SHRINKAGE CRACKS IN CONCRETE- RESEARCH NEEDS

STPL

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Concrete shrinkage research …

“ To look is one thing.

To see what you look at is another

To understand what you see is another.

To learn from what you understand is something else

But to act on what you learn is all that really matters”

Sir Winston Churchill

Whenever there is a call from a construction site …

- Immediately after placing the concrete within 12 hours
- After de-shuttering is done
- Weeks after placing the concrete
- Months/years after construction is completed

- **What we get to look and see**

↓

AFTER LOOKING AT CRCKS FIRST IMPRESSION (ALSO THE LAST IN MOST OF THE CASES)

- These are essentially shrinkage cracks which are in random in nature
- Occurs when concrete surface dries up starving from water curing
- Structurally from strength of concrete point of view no issue
- Yes…it is an issue from functional point of view as the slab leaks…

But no customer likes to see/have cracks in their constructions irrespective of best solutions/remedies offered

DEFINITION OF SHRINKAGE:

Shrinkage is an inherent property of concrete. The shrinkage in concrete can be defined as the volume changes observed in concrete due to the loss of moisture at different stages due to different reasons.

Types of Shrinkage in Concrete

The shrinkages can be classified into the following:

- Plastic Shrinkage
- Drying Shrinkage
- Autogenous Shrinkage
- Carbonation Shrinkage

Shrinkage strain of concrete - causes and types

- The shrinkage represents a time dependent deformation which reduces the volume of concrete, without the impact of external forces.
- The time flow and the final values of shrinkage are influenced by numerous factors: temperature and humidity, dimensions of elements, the type and quantity of cement, w/c factor, granulometric and mineralogical composition of aggregates, concrete strength, method of workability and curing, concrete age at the end of curing and many other factors. Basically, it is a combination of several basic types of shrinkage

PLASTIC SHRINKAGE

If the volume reduction occurs before the **concrete** hardens, it is called plastic **shrinkage**. The volume reduction that occurs primarily due to moisture loss after the **concrete** has hardened is known as drying **shrinkage**. ... It can be significant in **concrete** with a very low water-cementitious materials ratio.

Non-structural cracking of concrete is a serious problem and the underlying phenomena, namely, shrinkage and creep, need to be better understood. **Much research has been devoted to this complex problem. However, despite major successes, the phenomenon of shrinkage is still far from being fully understood.**

Plastic Shrinkage in Concrete

- It is observed after the casting of concrete that water required for concrete strength gain is escaped into the atmosphere due to the process of evaporation, from the surface of the structure.
- This will create cracks on the surface of the structure. Another reason for shrinkage cracks under plastic shrinkage type is due to the water absorption from the concrete by the aggregate.
- The aggregate particles or the reinforcement will come in the way of subsidence due to which the cracks may appear on the surface of the structure or internally around the aggregates.
- In the case of floors and the pavements, where the surface area is exposed to drying in a large extent compared to the depth when are subjected to the sun and the drying wind, the surface dries very quickly causing plastic shrinkage

DRYING SHRINKAGE

Drying shrinkage is caused by the loss of surface -absorbed water from the calcium silicate hydrate (C-S-H) gel and also due to the loss of hydrostatic tension in the small pores. Swelling is the opposite phenomenon of shrinkage.

This shrinkage is mainly due to the deformation of the paste, though the aggregate stiffness also influences it. It takes place once the concrete has set is called as the drying shrinkage. Most of the kinds of drying shrinkage take place in the first few months of the concrete structure life.

Factors Affecting Drying Shrinkage

Main factors that affect the drying shrinkage

1. Material Selection

Ingredients that are chosen for the concrete mix must be good quality to ensure chances of drying shrinkage. The properties of the ingredients in terms of quality and specification must be as per the standard codes of that region.

2. Water cement Ratio

Higher the water /cement ratio of the concrete mix, more is the chances for drying shrinkage. As the water/cement ratio increases, the strength of the paste and the whole stiffness will decrease. Hence shrinkage increase with the increase of water.

3. Environmental Conditions

The relative humidity of the site plays an important role on the drying shrinkage of the concrete structure. With the increase in humidity in the environment, there is a decrease in the decrease of shrinkage.

4. Cement Content

The rate of shrinkage will increase with the increase in the cement content

5. Aggregates

Type used in the Mix: Size of aggregate will influence the cause of drying shrinkage. The increase in the maximum size of aggregates will decrease the shrinkage.

The aggregate grading and shape have no appreciable influence on the shrinkage characteristics of concrete. Those aggregates that have high rough surface will resist the shrinkage.

5. Type of Cement used in the mix

As depending on the purpose, a wide variety of cement can be used, the shrinkage also varied accordingly. The rapid hardening cement will harden fastly, hence the shrinkage is more in the same compared to the ordinary Portland cement.

The rapid hardening cement will ask for higher water and high fines that will result in more shrinkage. The use of shrinkage compensating cement will help in either reduction or the elimination of the shrinkage cracks.

6. Admixture in Concrete

The addition of calcium chloride as an admixture into the concrete mix will increase the shrinkage. But this rate of shrinkage will decrease when it is replaced with the help of lime.

7. Size and Shape of the Specimens

The surface to the volume ratio is a factor that can influence the rate of shrinkage. The rate and the magnitude of shrinkage will decrease with the increase of surface to volume ratio.

8. Other Factors

The method of steam curing has little effect on the shrinkage. But it shows an effect when the carried out at high pressures.

MEASUREMENT OF LINEAR SHRINKAGE WITH A LENGTH COMPARATOR

Shrinkage of concrete is of the order 0.0003 means?

This shrinkage deflection,i.e., shrinkage strain's Ultimate value is 0.0003.

It means that while designing, you have to consider shrinkage strain ultimate value as 0.0003. Normally you have to limit within 0.0002

It means dL/L= 0.0003. ie for every one unit of length there is 0.0003 units of strain. if the length of the member is, say, 1 m, the strain would be 0.0003 m or 0.3 mm. that's all.

Early age shrinkage of concrete is a major concern in reinforced concrete members such as slabs, shear walls, raft footing etc. where the exposed surface area is more.

As soon as water is added to the mix, a chemical reaction between water and cement (hydrates) is initiated although its effects may not be apparent for the first few hours.

The impact of this time dependent reaction on the setting, stiffening, hardening and strength development of concrete is well documented, but the fact that shrinkage occurs in the first few hours of its life has not been adequately required.

ASTM C157 / C157M - 17

Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete

Concrete Shrinkage

- **Plastic shrinkage – Rapid loss of moisture in plastic concrete**
- **Drying shrinkage – Long-term loss of moisture in hardened concrete**

EXPERIMENTAL CASE STUDY

Comparative study on plastic shrinkage of concrete made with CONEX- Shrinkage Compensating Admixture @1 % and 2% dosage against control sample (Concrete without CONEX)

for

M/s. Flowcrete India Private Limited

INTRODUCTION

Early age shrinkage of concrete is a major concern in reinforced concrete members such as slabs, shear walls, raft footing etc. where the exposed surface area is more. As soon as water is added to the mix, a chemical reaction between water and cement (hydrates) is initiated although its effects may not be apparent for the first few hours. The impact of this time dependent reaction on the setting, stiffening, hardening and strength development of concrete is well documented, but the fact that shrinkage occurs in the first few hours of its life has not been adequately required.

Concrete maintains almost semifluid properties for a few hours. Hydration reaction is very slow during first 3-4 hours of concretes life but accelerate over the following 8-12 hours. When the concrete charges from semifluid state into a more rigid are capable of cracking. The time period depends as many variables including the constituents of the concrete, the mix proportions and weather conditions.

In a freshly consolidated concrete, water in the spaces between the cement and the aggregates rises to the surface which is called as bleeding water. This bleeding water gets evaporated due to hot weather conditions and fast blowing wind, concrete surface cracks due to plastic shrinkage. Concrete is unable to resist tensile stresses resulting from volume change (plastic shrinkage) as the concrete is weak in tension. Addition of an admixture which would compensate and reduce shrinkage of concrete is studied in our laboratory and the test results are furnished in this report.

DETAILS OF PRODUCT:

CONEX- shrinkage Compensating Admixture, Batch No. QC 744, Mfg. Date- 06/07/2018

Plastol 3630- High range water reducer, Batch No. QC 581, Mfg. Date- 21/07/2018

DETAILS OF MIX PROPORTION ADOPTED:

In order to test the Shrinkage compensating Admixture (CONEX), the Mix proportion is adopted as given in Table 1.

T A B L E – 1

DETAILS CONCRETE MIX AND SLUMP TEST RESULTS

Cement used*	Mix Designation	Aggregate Max. size (mm)	Cement Content (kg/cu.m)	Free Water Cement ratio (max)	Mix Proportions C:CSS:CA**	Dosage of Admixture by weight of cement (%)+	Slump Obtained (mm)
							Initial
Bharathi 53 Grade OPC	M 20 Control	20	300	0.55	1 :2.70 : 3.89	0.25	110
	M 20 (1% Conex)	20	300	0.55	1 :2.03 : 2.92	0.25	110
	M 20 (2% Conex)	20	300	0.55	1 :2.03 : 2.92	0.25	105

TESTS CONDUCTED

Fresh concrete – Methods of Sampling, Testing and Analysisas per IS 1199 (Part 2) – 2018

Hardened concrete properties- Length change as per ASTM C 157/ C 157 M. Test results are furnished in Table- 2.

PROCEDURE

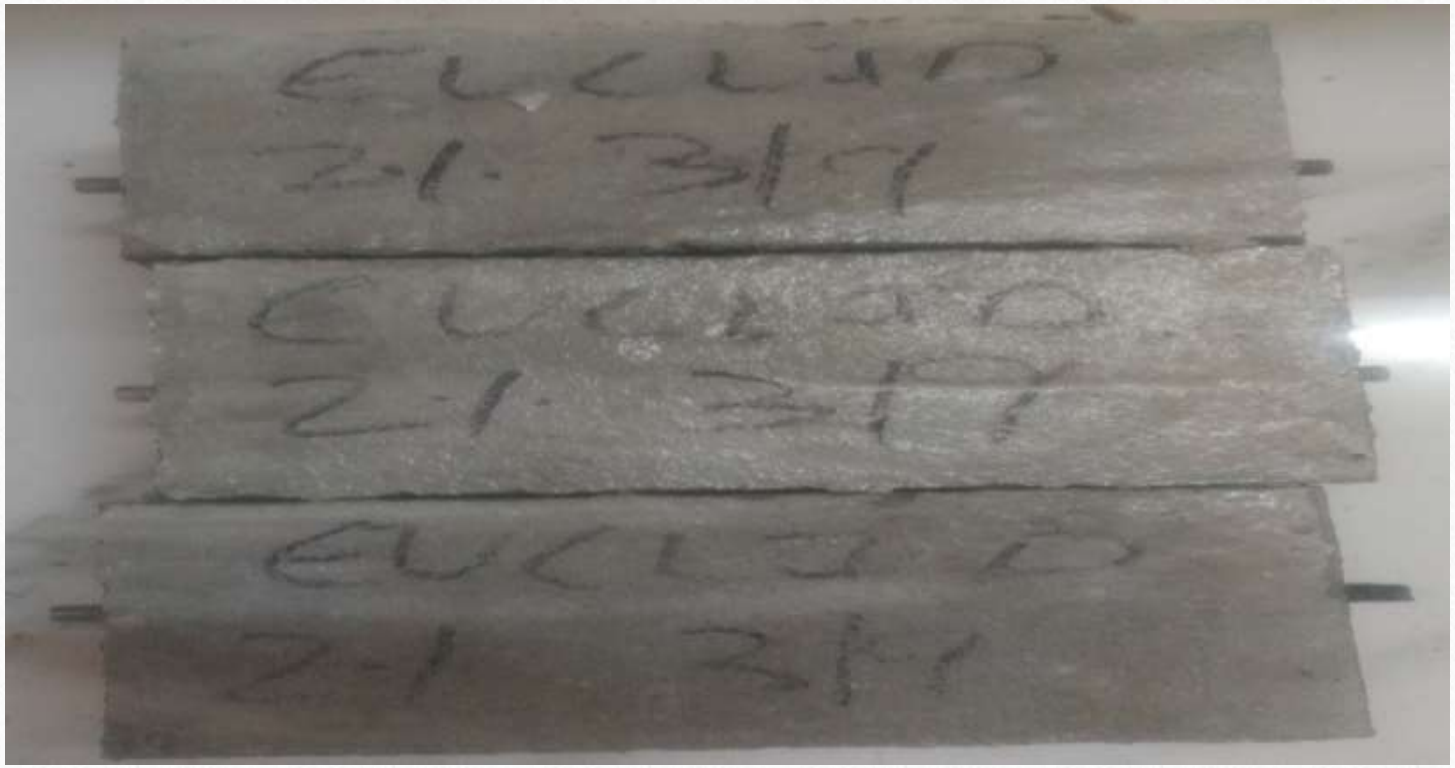
a) Concrete specimens are cast with a length of 150 mm and a cross section dimension of 75mm x 75mm.
b) Gauge pins are inserted into the mould before casting the sample.
c) After finishing the surface, moulds are covered with plastic and stored in environmental chamber maintained at 90 % humidity and 27 ±2 ºC for 12 hours
d) After 12 hours, specimen are carefully removed without disturbing the pins.
e) Immediately after demoulding, an initial comparator reading is noted.
f) As soon as the initial reading is complete, specimens are placed in curing tank.
g) Additional comparator readings are taken at 24 and 72 hours as well as at 7 and 28 days in the saturated wet cure condition.

Shrinkage compensating Admixture-: EUCLID Chemical company- CONEX

Slump cone test

Hardened test specimens- 1% CONEX

- Hardened test specimens- CONTROL



Hardened test specimens- 2% CONEX

Length change measurements

T A B L E – 2

LENGTH CHANGE TEST RESULTS

Type of Mix	24 Hours	Average Length change (%)	72 Hours	Average Length change (%)	168 Hours	Average Length change (%)	672 Hours	Average Length change (%)
Control	-0.003	-0.001	-0.010	-0.009	-0.014	-0.012	-0.016	-0.015
	0.001		-0.008		-0.010		-0.013	
1% CONEX	0.017	0.015	0.0075	0.0077	0.0020	0.0023	0.0009	0.0007
	0.013		0.0079		0.0026		0.0005	
2% CONEX	0.027	0.024	0.011	0.013	0.0054	0.0057	0.0024	0.0022
	0.021		0.015		0.0060		0.0020	

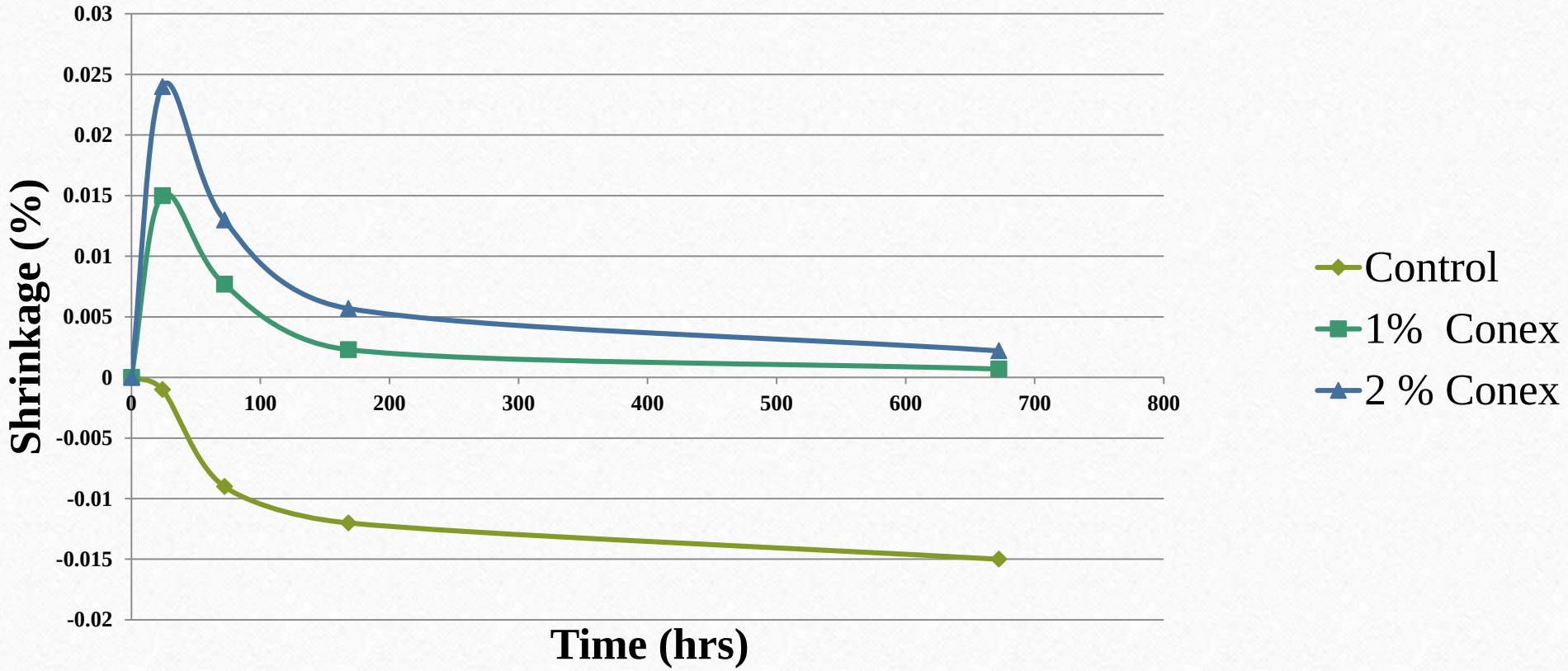


Fig. 1 Graph of Shrinkage results

INFERENCES

Based on the physical observations and results of the Length change test conducted following inferences are drawn.

1. Based on the comparator readings taken, it is evident that the CONEX is an expansive component.
2. Expansion characteristics of CONEX allow Shrinkage Reduction/ Compensation for concrete.

CONCLUSIONS OF THE EXPERIMENTAL STUDY

Based on the inferences drawn on the Length change test results, it can be concluded that CONEX- which is a powdered admixture can be used for the compensation and reduction of shrinkage for Portland cement concrete. CONEX is found to perform well when used with EUCON and PLASTOL Admixture which allows Shrinkage Reduction/ Compensation for concrete.

CONCLUDING REMARKS ON NEED FOR RESEARCH ON SHRINKAGE OF CONCRETE

Laboratory experiments on Drying Shrinkage as per standards do not reflect actual behavior of concrete in the field. Field conditions reflect something different in spite standard construction practices followed. Limited information is available on studies on plastic shrinkage. Experimental procedures needs to designed taking into account of site conditions. To minimize shrinkage cracks it is always recommended to ensure continuous curing which cannot be guaranteed. To mitigate shrinkage cracks, use of fibers (metallic/non-metallic) is widely being adopted. However, use of Shrinkage Reducing/Compensating Admixtures needs research studies as it is going to be another chemical into concrete.

We cannot always say... basically concrete is bound to crack and it can be repaired. Why we should we live with concrete which has cracked, repaired bringing back its functionality ???

Is it not a cracked concrete might suffer durability, longevity and Life span of concrete members ???

I hope needs of R&D in addressing the shrinkage cracks in concrete should get the attention it deserves


Thank You
24Slides