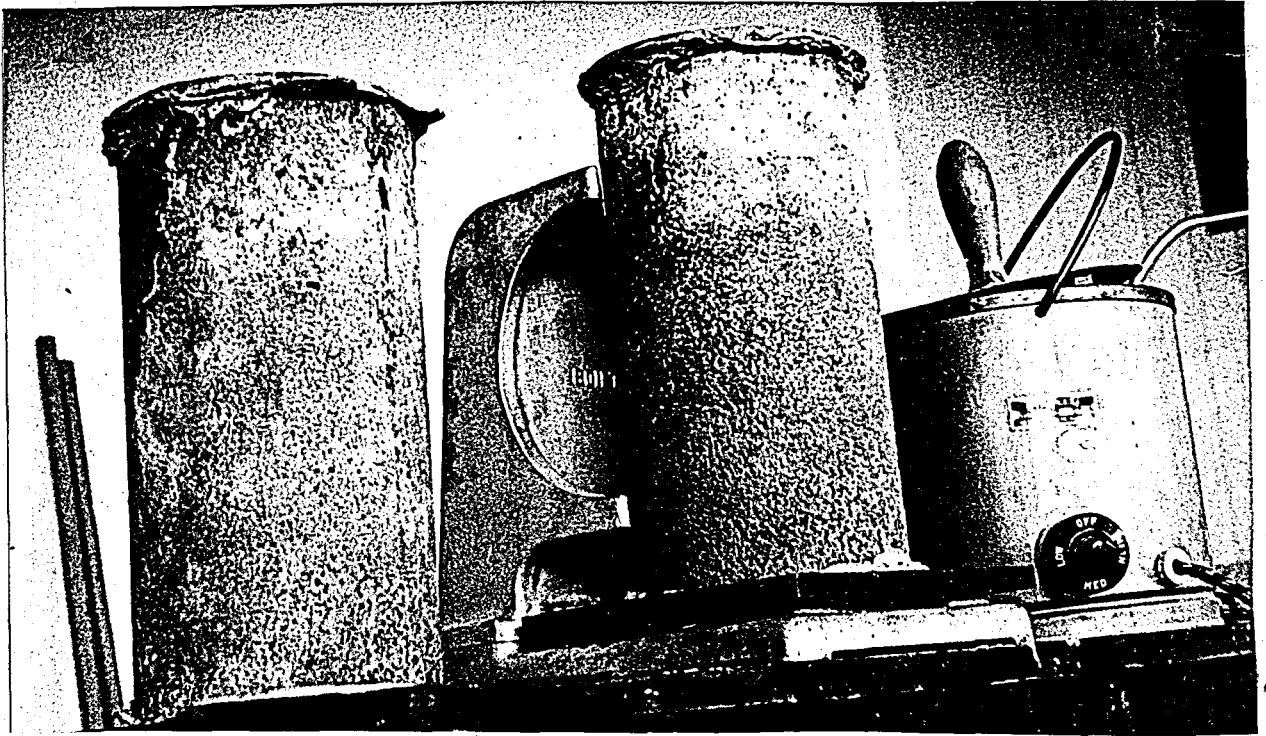


Fig :7

Represents the cap-
ping set used in
laboratory for
cylinders.

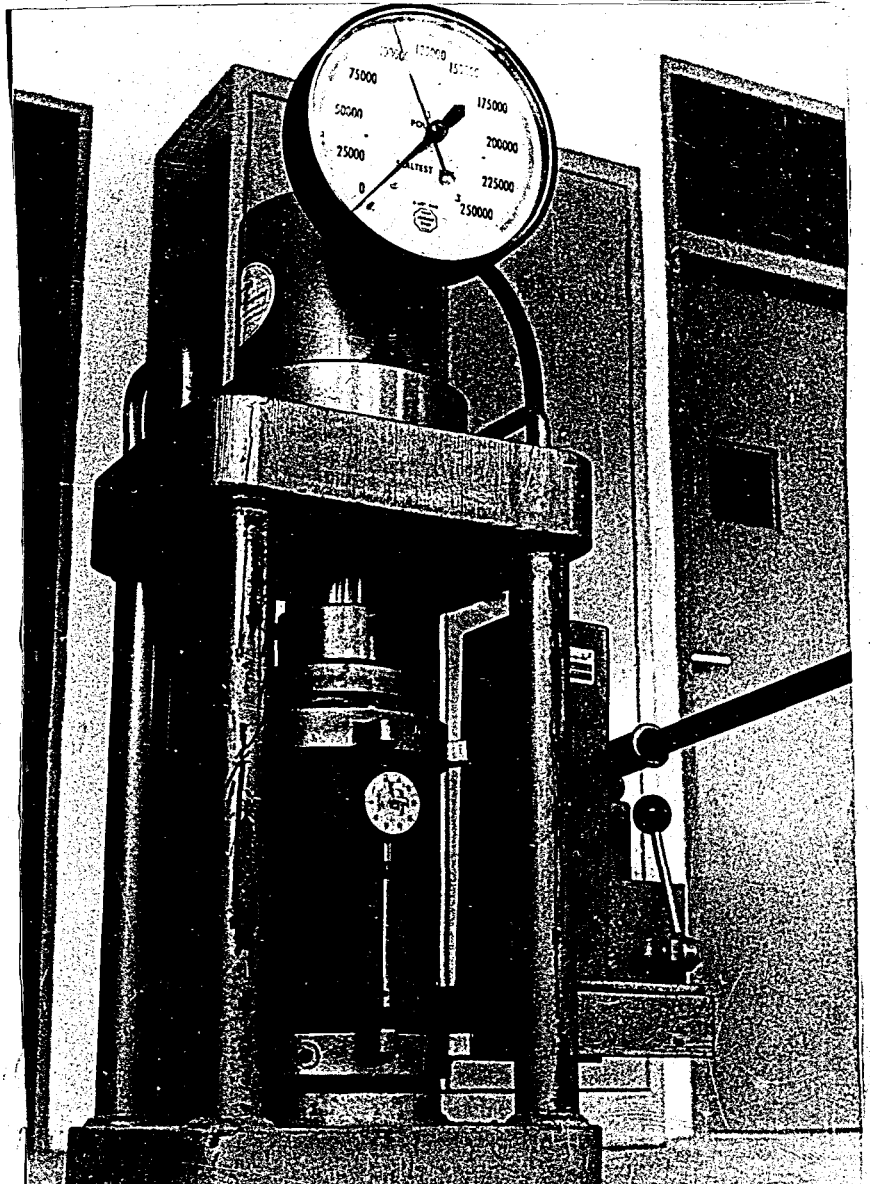


Fig: 8

Shows a cylinder ready
for the compression
test.

III - Group T - 3

Mix identification :	A T-31	A T-32	A T-33	A T-34	A T-35
age at 28 days	"	"	"	"	"
Test results in psi	3580	3430	3200	3060	2940
	3560	3400	3240	3120	2800
	<u>3480</u>	<u>3340</u>	<u>3220</u>	<u>3070</u>	<u>2980</u>
average stress	3540	3390	3220	3080	2880
per cent comp. stress	100	96	91	87	81.5
taking plain mix as 100	121	117	111	106	99

Mix identification :	B T-31	B T-32	B T-33	B T-34	B T-35	B T-36
age at 28 days	"	"	"	"	"	"
test results in psi		3400	3080	3020	2840	2560
		3550	3260	3030	2910	2660
	Interpol.	<u>3330</u>	<u>3340</u>	<u>3020</u>	<u>2700</u>	<u>2730</u>
	3490	3430	3230	3020	2810	2650
PER cent comp. stress	100	98	92.5	86.5	80.5	76
Taking plain mix as 100	119	117	111	104	98	91

CHAPTER X

EFFECT OF LISSAPOL ON THE WORKABILITY OF CONCRETE

I - Workability has been defined as the ease with which a given set of materials can be mixed into concrete and subsequently handled, transported and placed with minimum loss in homogeneity.

Although at the present time there is no adequate test procedure for measuring this property of concrete, it is possible to measure the following components of workability.

- 1) Consistency or resistance to flow.
- 2) Ease of compaction
- 3) Homogeneity or lack of segregation.

The consistency or fluidity of concrete is measured by the slump test. This test (ASTM C-143 - 52) consists of measuring the subsidence of a truncated cone of fresh concrete and although crude does give a fairly good indication of difference in water content in various mixes of any one given design. But it does not measure the variations that exist in the workability of different concretes at equal slump.

Lissapol concrete is far more cohesive and plastic than plain concrete of equal slump. Therefore time require to compact it is lesser than plain concrete. During this investigation at R.C. laboratory modified type of "VB" consistometer is used in order to take this effect into consideration.

The apparatus consists essentially of an electrically operated vibrating table, to which is clamped a cylindrical vessel. A slump cone of freshly mixed concrete is cast inside the latter in the usual way, and circular horizontal plate is lowered on the top surface of the concrete cone enabling a measurement of the slump

to be made (if desired)
on an attached scale.

The vibrator is then
switched on and a stop
watch started at the same
time. As the cone subsides
under the influence of
vibration, the plate des-
cend with it until a
point is reached where
the concrete can be seen
to be fully compacted to
the cylindrical shape of
the container. At this
point the watch is stopped
and the number of seconds
taken for compaction is
noted. The workability of
a concrete mixes may thus
be expressed in seconds.
The lower the time means
that concrete is more
workable. -----

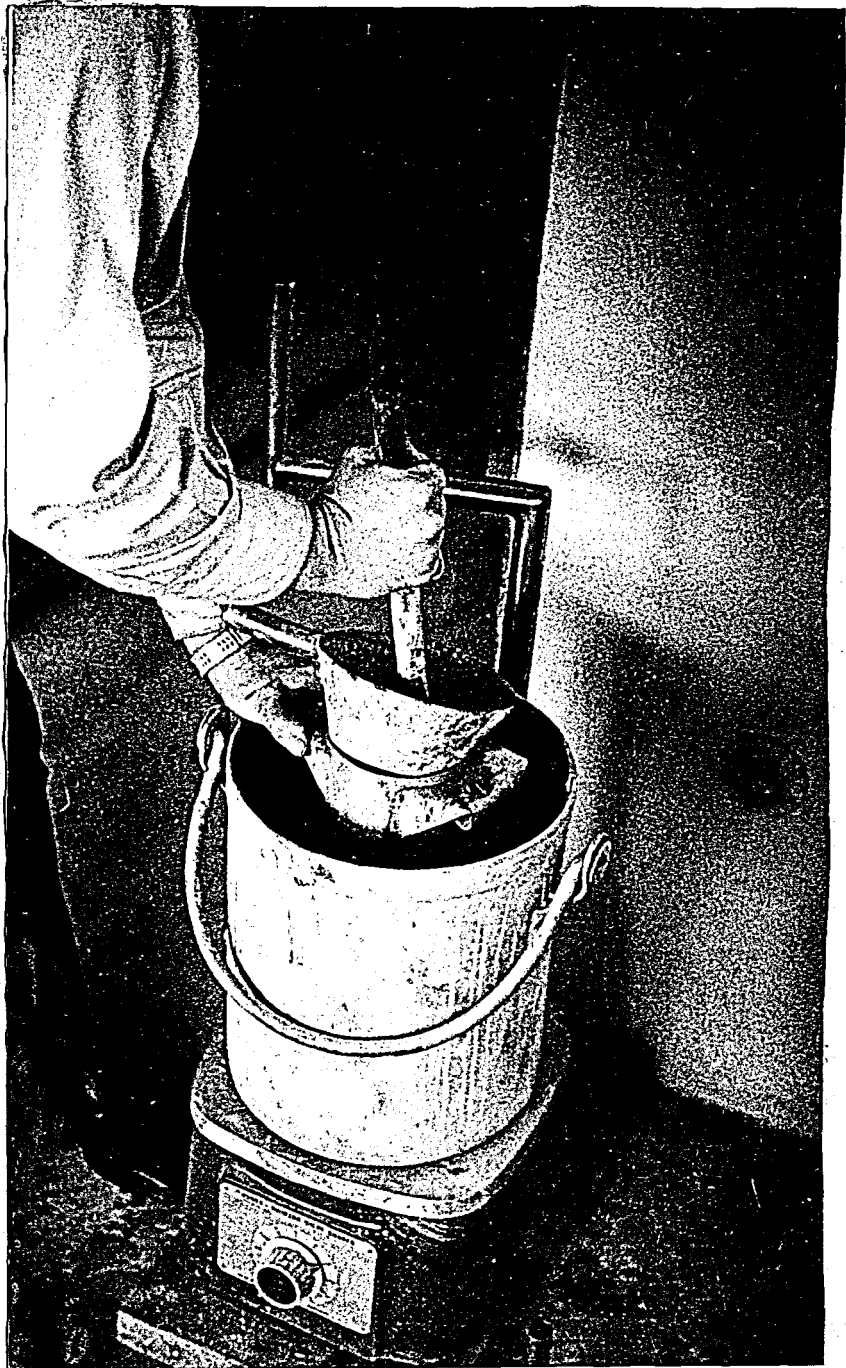


Fig : 9

preparation of concrete
sample for 'VB' test.

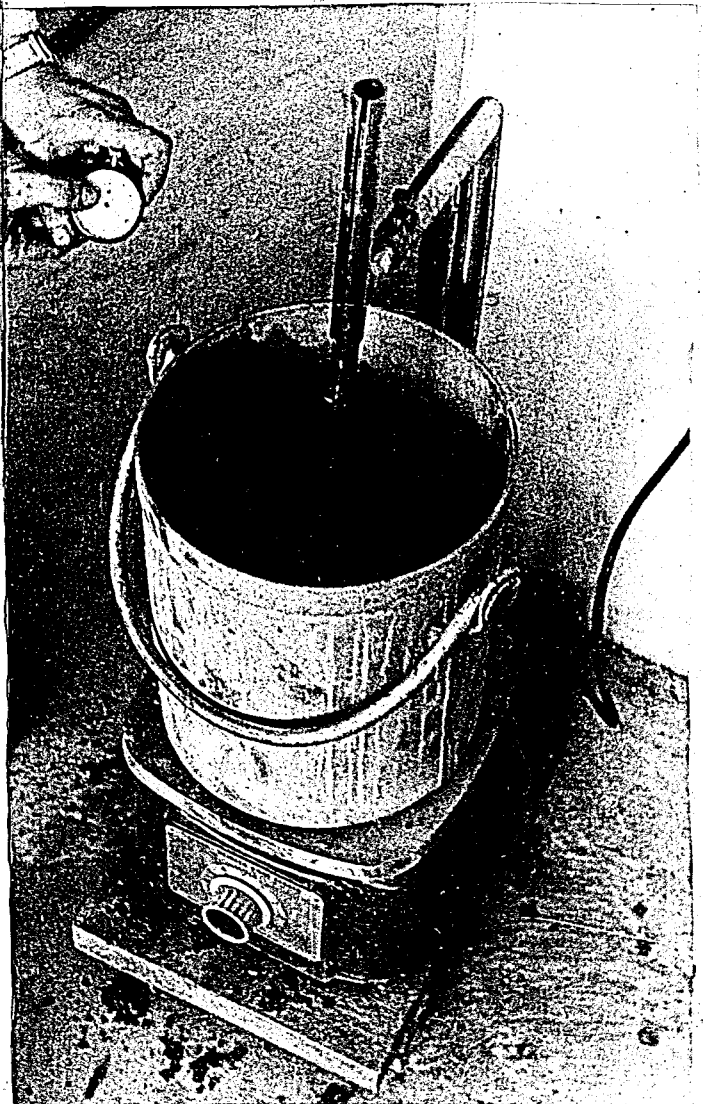


Fig : 10

Slump cone is ready
for compaction .

8

Fig II
table vibrates and
causes compaction
as shown in 20 sec



II - Object :

- 1) To investigate increase in the workability of concrete by increasing amount of lissapol. (Test group T - 1). In this test all ingredients in the mix are constant except lissapol.
- 2) To investigate water reduction without loss in workability (Test group T - 2). In this test amount of lissapol is constant.

III - Test data :

For mix data see chapter VIII page 38 for T - 1
page 39 for T - 2 (A)
page 40 for T - 2 (B)

For compressive strength data see chapter IX
page 43 for T - 1
page 44 for T - 2 (A)
page 44 for T - 2 (B)

IV - Result and Discussion :

- 1) Result of test group No: T - 1
 - a) Consistency increases with increase of admixture (Fig: I2)
 - b) Amount of air increases with increase of consistency (Fig: I3)
 - c) Bleeding decreases with increase of consistency (Fig: I4)
 - d) Strength first increases then decreases (Fig: I5)
 - e) Unit weight of concrete decreases when consistency increases (Fig: I6).
- 2) Discussion of test group No: T - 1
 - a) Increase of consistency is partly due to air entrainment because air increases when amount of lissapol increases (Fig: I3)
 - b) Increase in air causes decrease in bleeding since amount of water is constant . (Fig I3, I4)

Increasing per cent of Lissapol when all ingredients are constants (T-1)

a) Consistency against amount of admixture

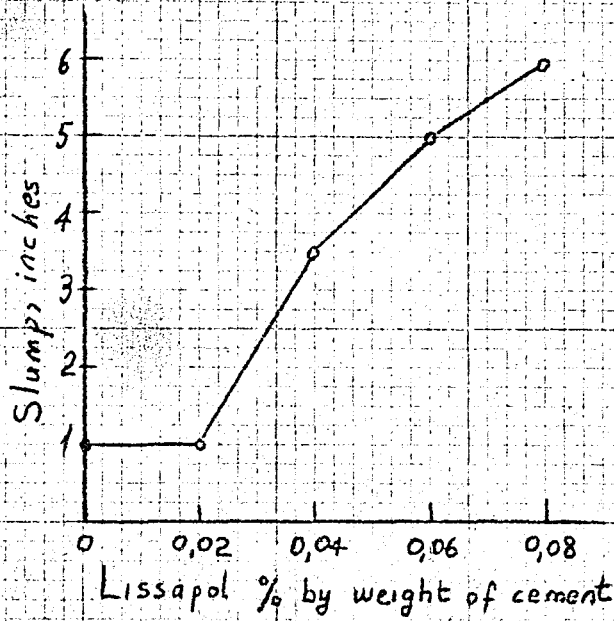


Fig: 12a

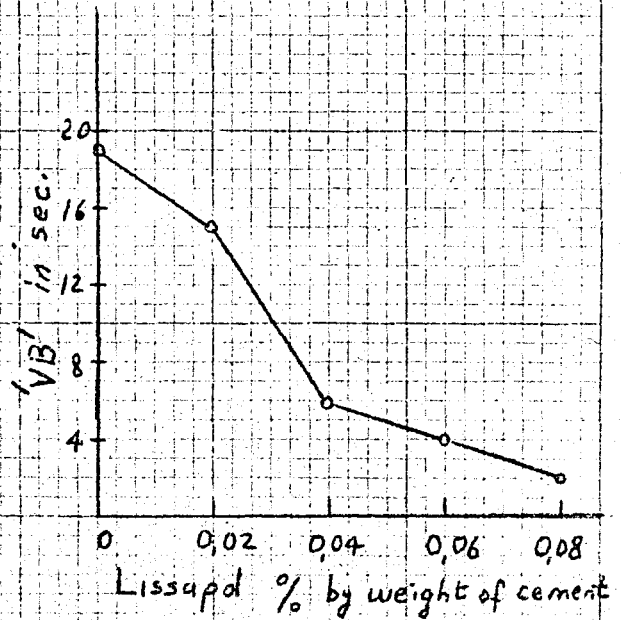


Fig: 12b

b) Amount of entrained air against consistency

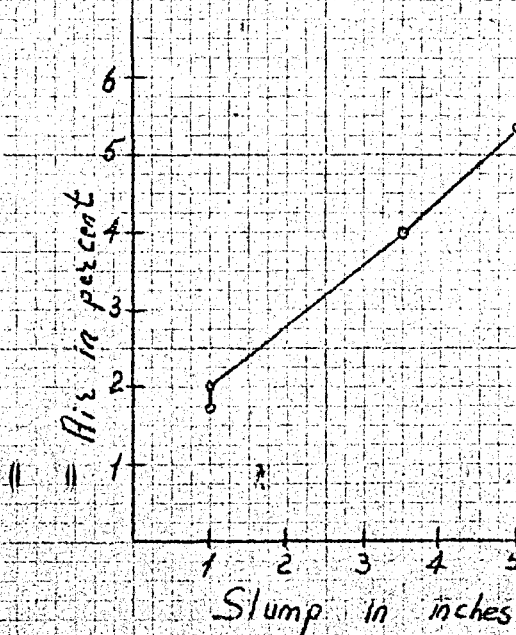


Fig: 13a

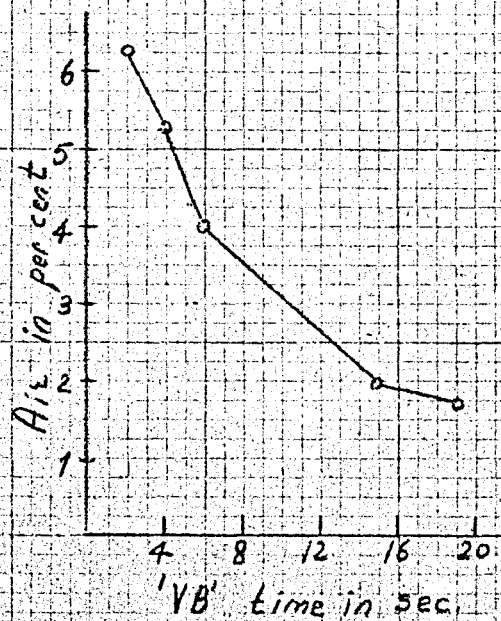


Fig: 13b

c) Bleeding water against consistency

(T-1)

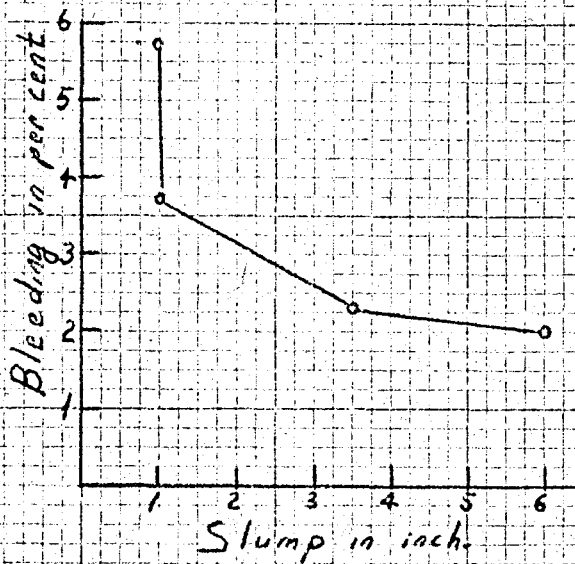


Fig: 14a

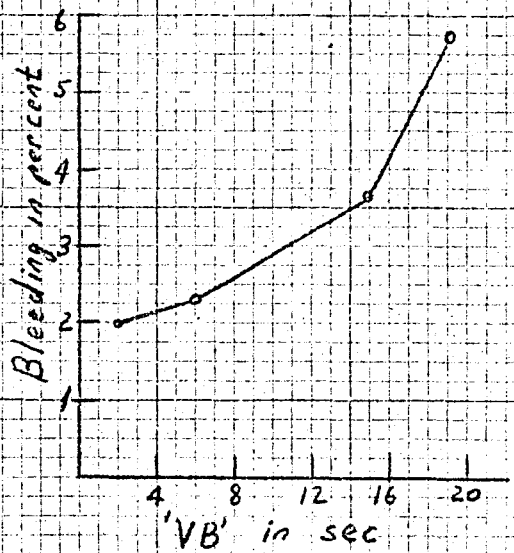


Fig: 14b

d) Compressive Strength against consistency

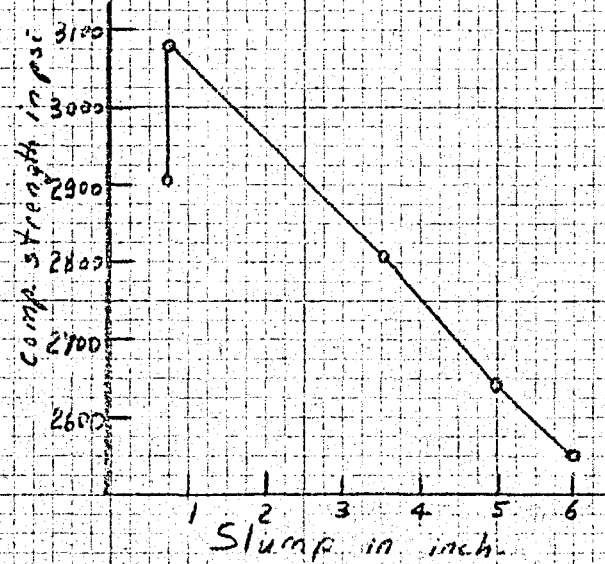


Fig: 15a

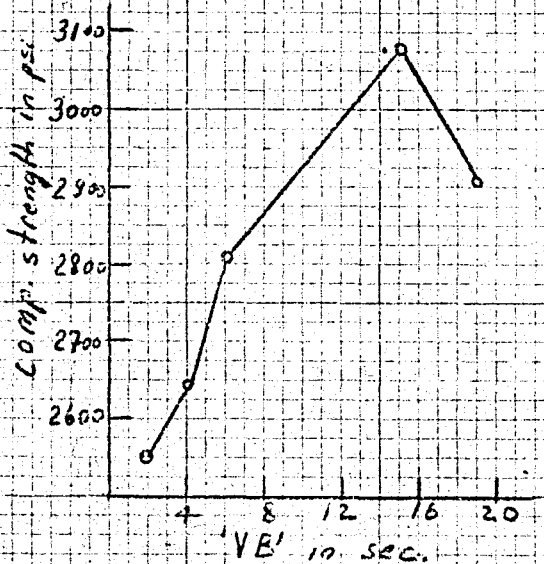


Fig: 15b

e) Unit weight of fresh concrete against consistency

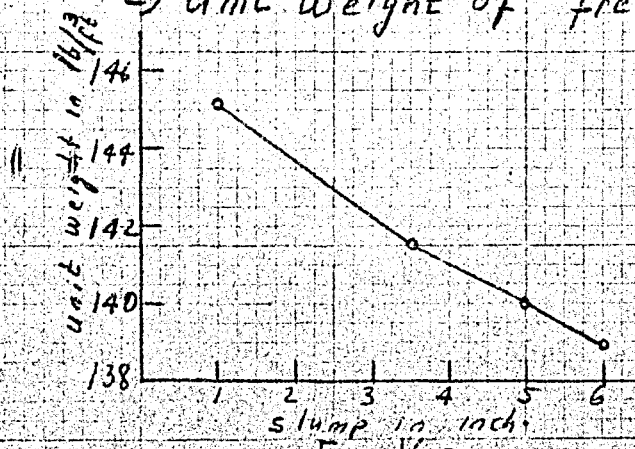


Fig: 16a

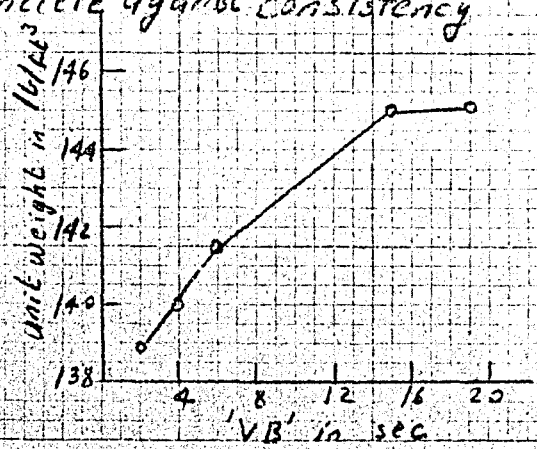


Fig: 16b

c) Strength is increasing probably of better hydration.

d) Strength then decreases because amount of air increases. (Fig: I6)

2..I : Result of test group A T - 2

a) Reduction of water cause loss in consistency (Fig:I7)

b) Bleeding is almost constant slight decrease is due to reduction of water (Fig: I8).

c) Air per cent is almost constant (Fig: I9)

d) Compressive strength increases because of reduction of water.

(Fig: 20).

e) Unit weight is almost constant.

2.. 2 : Discussion of test group A T -2

a) With 0.04 per cent Lissapol reduction of water is 10 per cent Since 0.08 per cent by weight of cement lissapol gives higher consistency than 0.04 mix. It seems that it is possible to cut more water without effecting consistency and reach to a high compressive strength. Test group No B T-2 investigates water reduction for 0.08 per cent lissapol mix.

3.. I : Result of test group B T-2

a) More reduction of water is possible with addition of more lissapol (Fig: I7 , 2I)

b) More lissapol causes more air entrainment (Fig: I9,23)

c) Bleeding is slightly decreasing due to reduction of water.
(Fig: 22)

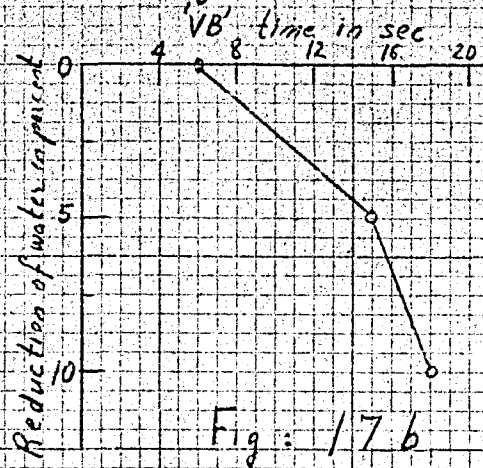
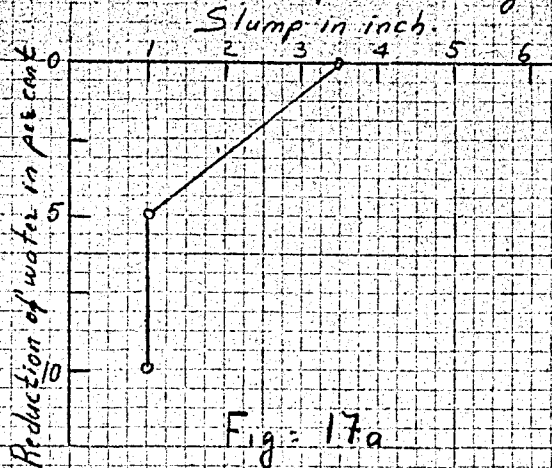
3.. 2 : Discussion of test group B T-2

a) Increase in compressive strength is not so rapid as in the case of 0.04 per cent lissapol concrete, this may be due to additional air voids. (2 per cent more).

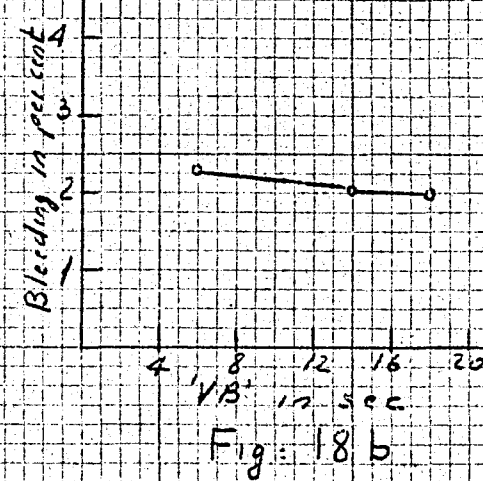
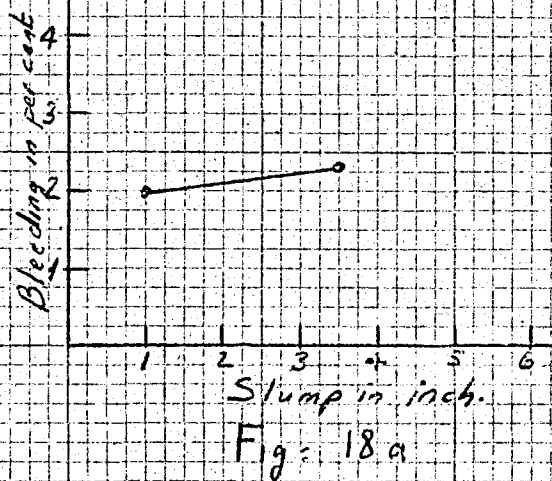
REDUCTION of WATER for 0.04 per cent LISSAPOL (T-2(A))

a) Reduction of water against consistency

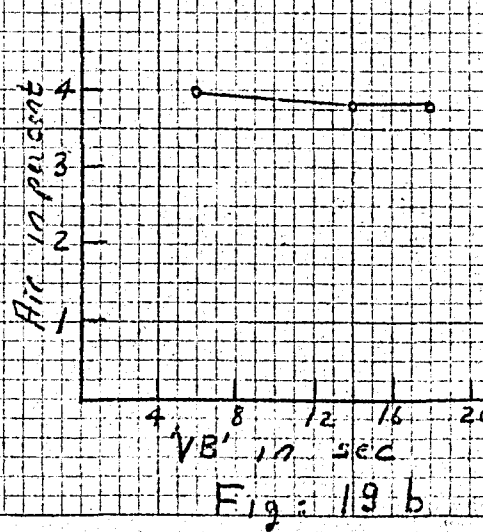
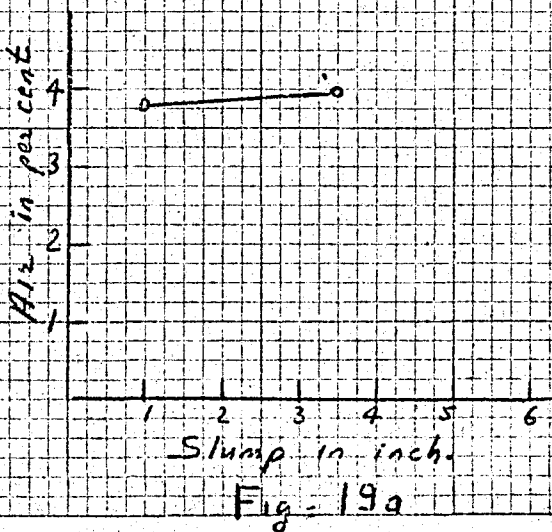
(T-2(A))



b) Bleeding water against consistency



c) Amount of entrained air against consistency



(T-2(A))

d) Compressive strength against consistency

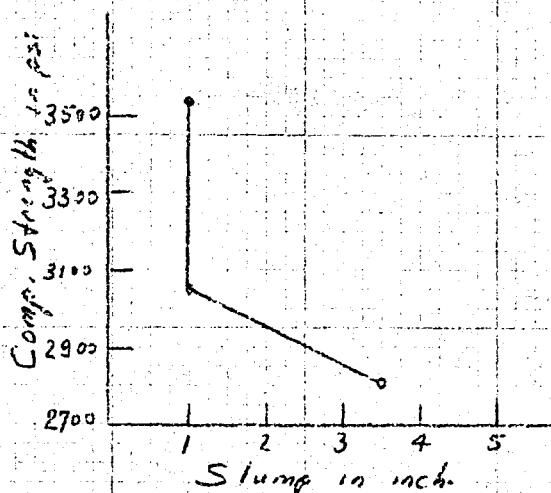


Fig: 20 a

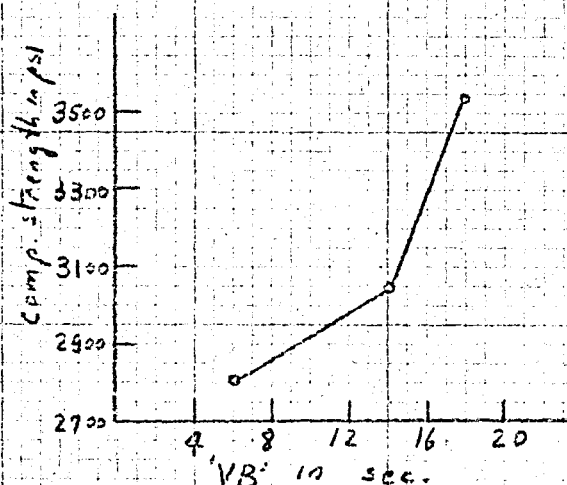


Fig: 20 b

V - Conclusion:

- 1) Lissapol causes increase in consistency see table IV

TABLE IV
Effect of lissapol on consistency

AdmiXture	w/c	slump inch.	compaction sec.
none	0.60	1	19
0.04 L	0.60	3.5	6
0.08 L	0.60	6	2

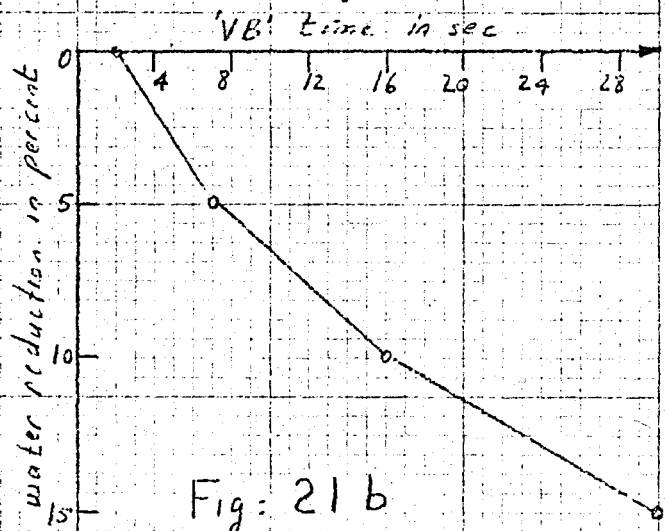
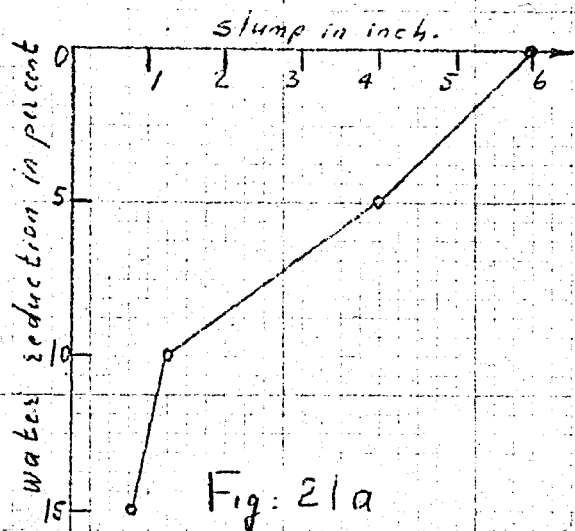
- 2) At equal workability lissapol provides water reduction therefore it improves the strength see table V

TABLE V
EQUAL WORKABILITY UNDER WATER REDUCTION

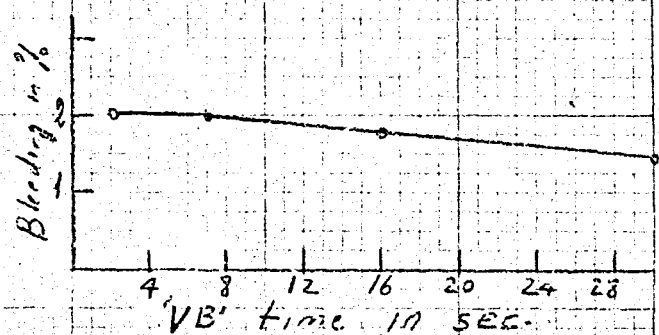
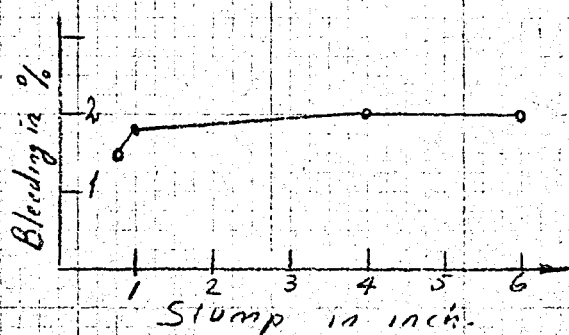
AdmiXture	plain	0.04 L	0.08 L
time for comp. "	19	18	20
Water reduction in per cent	-	10	12
Compressive str. in per cent	100	121	119

REDUCTION of WATER for 0.08 percent Lissapol

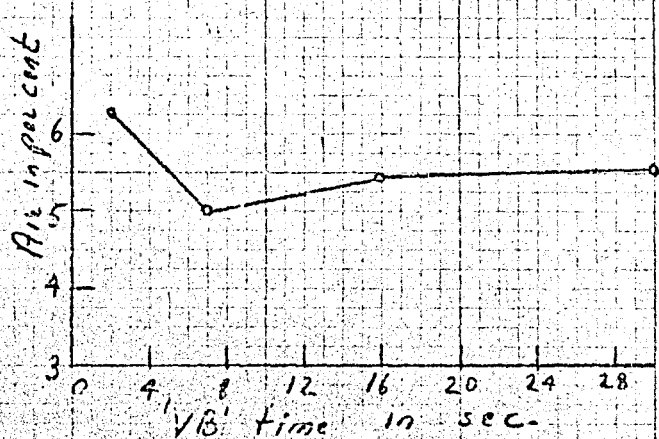
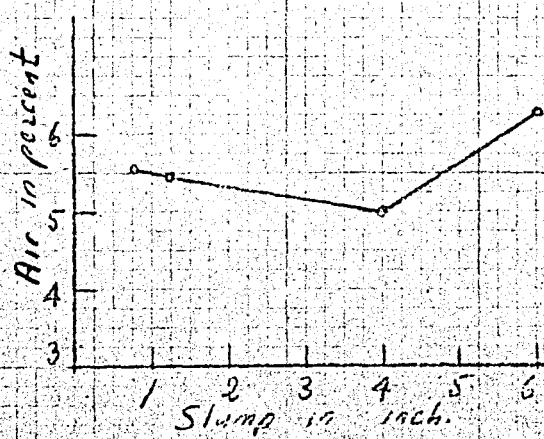
a) Reduction in water against consistency (T-2(B))



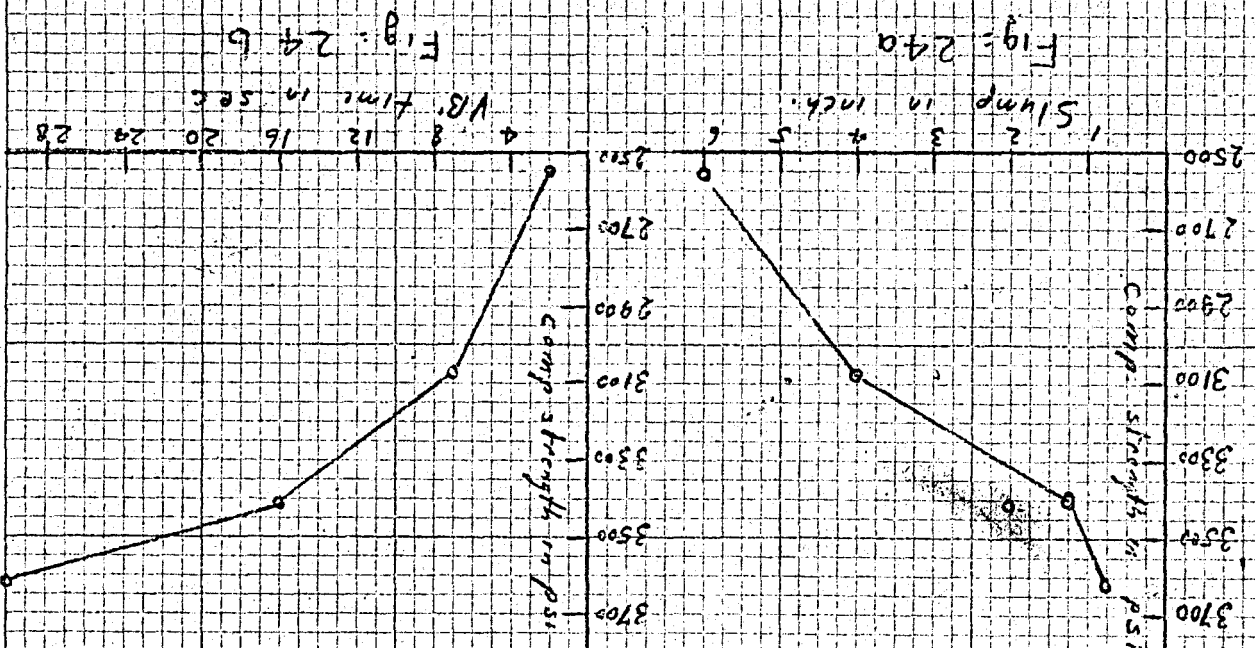
b) Bleeding water against consistency



c) Amount of entrained air against consistency



d) Compressive strength against consistency



(T-2(8))

EFFECT OF LISSAPOL ON THE BLEEDING OF CONCRETE

I * Introduction

Bleeding is the net result of a number of factors operative in the plastic concrete; but it is primarily an effect of excess water. Too much water permits aggregate to settle, forcing lighter materials, including water, to the top. The supernatant water contains a considerable amount of cement in suspension along with fine sand. Upon drying, this mixture forms a weak mortar. The cement thus displaced weakens the concrete to a certain extent but more serious are several other results. Porosity is created in the concrete mass, also segregation.

ASTM specification C 232-53 T is used for determining the bleeding of fresh concrete. In which surface water is collected from a container of 0.5 cu ft. capacity. Fresh concrete is put in three layers and compacted with 25 strokes per layer.

$$\text{Bleeding per cent equals } \frac{B}{C \times 454} \times 100$$

where B is total quantity of bleeding water withdrawn from the test specimen in milliliters.

454 x C is the quantity of water in the test specimen expressed in milliliters.

$$\text{where } C = \frac{W}{W} \times S$$

S weight of sample in pounds

w net weight of water in batch in pounds

W total weight of batch in pounds

C weight of water in the test specimen in pounds.

II - Object

1 : To investigate bleeding of concrete with increasing amount of lissapol

(Test group No: T-I)

2 : To investigate bleeding of concrete with water reduction.

(Test group No; T-2)

III - Test data :

For mix data see Chapter VIII page 38 for T- I

page 39 for T -2 (A)

page 40 for T -2 (B)

For compressive strength data see Chapter IX

page 43 for T- I

page 44 for T- 2 (A)

page 44 for T -2 (B)

IV - Result and Discussion :

I..I Result of test group No T-I

a) Increasing the amount of admixture cause decrease in the bleeding if water amount is constant. But after 0.04 per cent by weight of cement lissapol mix shows that bleeding does not vary too much . (Fig: 25)

b) Bleeding decreases with increase of air per cent (Fig: 26)

c) Usually when water is increasing bleeding will increase causing increase in workability. Here curve shows that workability is increasing with decrease in bleeding. This is completely due to lissapol effect since water amount is constant . (Fig : 27)

d) Strength is passing through a maximum because of better hydration of cement particles? (Fig: 28)

e) Unit weight is decreasing with decrease of bleeding due to air entrainment.

I..2 Discussion of test group No T-I

a) After 0.04 per cent lissapol mix shows that bleeding does not vary too much. This may be because of the total amount of water present in the mix (here 0.60 is water/cement ratio) (Fig:25).

b) The ~~sharp~~ sharp decrease with small amount of air is due to water reduction property of the lissapol. After that air voids prevent formation of capillaries and escape of water to the surface.

Increasing per cent of Lissapol when all ingredients are constant. (T-1)

a) Bleeding against amount of Lissapol

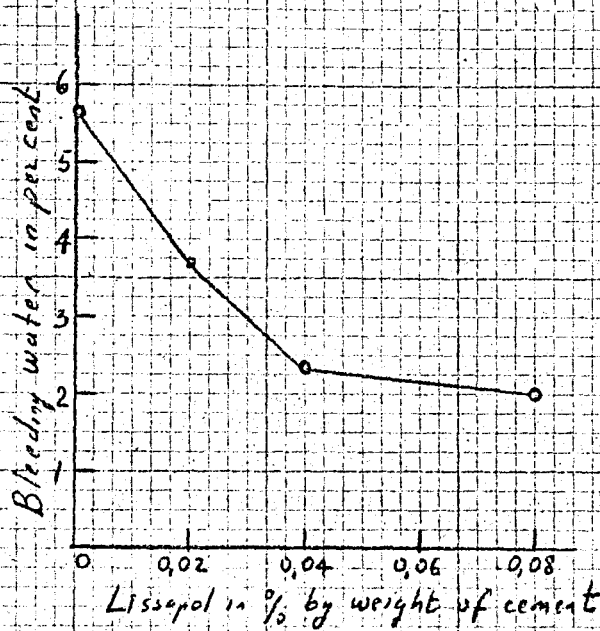


Fig: 25

b) Entrained air against bleeding water.

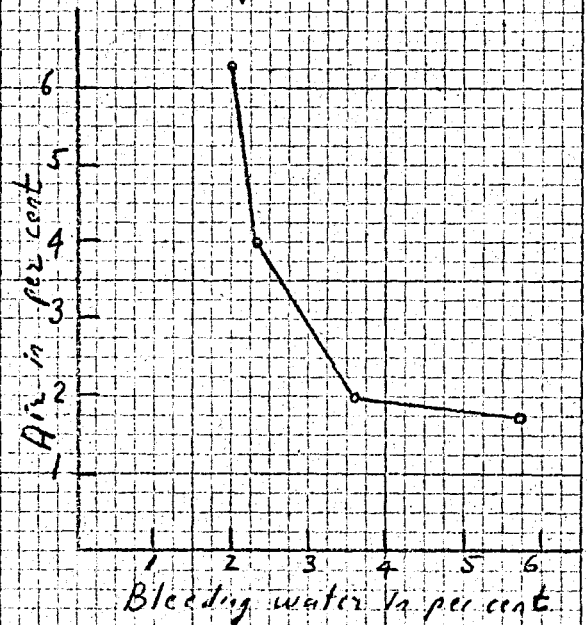


Fig: 26

c) 'VB' time in consistency against Bleeding water

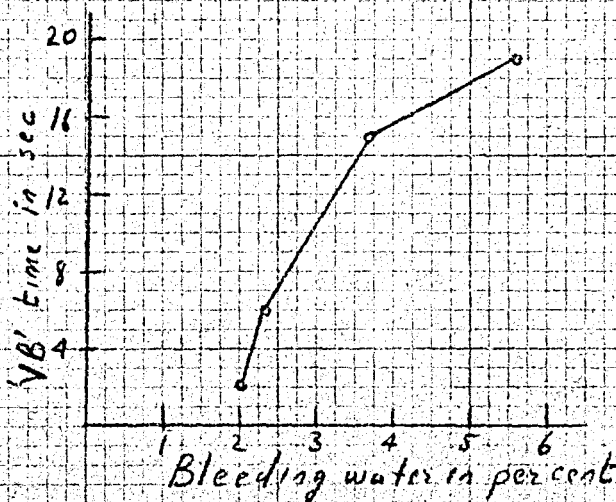


Fig: 27

d) Compressive strength against bleeding water

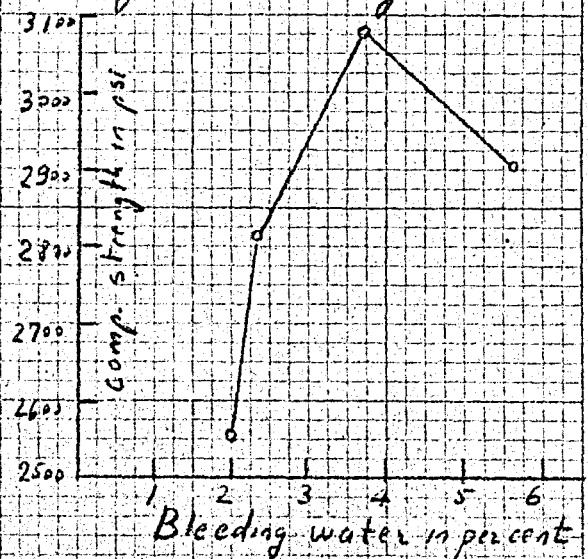


Fig: 28

2..I - Result of test group No T-2

- a) Water reduction decreases bleeding slightly (Fig: 29,33)
- b) Variation of bleeding is free from the air since amount of air is nearly constant. (Fig: 3I)
- c) Workability decreases when bleeding decreases They are both due to reduction of water. (Fig: 30, 34)
- d) Tests show that variation of air is more when amount of lissapol increases. This shows that control~~XX~~ of miX is more difficult when amount of lissapol is high.(Fig, 35).
- e) Reduction in bleeding cause increase in strength (Fig:32: 36)

2.. 2 - Discussion of test group No T-2

- a) Decrease in bleeding depends upon the total amount of water in the miX. If this amount is large then decrease will be more pronounced. Here totaml water is 338 lb/cu yd. (0.60 per cent by weight of cement)
- b) Main reason for increase in strength is the water reduction and not the slight decrease in bleeding.

V - Conclusion:

I) Water-reducing admixture, lissapol, that entrain air will reduce bleeding and settlement of plastic concrete compared to plain concrete having the same miX proportions. See table VI

TABLE VI

Effect of lissapol on workability, bleeding, and air

entrainment (w/c 0.60 , Agg/ Cement 5.5 by weight)

AdmiXture	Workability slump	comp time	bleeding in p,c.	air entrainment in p,c.
plain	I	I9 sec	5.6	I.7
0.04 L	3.5	6 sec	2.3	4
0.08 L	6	2 sec	2.0	6.3

REDUCTION of WATER for 0.04 per cent LISSAPOL (T-2(A))

a) Bleeding water against
Water reduction

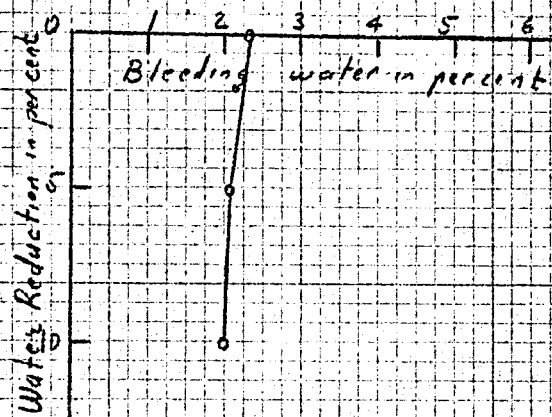


Fig: 29

b) 'VB' time for compaction
against bleeding water

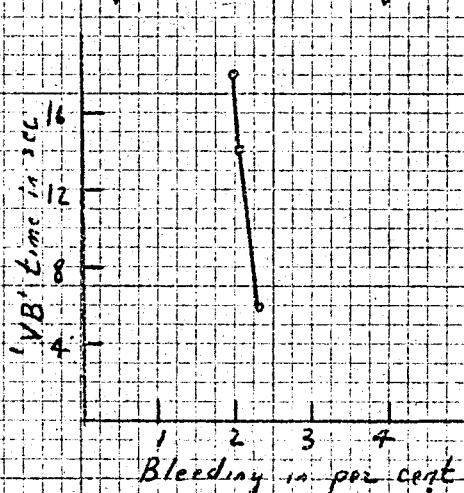


Fig: 30

c) Air per cent
against bleeding water

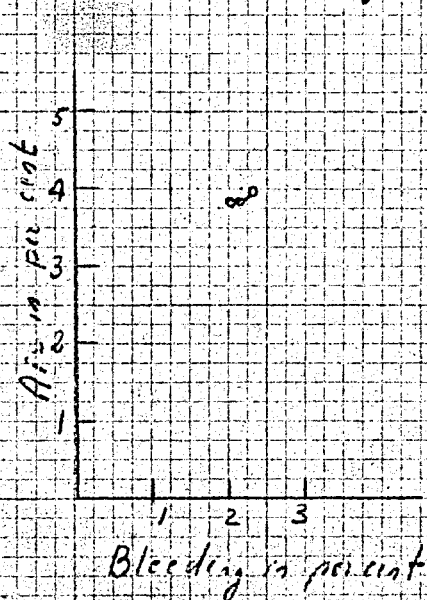


Fig: 31

d) Comp. strength
against bleeding water

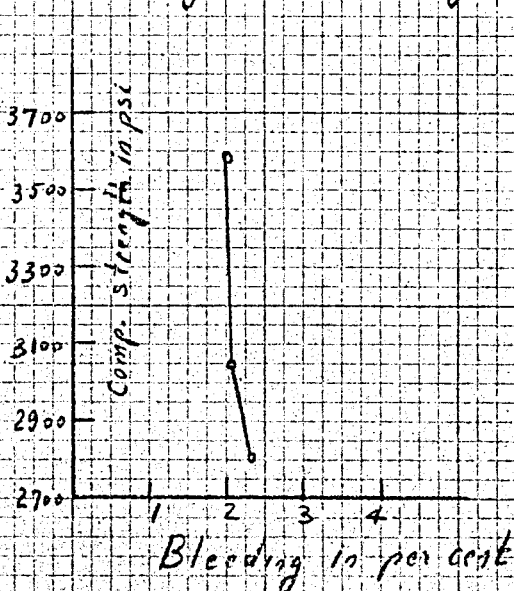


Fig: 32

REDUCTION of WATER for 0.08 per cent LISSAPOL (T-2(B))

a) Bleeding water against water reduction.

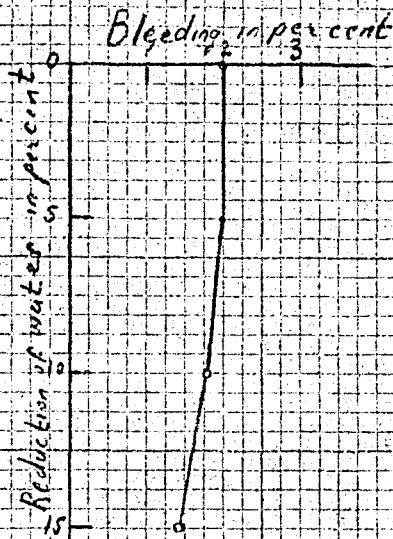


Fig: 33

b) 'VB' time for compaction against bleeding water

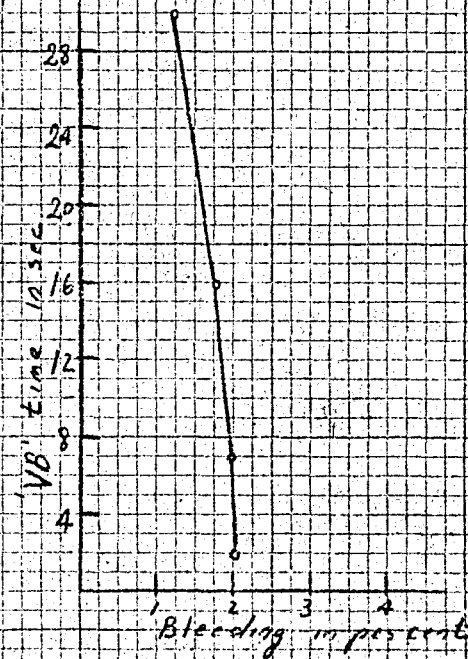


Fig: 34

c) Air per cent against bleeding water

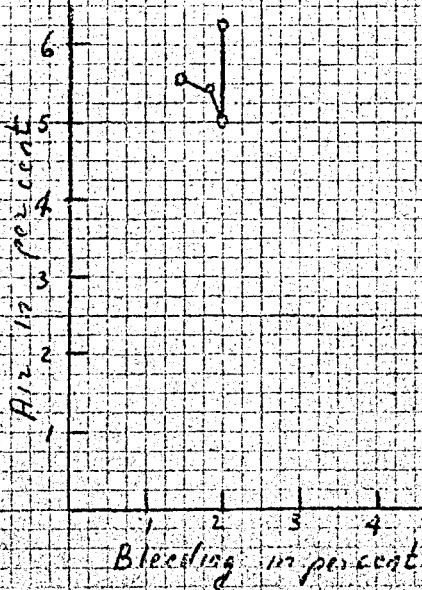


Fig: 35

d) Compressive strength against bleeding water

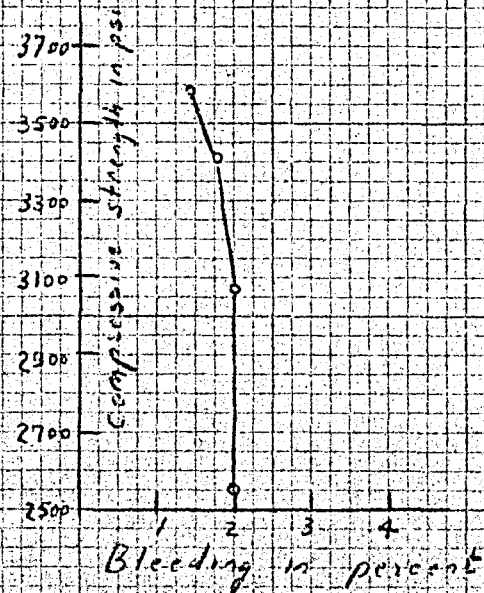


Fig: 36

2) Because of water reduction bleeding decreases. See table VII

TABLE VII
EQUAL WORKABILITY UNDER REDUCTION OF WATER
(slump, time of comp. are equals)

AdmiXture	bleeding per cent	air per cent	red. of water in per cent
plain	5.6	1.7	-
0.04 L	2.0	3.8	10
0.08 L	1.6	5.6	12

Note: Due to water reduction bleeding decreases from 2.3 to
2 for 0.04 L miX and from 2 to 1.6 for 0.08 L miX.

CHAPTER XII

EFFECT OF LISSAPOL ON THE AIR ENTRAINMENT

I - Introduction: Lissapol is the type of water reducers that entrained air in the concrete. If the concrete is to be exposed to freezing and thawing this entrained air will increase durability of concrete.

ASTM specification C - 138 -44 is used to determine air content of freshly mixed concrete. This method also determine the unit weight of fresh concrete rodded with 25 stroke per layer for 1/2 cu ft. measure. The exterior surface of the measure was tapped smartly and then was finished smoothly.

Air content shall be calculated as follows:

$$A = \frac{S - V}{S} \times 100$$

where A is air content in the concrete

S is volume of concrete produced per batch

V total absolute volume of the ingredients in the batch.

S equals total weight of ingredients in lb. divided by unit weight of concrete in lb/ cu ft.

II - Object

1)b To investigate effect of lissapol on air entrainment when all ingredients in the mix are constants , (Test group No T-I) and find related changes in other properties.

2) To investigate effect of ~~XXXXXX~~ water -reduction on air entrainment and find related changes in other properties.

Increasing per cent of Lissapol when all ingredients are constant.

a) Amount of air against Lissapol

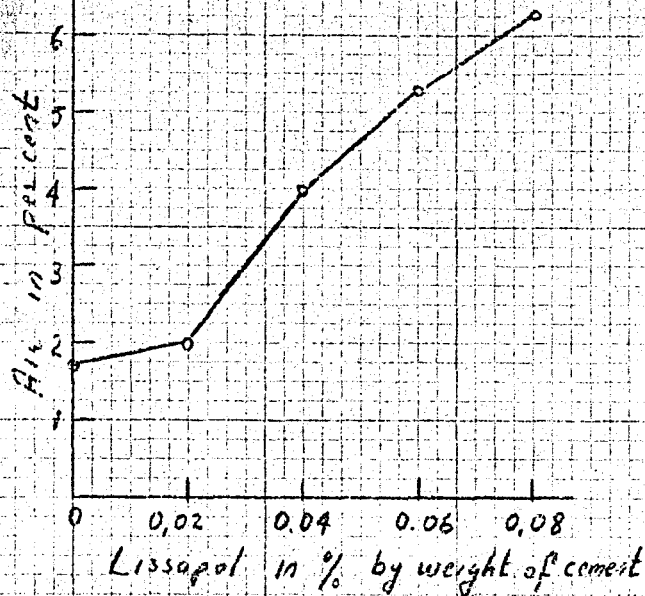


Fig: 37

b) Time for compaction against amount of air

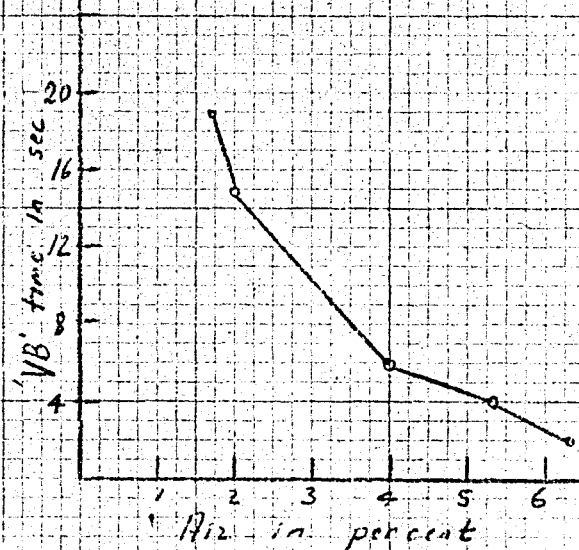


Fig: 38

c) Consistency against amount of air

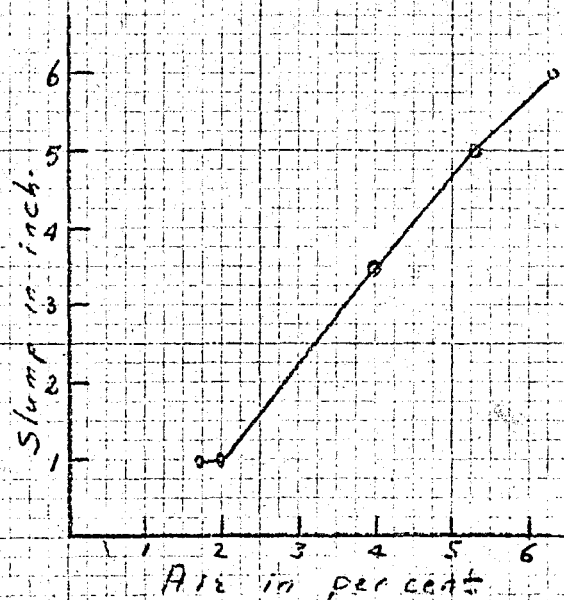


Fig: 39

d) Bleeding water against amount of air

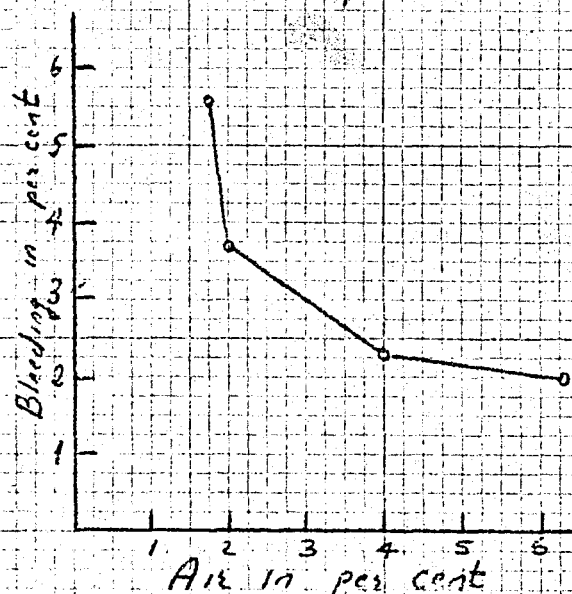


Fig: 40

e) Unit weight against amount of air.

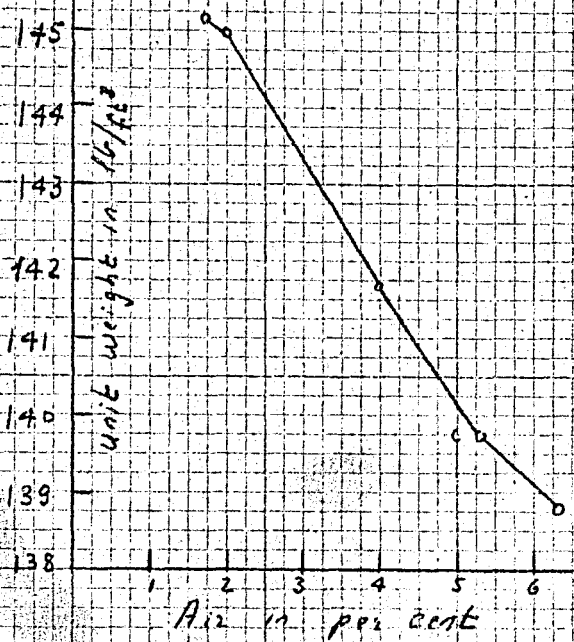


Fig: 41

f) Compressive strength against amount of air.

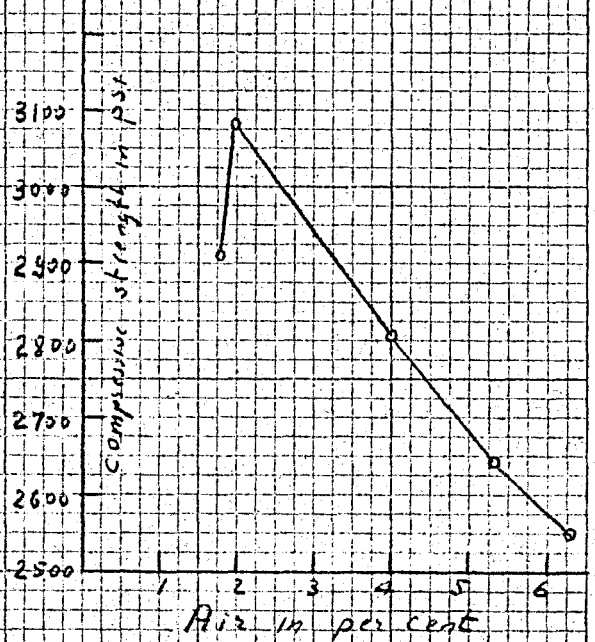


Fig: 42

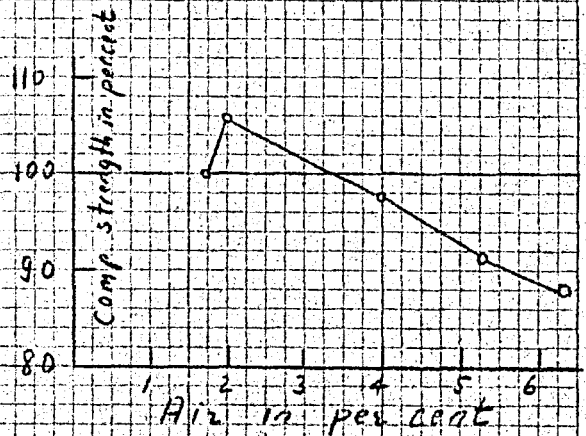


Fig: 43

III - Test data:

For mix data see Chapter VIII page 38 for T-I

page 39 for T-2 (A)

page 40 for T-2 (B)

For compressive strength data see Chapter IX

page 43 for T-I

page 44 for T-2 (A)

page 44 for T-2 (B)

IV - Result and Discussion:

I..I Result of test group No T-I

a) Lissapol entrained air this entrainment becomes dangerous for strength when lissapol amount increases. (Fig 37,42)

b) ~~XXXX~~ Air entrainment improves workability. (Fig 38,39)

c) Air entrainment cause decrease in bleeding water (Fig 40)

d) Unit weight decreases due to increase of air per cent in the mix. (Fig: 41)

e) Compressive strength first increases due to better hydration of cement particles but when amount of entrained air increases we notice decrease in strength. This is more obvious when we choose plain concrete strength as 100 and plot per cent of compressive strength against air per cent (Fig:43).

II..2 ~~XXXX~~ Discussion of test group no: T-I

a) Since only variable is lissapol decrease in the strength is because of the air, when amount of air increases causing decrease in strength. Therefore amount of air puts the limit for amount of admixture. Because for this fact we used for water reduction and cement reduction two mixes one 0.04 L and the other 0.08 L one having air content 4 per cent the other 6.3 per cent.

REDUCTION of WATER for 0.04 per cent LISSAPOL (A T-2)

a) Water Reduction against amount of air

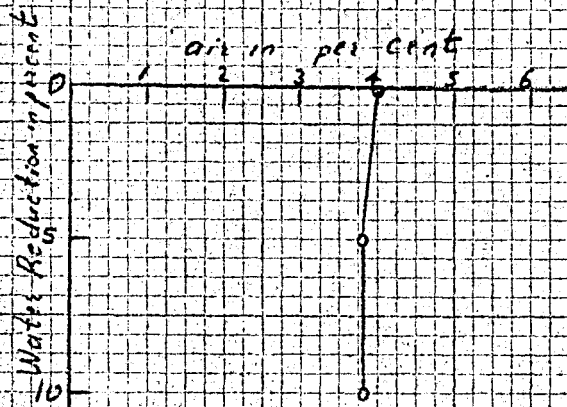


Fig: 44

b) Time for compaction 'VB' against amount of air

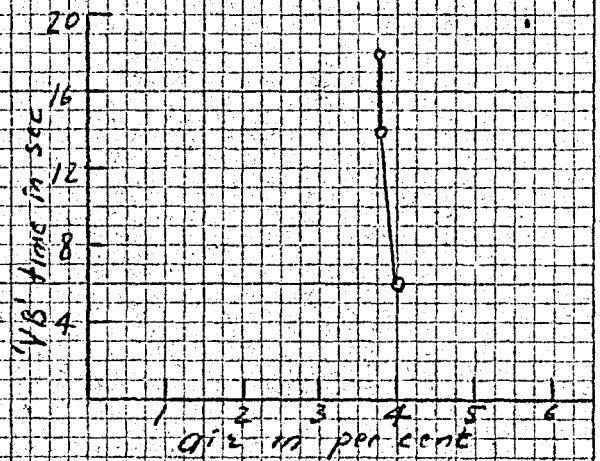


Fig: 45

c) Bleeding water against amount of air.

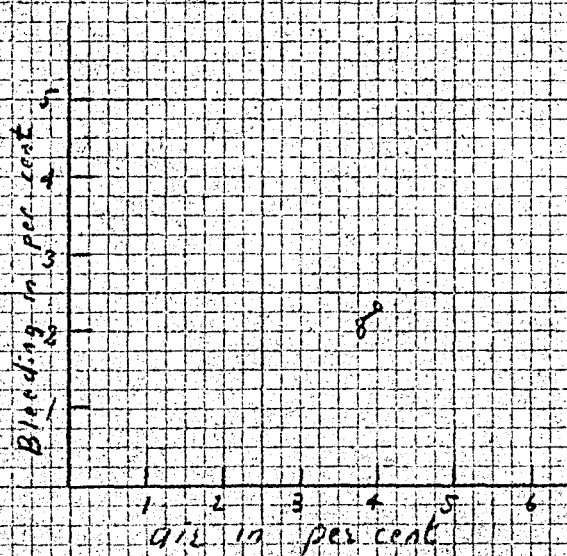


Fig: 46

d) Compressive strength against amount of air

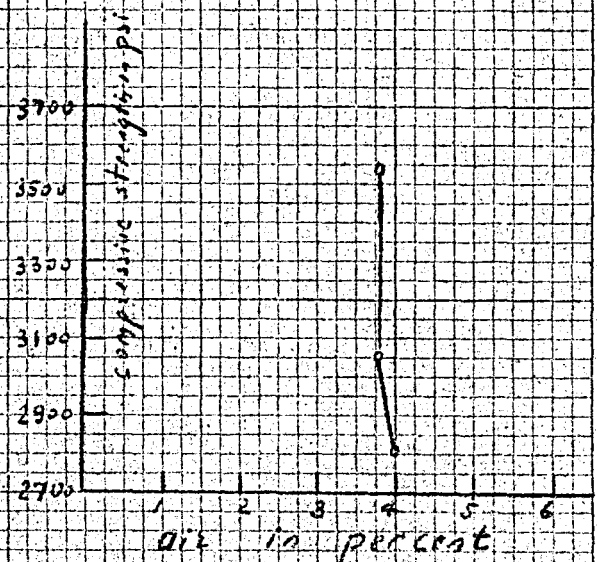
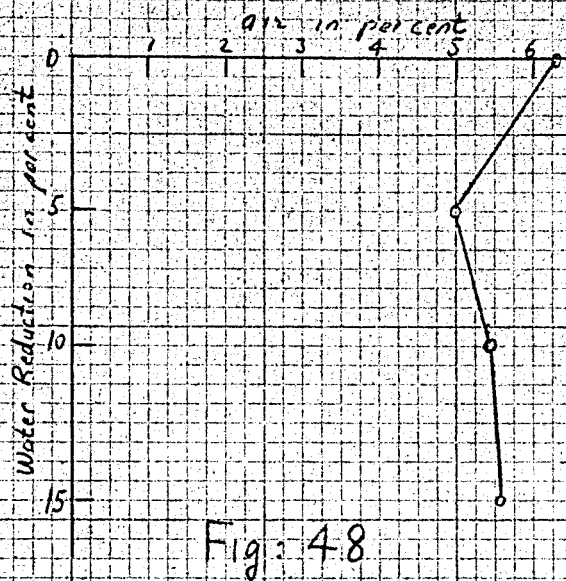


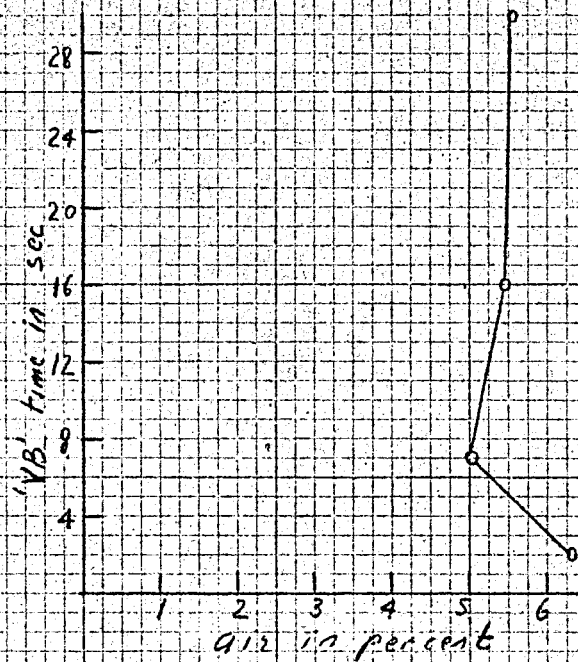
Fig: 47

REDUCTION OF WATER for 0.08 per cent LISSAPOL (T-2(B))

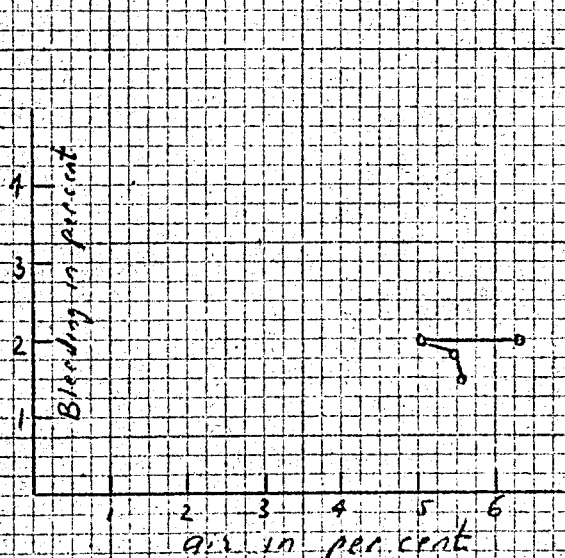
a) Water Reduction against amount of air



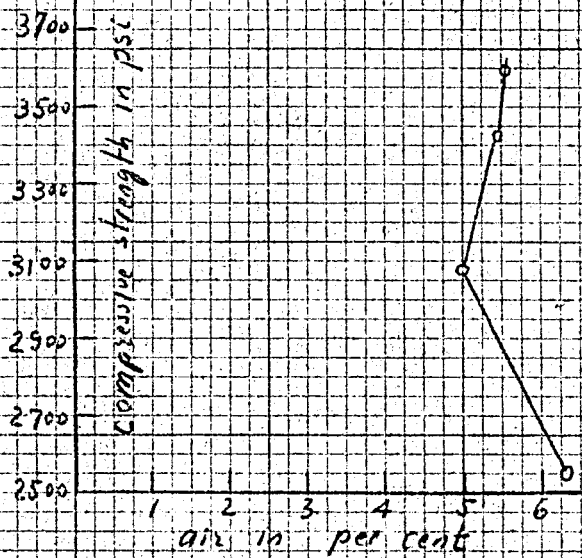
b) Time for compaction 'VB' against amount of air.



c) Bleeding water against amount of air



d) Compressive strength against amount of air.



2..I Result of test group T-2

a) Percentage of air is almost constant when amount of lissapol is constant. (Fig: 44)

b) Water reduction doesn't influence amount of air entrainment (Fig: 44, 48).

c) Air doesn't influence bleeding since it is constant. Slight decrease in bleeding is due to water reduction. (Fig: 46, 50)

d) Decrease in consistency is due only by reduction of water since amount of air is constant (Fig: 45, 49).

e) Compressive strength increase will solely be due to reduction of water in case of 0.04 L miX. In case of 0.08 L slight variation of air effects the compressive strength. (Fig: 47, 51).

2..2 Discussion of test group T-2

a) Slight variation of air per cent in case of 0.08 L miX may be due to miXing period. Therefore when amount of lissapol increases in a miX, control of air entrainment become more difficult.

b) In case of 0.08 L miX slight variation of air effects the compressive strength therefore reduction of water from 0 to 5 per cent (where air decreases from 6.3 to 5 per cent) gives more rapid rate of increase of compressive strength than reduction from 5 to 10 where air increases from 5 to 5.4 .

V - Conclusion: 1) Air increases with lissapol see table VIII

TABLE VIII

Effect of lissapol on air entrainment and strength
when all ingredients are constants

AdmiXture	workability slump	air per cent	strength per cent
plain	1	1.7	100
0.04 L	3.5	4	97
0.08 L	6	6.3	88

2) When amount of lissapol is constant, amount of air is constant too and it does not depend upon water reduction. see table IX

TABLE IX

Effect of lissapol on air entrainment and compressive strength with or without reduction of water.

AdmiXture	air per cent	per cent comp. strg.		water reduction
plain	1.7	100		-
0.04 L	4	97	100	-
0.04 L	3.8	121	126	10
0.08 L	6.3	88	100	-
0.08 L	5.6	119	135	12

CHAPTER XIII

EFFECT OF LISSAPOL ON THE COMPRESSIVE STRENGTH

I - Introduction:

In these tests, cylinders are used to measure compressive strength of concrete they are prepared according to ASTM C -192 -55.

Cylinders are 6in. in diameter by 12in. in length. They are molded by placing the concrete in the mold in three layers of approximately equal volume. Each layer was rodded with 25 strokes of the tamping rod.

The test specimens were removed from the molds 20-24 hr. after molding and stored in water at room temperature. All of the specimens were capped in order to eliminate any roughness to the surface. All cylinders are broken at 28 days age.

II - Object:

1) To investigate effect of lissapol on compressive strength of concrete and find related changes in the other properties of concrete.

(Test group No: T-1)

2) To investigate increase of compressive strength with water reduction and find related changes in the other properties of concrete.

(Test group No: T-2)

3) To investigate cement reduction. (Test group No: T-3)

III - Test data:

For mix data see Chapter VIII page 38 for T - I

page 39 for T - 2(A)

page 40 for T - 2(B)

page 41 for T - 3(A)

page 42 for T - 3 (B)

For compressive strength data see Chapter IX

page 43 for T - I

page 44 for T - 2 (A)

page 44 for T - 2 (B)

page 46 for T - 3 (A)

page 46 for T - 3 (B)

IV - Result and Discussion:

I..I Result of test group No T-I

a) Amount of lissapol is inversely proportional to the strength.

Increasing amount of lissapol results decrease in strength. (Fig: 52)

b) Slight increase in strength is due to better hydration of cement particles (Fig: 52, 53)

c) Increase of air causes low compressive strength. (Fig: 54)

d) Increase in consistency causes low compressive strength since amount of water and other ingredients are constant, this low compressive strength exists because of air. (Fig: 55)

e) Strength decreases with unit weight since all ingredients in the mix are constant this is due to air effect of lissapol.

(Fig: 57).

II..2 Discussion of test group T-I

a) Increase workability can be obtained only with decrease in strength. Therefore after to a certain level due to air entrainment effect we will gain in workability while strength loss will occur. Therefore control of amount of lissapol is necessary.

Increasing per cent of Lissapol when all ingredients are constants. (T-1)

a) Compressive Strength against amount of Lissapol.

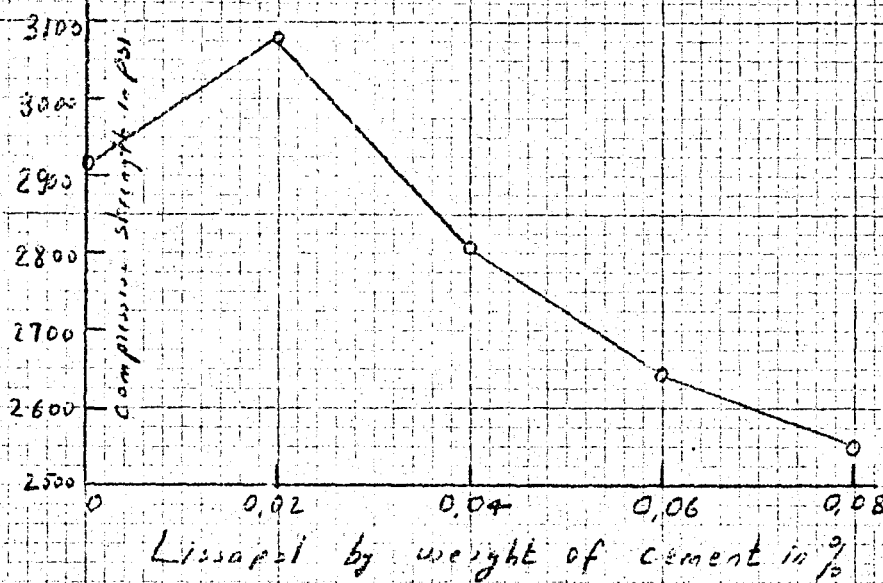
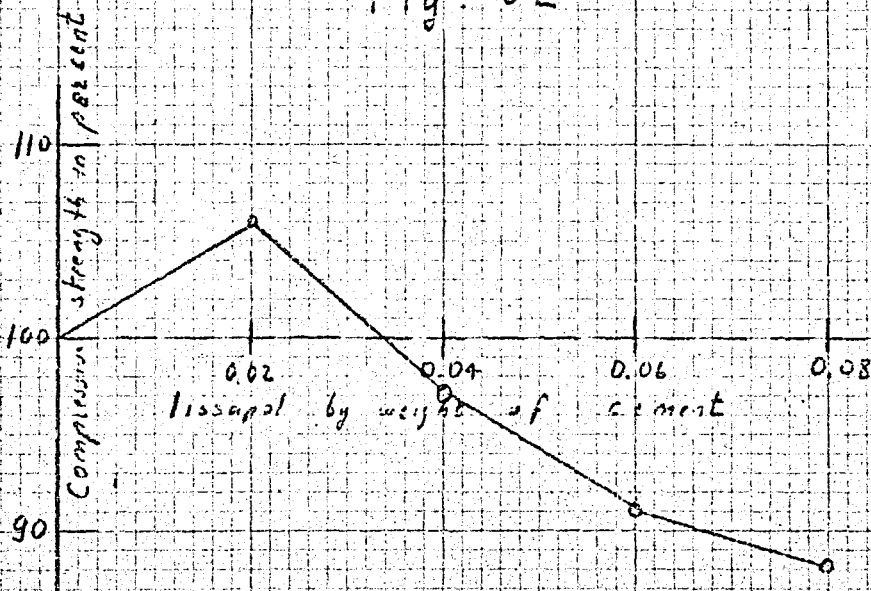


Fig: 52



Compressive strength in per cent

Fig: 53

b) Entrained air against compressive strength.

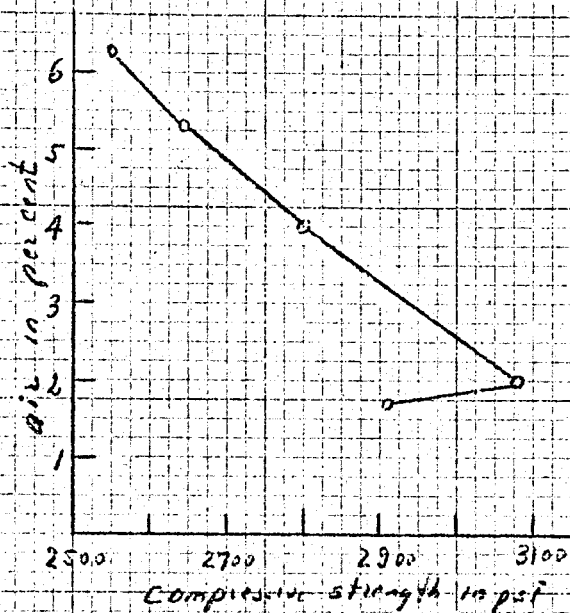


Fig: 54

c) Time for compaction 'VB' against compressive strength.

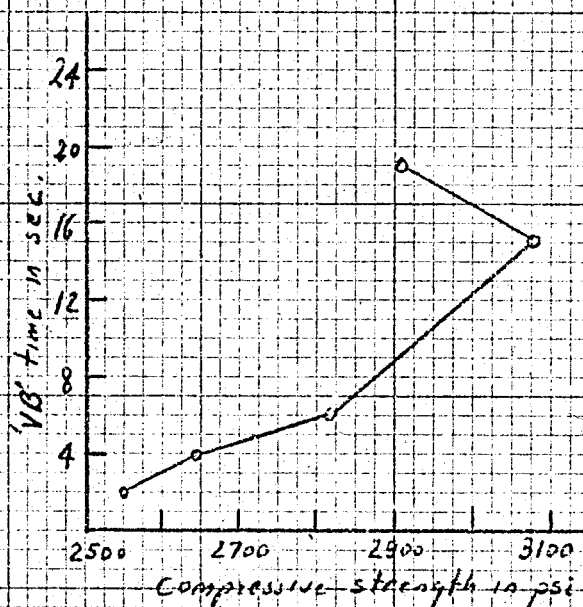


Fig: 55

d) Bleeding water against compressive strength

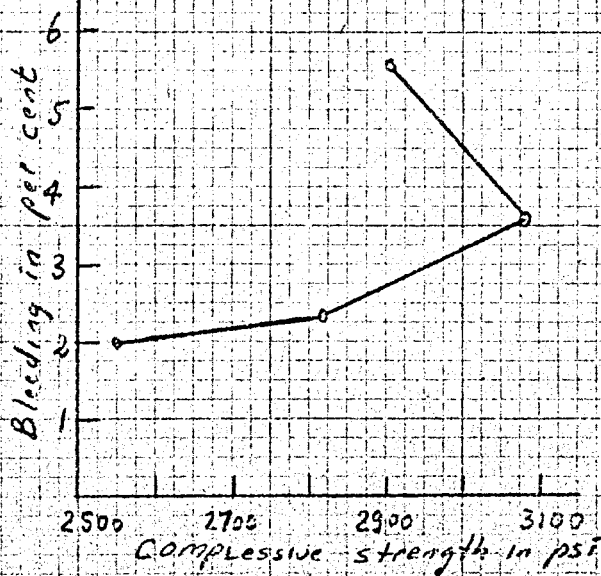


Fig: 56

e) Unit weight against compressive strength

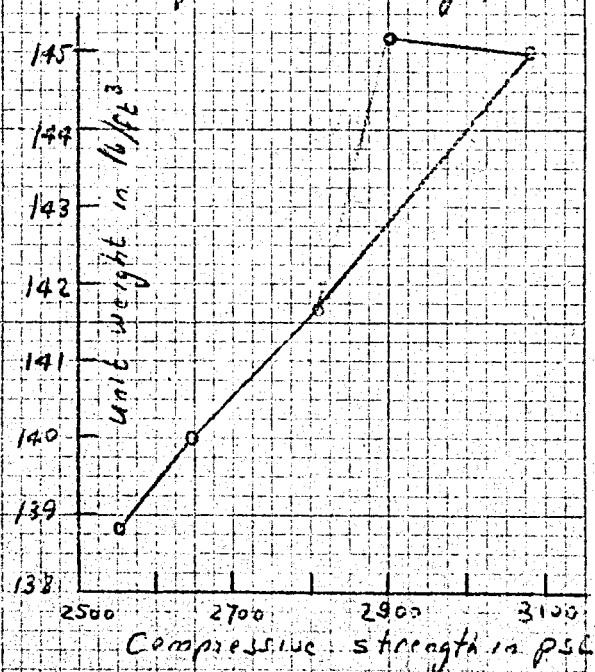


Fig: 57

II..I Result of test group T-2

- a) Water reduction causes increase in strength (Fig 58 ,62).
- b) Decrease of consistency is due to water reduction less water give us better concrete. (59 ,63).
- c) Air per cent is almost constant therefore it doesn't effect i increase of compressive strength. (Fig: 60 ,64).
- d) Decrease in bleeding is due to decrease of water. Therefore it is obvious that strength will increase when bleeding decreases without air-entrainment which is true. for this case (Fig 6I ,65).

II..2 Discussion of test group T-2

- a) In the case of 0.08 per cent of lissapol by weight of cement rate of increase in the compressive strength is rapid for first reductions and then it decreases. This is probably due to air since the 0.04 L miX and 0.08 L miX are different from each other only with amount of air.
- b) Slight variation of air shows that control of miX becomes difficult for high amount of lissapol. (Fig:64)

III.. I Result of test group T-3

- a) Cement causes strength reduction . (Fig:67 ,70)
- b) ApproXimately 96 lb of cement can be reduced without loss in compressive strength if we compare with plain miX. (I7 per cent) for 0.08 miX (Fig: 7I)
- c) ApproXimately 105 lb of cement can be reduced in case of 0.04 L miX (Fig: 68)
- d) This means that it is possible to safe I bag of cement.

III..2 Discussion of test group T-3

- a) Aggregate/cement ratio by Weight is 7.5 after cement and Water reduction (Fig: 69,72) In the case of plain it is 5.5 this shows the economy in using lissapol in concrete.

REDUCTION of WATER for 0.04 per cent LISSAPOL (T-2A)

a) Water Reduction against Compressive strength.

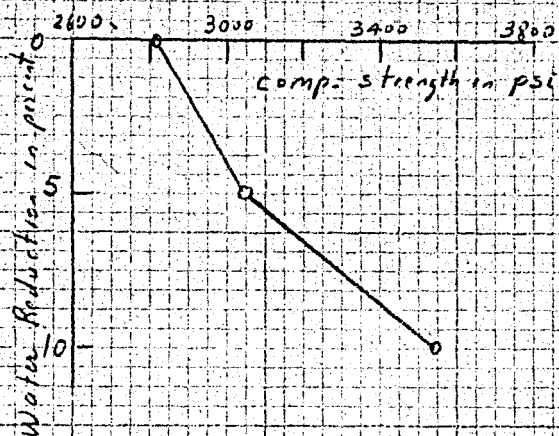


Fig: 58

b) Time of compaction 'VB' against compressive strength

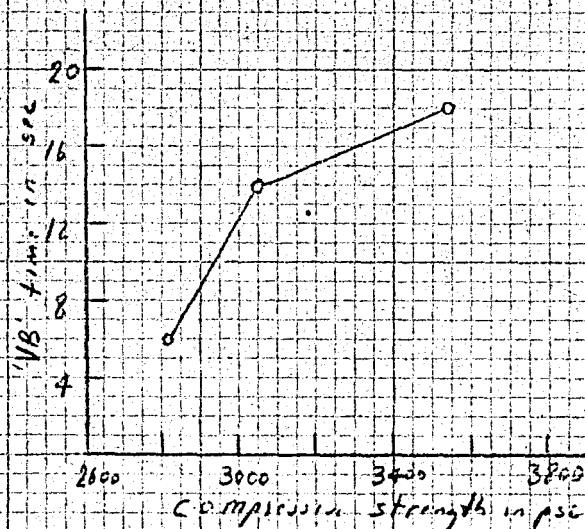


Fig: 59

c) Entrained air against Compressive strength

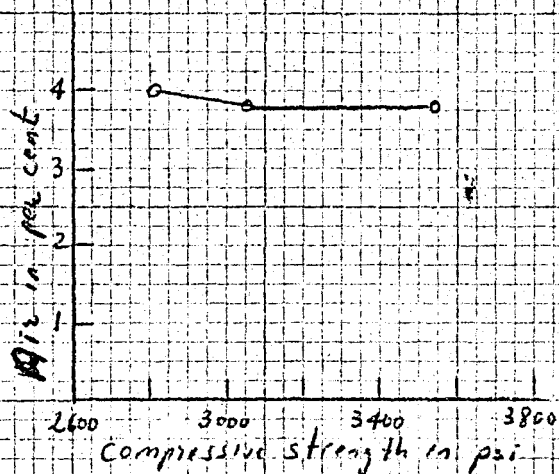


Fig: 60

d) Bleeding water against compressive strength

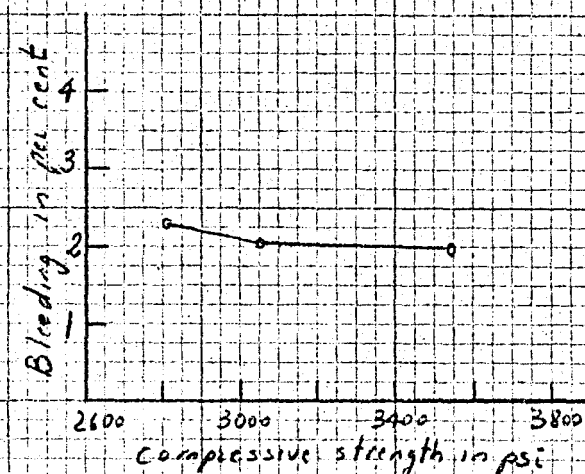


Fig: 61

REDUCTION of WATER for 0.08 per cent Lissapol (T-2B)

a) Water Reduction against compressive strength.

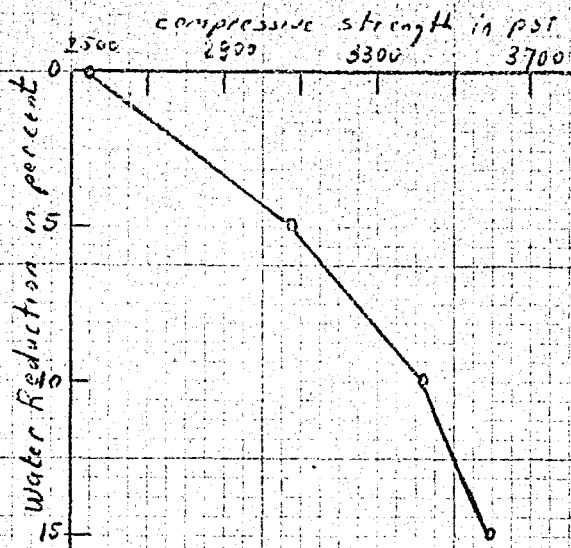


Fig: 62

b) Time of compaction 'VB' against compressive strength.

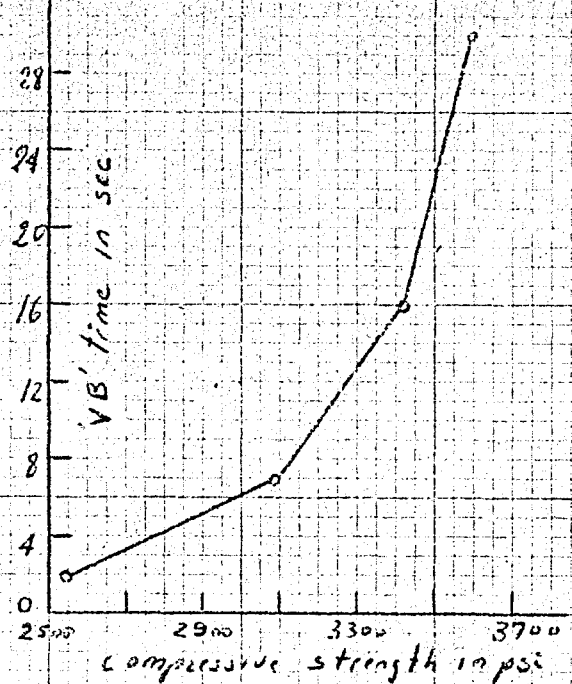


Fig: 63

c) Entrained air against compressive strength.

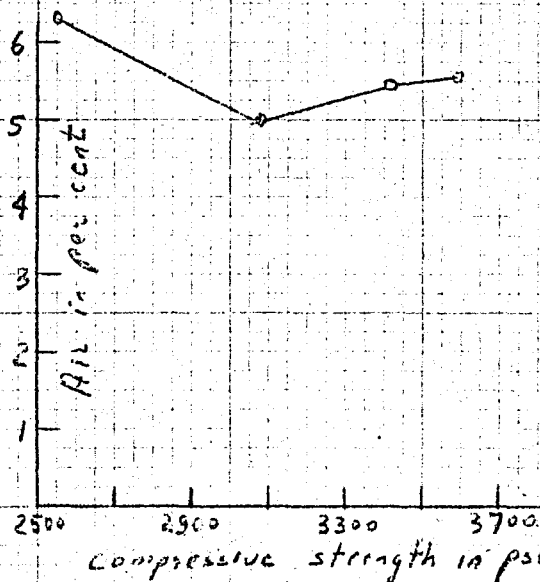


Fig: 64

d) Bleeding water against compressive strength.

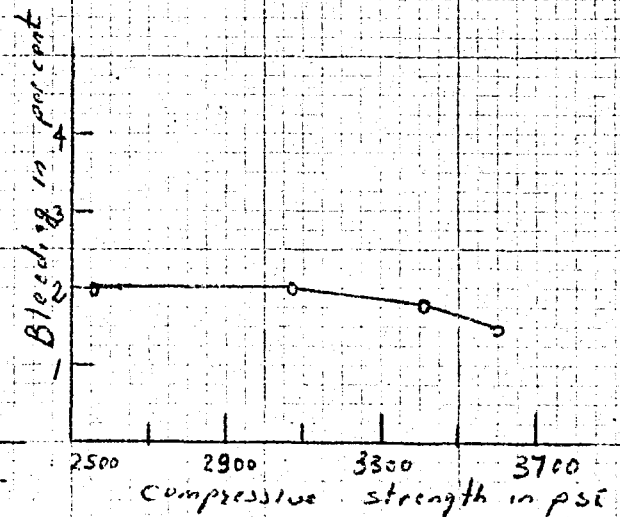


Fig: 65

Increase in compressive strength at equal workability.

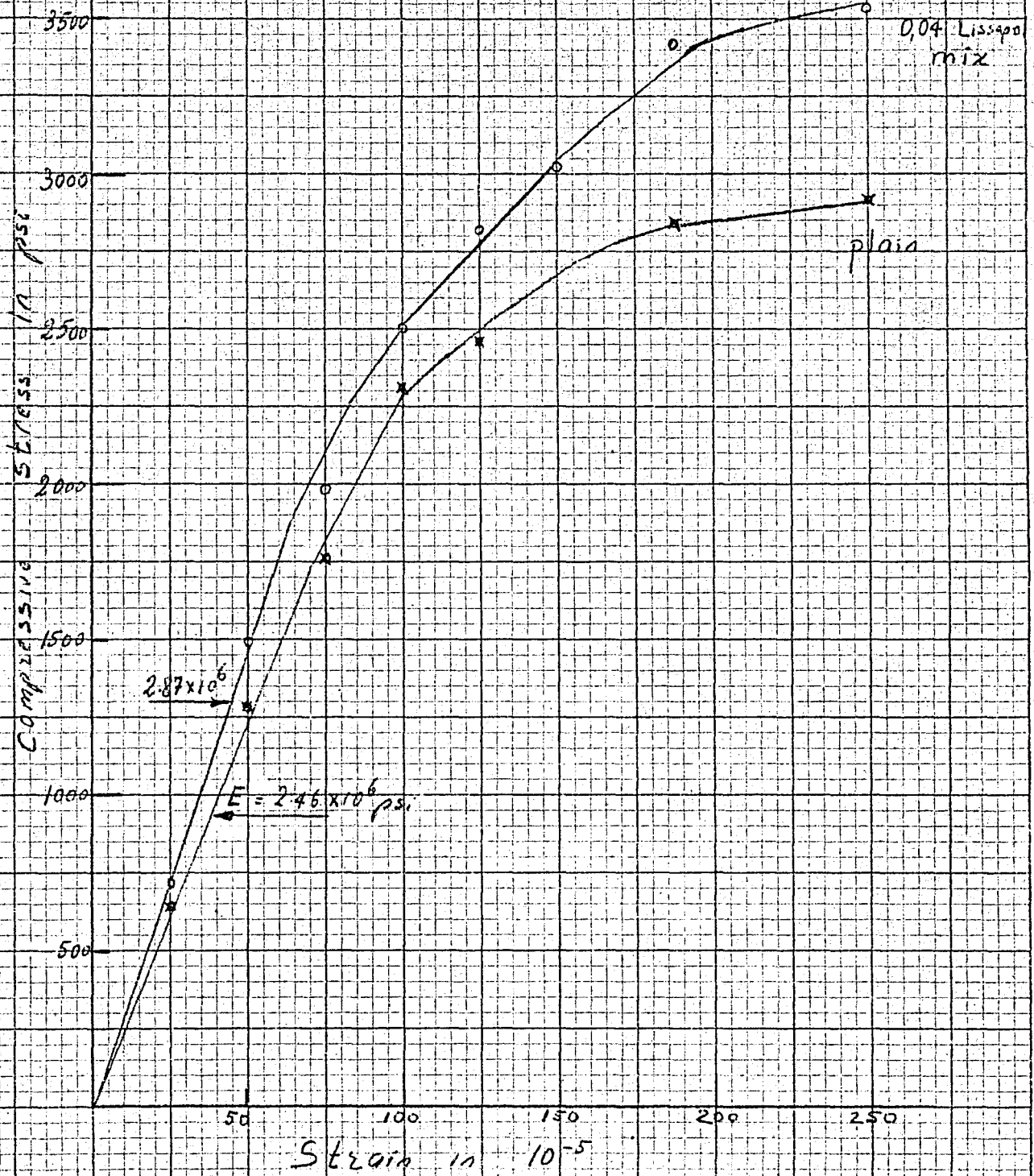


Fig: 66

REDUCTION of Cement for 0.04 per cent Lissapol

a) Reduction of cement against compressive strength

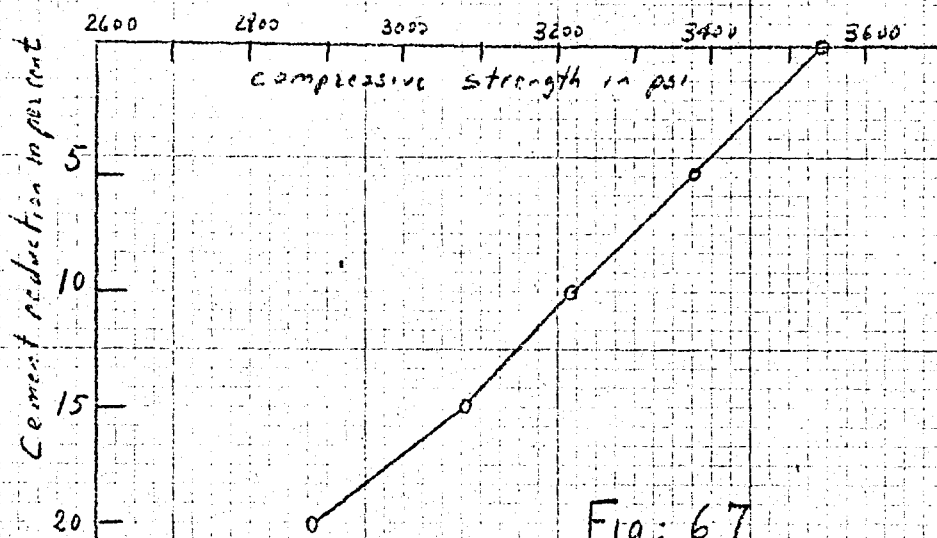


Fig: 67

b) Per cent of compressive strength against reduction of cement

Note: strength of plain mix is 100

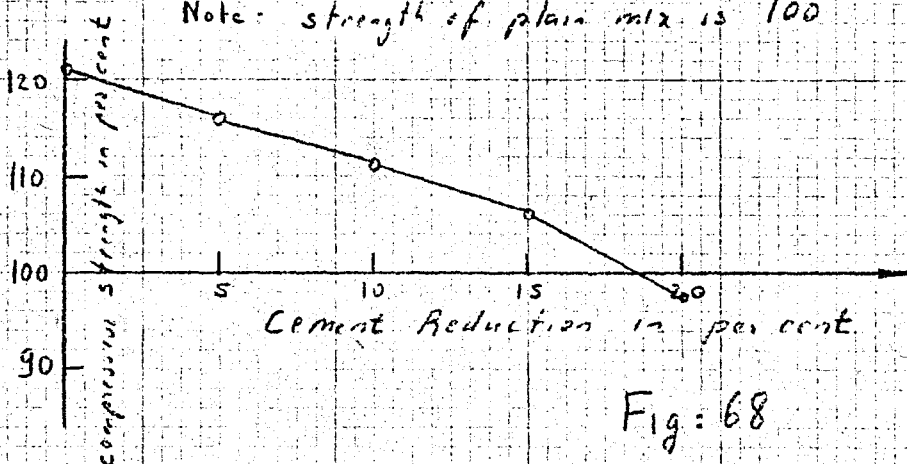


Fig: 68

c) Aggregate/cement ratio by weight against compressive strength

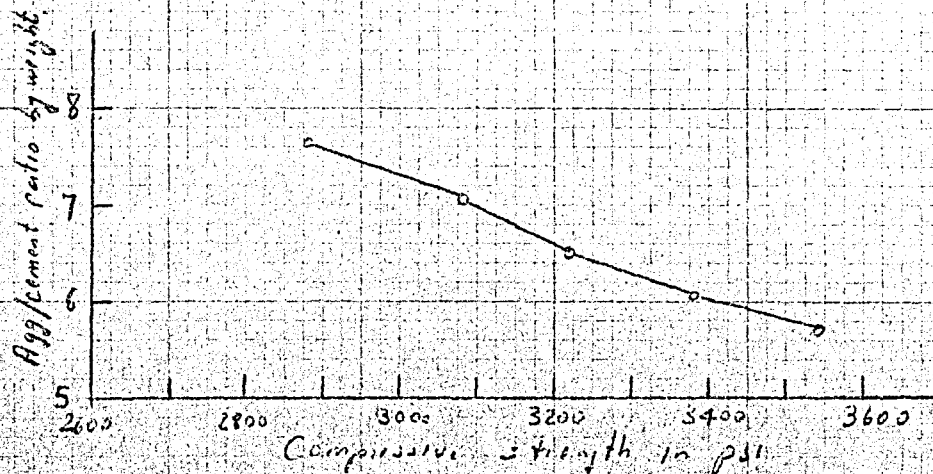
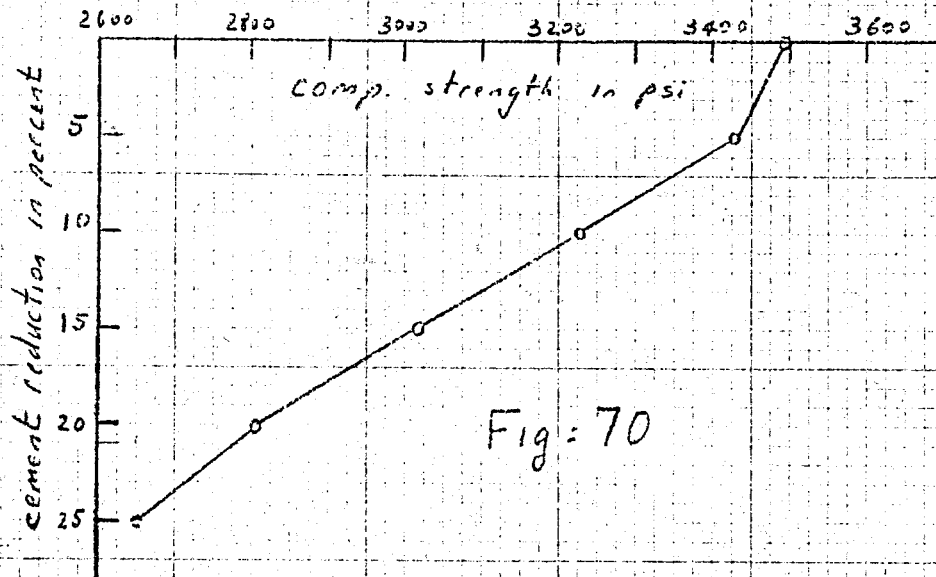


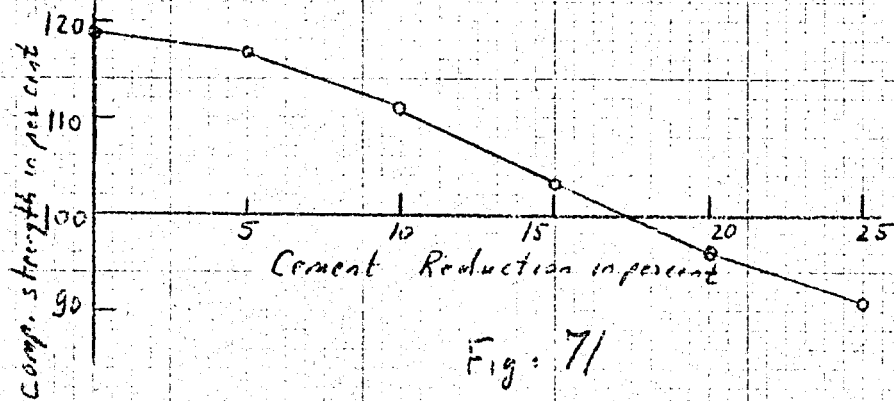
Fig: 69

REDUCTION of Cement for 0.08 per cent Lissapok

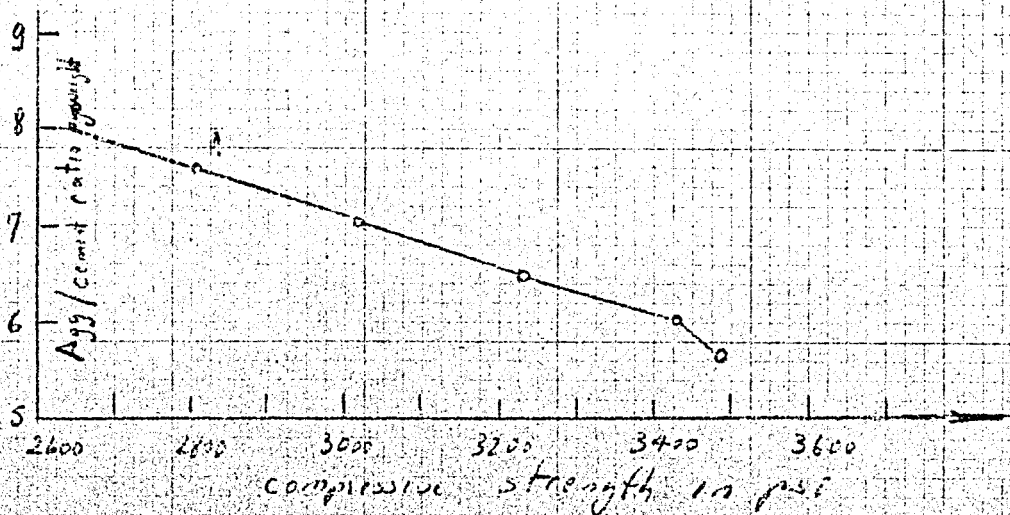
a) Reduction of cement against compressive strength.



b) Percent of Compressive strength against reduction of cement



c) Aggregate/cement ratio by weight against compressive strength



V Conclusion:

I) Increase in the amount of lissapol causes decrease in the compressive strength. (See table X)

TABLE X

Increase in workability by lissapol taking into consideration compressive strength.

Amount of liss. in perc.	workability		compressive strength	
	slump in.	comp. sec,	in psi	in perc.
plain	I	I9	2910	100
0.04 L	3.5	6	2810	97
0.08 L	6	2	2550	88

2) Water reduction causes increase in compressive strength.

see table XI

TABLE XI

Increase in compressive strength having the same workability by reducing water

Amount of liss. in perc,	Water reduction		Compressive strength	
	IN percent		in psi	in perc.
plain	-		2910	100
0.04 L	10		3540	121
0.08 L	12		3490	119

Note : Fig: 66 compare plain and 0.04 L mix taking strain into consideration see page 82.

3) Reduction of cement reduces strength, see table XII

TABLE XII

TABLE XII

Equal workability with water
and cement reduction

Amount of liss.	compressive strength	cement red.	water red.
	in per cent	in per cent	in per cent
plain	100	-	-
red. of water 0.04 L	121	-	10
red. both cement and water 0.04 L	100	19	10
red. of water 0.08 L	119	-	12
red. both cement and water 0.08 L	100	17	12

CHAPTER IVX

EFFECT OF LISSAPOL ON MODULUS OF ELASTICITY AND ABSORPTION OF CONCRETE

MODULUS OF ELASTICITY:

- I - Introduction: For modulus of elasticity strain ~~XXXX~~ measurement is done by concrete cylinder compressometer (see fig:56page35).
- II - Object: To investigate effect of lissapol on modulus of elasticity of concrete.

III- Test data :

For miX data see Chapter VIII page 38 for T-I

For test data both compressive and strain variation

see Chapter IX page 43 for T-I

page 44 for T-2

IV - Result and discussion

I..I Result of test group T-I

a) Since number of test specimens are not very much, it is not possible to reach to the concrete conclusion about effect of lissapol amount on elasticity. (Fig 73,74)

I..2 Discussion of test group T-1

a) Lissapol, when properly used, aids in the development of superior elastic properties (see table XIII) These elastic properties are particularly depend upon the amount and type of paste as well as volume ratio of paste to aggregate.

V - Conclusion

I) With water reduction elasticity of concrete increases.

(see table XIII page 86)

TABLE XIII

ELASTICITY AT EQUAL WORKABILITY BY REDUCTION OF WATER

Plain (w/c 0.60)	E is 2.40×10^6 psi
0.04 L mix with 10 per cent water reduction	E is 2.60×10^6 psi
0.08 L mix with 12 per cent water reduction	E is 2.73×10^6 psi

a) Modulus of elasticity against
amount of Lissapol

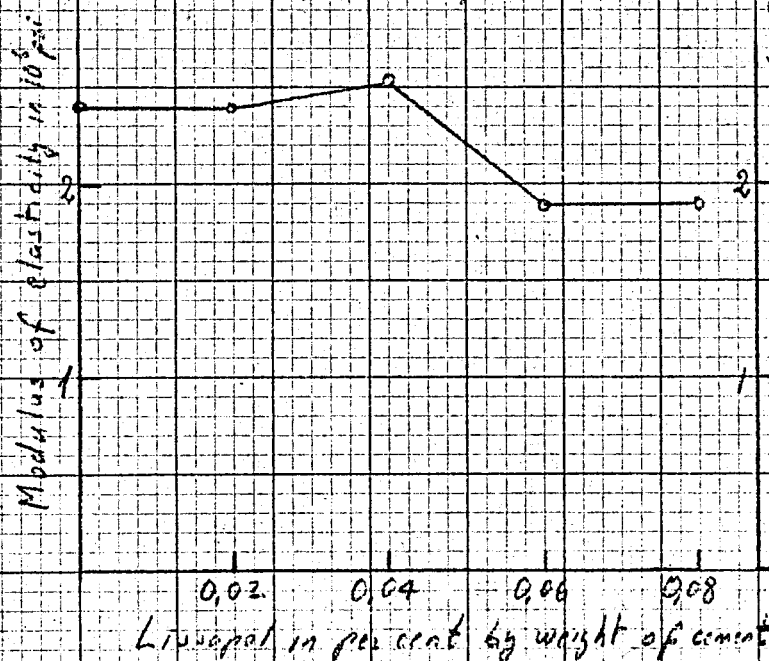


Fig: 73

b) Modulus of elasticity
against air.

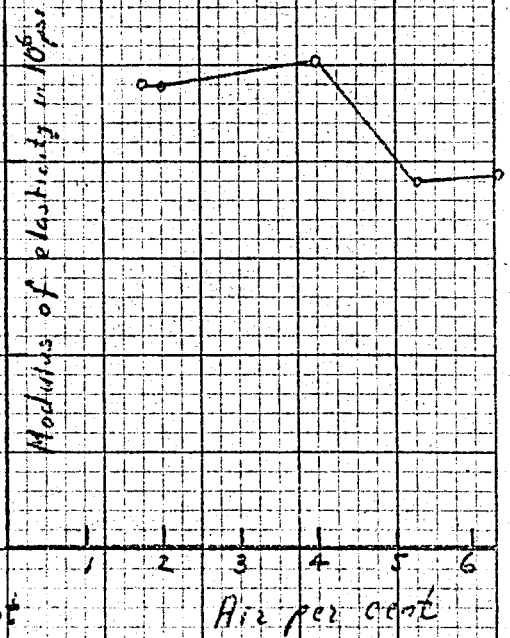


Fig: 74

ABSORPTION TEST

I - Introduction

Three 6 inch cylinders were made from each mix cured in moist condition until age of 14 days, after which they were removed and dried to constant weight, at room temperature, then immersed in water at 28 C, for 24 hours and 48 hours.

II - Object

Investigate amount of water absorbed by concrete made with and without lissapol.

III - Test data

We made two series of sample

1) T-II plain mix for mix data see Chapter VIII page 38

2) T-23(A) mix with 0.04 L and with 10 per cent water reduction
for data see Chapter VIII page 39

IV - Result and Discussion

I..I Result

a) plain mix :

specimen No	Absorption	
	percent 24 H	per cent 48 H
I	1.40	1.50
2	1.35	1.42
3	1.39	1.48

b) 0.04 L with 10 per cent water reduced

specimen NO	Absorption	
	percent 24 H	percent 48 H
I	0.90	1.00
2	0.93	1.01
3	1.00	1.06

V - Conclusion

Concrete treated with lissapol gives better waterproofing than plain concrete.

CONCLUSION

Lissapol increases the workability of plastic concrete, there is no limit for it ~~KXX~~ if we increase lissapol concrete becomes more fluid. But lissapol introduces air into the concrete and this air causes decrease in compressive strength therefore amount of air and compressive strength put the limit of amount of lissapol for the mix .

Since the workability is increasing when we use lissapol it is possible to keep it at a constant level and to reduce the water in the mix and to obtain better concrete. This concrete has less bleeding high compressive strength and high elastic characteristic than plain concrete. (Approximately 20 per cent increase of compressive strength when 10 per cent water reduction is done.

And finally it is possible to reduce amount of cement when water reduction is done. By this way we reach for more economical mix. Test shows that from 6 bags of cement 1 bag can be saved. Also water absorption test shows that lissapol concrete absorbs less water than plain concrete.

APPENDIX A

LISSAPOL N and SURFACE -ACTIVITY

Lissapol N is a surface-active agent which finds many applications in the building industry, both in construction work on the site and in the factory manufacture of materials intended for use in construction work.

Surface active agents are substances which because of their chemical configuration or due to the influence of substituent groups therein are concentrated at interface between two immiscible phases and alter the physicochemical forces acting at this interface. Such adsorption is sometimes due to the amphipathetic nature of the molecule or a chemisorption effected by hydrogen bonding. The net effect is the same in either case. ("surface activity" written by Molliet and Collie D.V.Nostrand Co. Princeton N.Y.)

The reaction between cement powder and water, which is the primary mechanism the setting of concrete, involves an enormous solid liquid interface on account of the finely ground cement particles, and thus any modification of this large surface may be expected to result in a marked alternation to the properties of the mixture. The first function of the surface-active agent is that of assisting the wetting out of the dry cement particles and ensuring that the water comes into intimate contact with the cement or in the surface chemical language, the phenomenon results from lowering of the contact angle between cement and water. The cement is utilised more efficiently in the presence of a surface active agent, and the amount of dry or imperfect hydrated cement in the mix is very much reduced.

A further feature of certain surface active agent is their ability to keep fine particles in suspension. This is naturally of great importance in concrete since it results in a greater fluidity of the mix due to the increased ease with which the individual cement or sand particles are enable to move past each other. This suspending action is also manifested in the reduced segregation which is apparent when Lissapol N is used.

Lissapol N belongs to the class of non-ionic surface active agents represented by the alkylphenol-ethylene oxide condensates and these are remarkably inert chemically although very active physically. It may be noted that, when used at the concentrations recommended, the Lissapol contained in the finished concrete amounts to less than 1 part in 10000 i.e. probably less than soluble impurities present in the aggregate and water used.

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- I6) C.A.Vollick "Effect of water-reducing admixtures and set _
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