AUTOGENOUS SHRINKAGE OF STEEL FIBER-REINFORCED CONCRETE

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF REQUIREMENT FOR THE AWARD OF THE DEGREE OF

MASTER OF TECHNOLOGY
(Structural Engineering)

SUBMITTED BY

MANPREET SINGH BAINS
(2204097)
December 2023

I.K GUJRAL PUNJAB TECHNICAL UNIVERSITY
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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the thesis entitled “EFFECT OF FLY ASH AND NANO TITANIUM DIOXIDE ON COMPRESSIVE STRENGTH OF CONCRETE” by “MANPREET SINGH BAINS” in partial fulfilment of requirements for the award of degree of M.Tech. (Structural Engineering) submitted in the Department of (Civil Engineering) at GURU NANAK DEV ENGINEERING COLLEGE, LUDHIANA under PUNJAB TECHNICAL UNIVERSITY, JALANDHAR is an authentic record of my own work carried out during a period from 16 August 2023 to 25 December 2023 under the supervision of PROF.HARVINDER SINGH. The matter presented in this thesis has not been submitted by me in any other University / Institute for the award of M.Tech Degree.

Signature of the Student

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

Signature of the Supervisor (s)

The M.Tech Viva Â–Voce Examination of (MANPREET SINGH BAINS) has been held on 30 December 2023 and accepted.

Signature of Supervisor(s) Signature of External Examiner

Signature of H.O.D.

ABSTRACT

There are several factors affecting the durability of concrete, shrinkage being one of them. Dry shrinkage can be controlled but autogenous shrinkage, that occurs automatically within the concrete generating micro cracks. These cracks widen up with time. The presence of randomly distributed fibers was found to reduce both the total and autogenous shrinkage, and more specifically, an increase in fiber volume fraction or fiber aspect ratio results in significant mitigation in both total and autogenous shrinkages Different types of steel fibers are available and each of them has different effect on properties. The percentage of fibers can only be used up to a limit it has adverse effects on workability of concrete. The review of research studies has been presented to provide outline on durability of concrete structures.

KEYWORDS: Autogenous shrinkage, steel fibers, early age, Dramix 3d steel fibers

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CONTENTS

CHAPTER 1 - INTRODUCTION

1.1. GENERAL

Concrete is a composite material, which is used widely as a construction material worldwide. It majorly consists of binding material - cement, aggregates, water and admixtures. Being a major construction material, it is important to consider the problems or factors which come into consideration, when accepting or rejecting the use of concrete for some specific conditions. The factors considered are – strength, service life, minimal losses, cost effectiveness and environmental impacts. The losses that occur in concrete can be reduced, but never brought to zero. Loss due to shrinkage of concrete and creep in concrete are major being observed in concrete. Further, total shrinkage loss i.e., loss due to volumetric change of concrete is summation of autogenous shrinkage and dry shrinkage.

Autogenous shrinkage is the volumetric reduction of the size of concrete specimen. It is an early age shrinkage that develops immediately after casting. Cement contain bogous compounds – C_2S, C_3S, C_3A, C_4AF require water for reaction. When C_2S and C_3S uses water present in pores for hydration. As a result, hydration product - CSH gel is produced, which has lesser volume than the sum of volume of water and binders. Pore pressures and tensile forces act on the pore walls.

Since the concrete strength is a time dependent factor, it is minimal at the early age. The tensile stresses become greater than the tensile strength of concrete and along with the pore pressure in the cavities or capillaries, micro-cracking may occur within the concrete, therefore durability of concrete is compromised, owing to subsequent macro-crack formation. Micro cracking further accelerates the rate of water loss from the pores or capillaries resulting in dry shrinkage. High-strength concrete is more prone to autogenous shrinkage. A high-strength concrete has lower water-cement ratio, further the water is used up by bogous compounds and capillaries are generated, resulting in crack formation and strength loss.

To overcome the problem of microcracking, different types of materials has been used along the basic constituents of concrete, the main objective being imparting tensile strength to concrete. Self-healing concrete, supplementary cementitious materials and fibers are widely used. However, one of its limitations is its relatively weak tensile strength due to its lack of tensile strength, concrete is more likely to crack when subjected to tensile stresses. To address

this limitation, different methods and materials can be used to reinforce concrete. One of them is steel fiber. When steel fibers are added to the concrete mixture it improves the tensile strength and enhance crack resistance. They act as tiny reinforcements within the concrete matrix as provides an additional benefit by reducing the shrinkage within the concrete matrix. In experiments, the values of shrinkage are measured in micrometres.

CHAPTER 2 - LITERATURE REVIEW

2.1. GENERAL

Number of researches had been conducted to find out how to mitigate the autogenous shrinkage with introduction of steel fibers. A brief review of various studies in this field has been considered along with the governing parameters.

2.2. LITERATURE SURVEY

(Chowdhury et al., 2023) study the effect of autogenous shrinkage on light-weight concrete along with steel fibers. A cylinder of 100 mm diameter and 400 mm length was prepared for calculation of autogenous shrinkage. A polyethylene sheet was placed in a steel cylinder mould and concrete was poured. Crimped fibers (shear and wavy) with percentage of 0%, 0.5 %, 1% and 2% by volume of concrete and superplasticizer was added to improve workability and reduce water content. The ends were closed by placing plates and micrometer gauges were used to find the shrinkage. The constant temperature of 20 ± 2^0 C was maintained. Light-weight concrete with crimped steel fibers of length 30 mm and aspect ratio of 40 at 336 hours (14 days) decreases the autogenous shrinkage values by 15% and 7.6% when the percentage of crimped steel fibers was increased from 0% to 0.5% and then 0.5% to 1% respectively.

(Murari et al., 2022) carried out research using Ultra-High-Performance Fibers. Ultra-High Performance Reinforced Concrete members can be constructed with reduced quantities of the traditional reinforcement. These provide good early age compressive and tensile strength, which is required to alter the effect of shrinkage. Micro-steel fiber and three Dramix 3d steel fibers were used. A total of 12 concrete mixtures were made. Micro fiber had length of 13 mm and aspect ratio of 65. The Dramix 3d steel fibers had length of 35, 36, 60 mm and aspect ratios of 45,65, 80 respectively. Prisms of size of 285 X 75 X 75 mm were casted and were sealed with aluminium foil and then taped properly. The temperature was maintained at 25^0 C and relative humidity of 50 %. Only 2.5% of UHPF makes over 70% reduction in autogenous shrinkage compared to that of the specimen without fibers. Micro -fibers and UHPH with same aspect ratio have reduction of 35% and 55% respectively. The aspect ratio not had any significance change in reduction of autogenous shrinkage. Increasing percentage of fibers from 2% to 2.5% had no significant difference in shrinkage values.

(Nasser et al., 2018) investigated the effect of Dramix 3D steel fiber on autogenous shrinkage of concrete. It has lower dry shrinkage and more crack resistance. It had length of 60 mm length and 0.75 mm diameter with aspect ratio of 80. The two ends of this fiber were hooked to enhance the binding force of concrete and absorbed the energy during the process of pull-out. The hooked-length and hooked-angle was about 4 mm and 45^0 respectively. A 750 X 150 X 150 mm mould was used with thin vinyl sheet placed in mould and concrete as poured. Superplasticizer was also used in order to make concrete workable and reduce water requirement. The autogenous shrinkage values for High-performance concrete reinforced with 0%, 0.3%, 0.6% and 0.9% hooked end steel fibers (Dramix 3D) of length 30 mm at 81.6 hours (3.4 day) decreases by 22.48%, 48.06% and 72.09% respectively. There is decrease of 56.94% in autogenous shrinkage when the amount of steel fibers is increased from 0% to 1%. A nominal percentage of 0.9% Dramix 3d steel fibers reduces autogenous shrinkage by 72.09% whereas ordinary steel fibers reduce autogenous shrinkage by 56.94% when the amount was 1.0%. The Dramix 3D steel fibers are much effective than the ordinary steel fibers in case of crack resistance even when used in same amounts.

(Rohini et al., 2012) investigated the effect of hooked end steel fibers with percentage of 0%, 0.3 %, 0.6% and 0.9% by volume of concrete were added. It had length of 60 mm, aspect ratio of 80, the linear section length of 50 mm, hooked-angle of $45^0$and hooked-length of 5 mm. The constant temperature of 20 ± 1^0 C was maintained. The effective length of specimen was 1080 mm and cross-section of 150 X 150 mm. The displacement sensors were fixed in the middle section of the mould with 450 mm. The mould was oiled, then double layer of polyethylene sheet was pasted inside the mould and after casting, the top face was covered with polyethylene sheet and aluminium sheet to minimise drying. The results of autogenous shrinkage were determined by Temperature Stress Test Machine (TSTM). With thermal expansion, shrinkage decreases, but with the increase in age of concrete after initial setting time, autogenous shrinkage also increases. The autogenous values were reduced by 17.6%, 29.4% and 64.7% with increase in hooked end steel fibers from 0% to 0.9% respectively at 168 hours (7 days).

The required results were obtained by Dramix 3d steel fibres. These have maximum tensile strength and minimum shrinkage. Instead of using more quantity (in percent) of other fibres, lesser quantity of Dramix 3d steel fibers solve the purpose.

CHAPTER 3 - CONCLUSION

The conclusions drawn after referring to the various studies are:

- The use of steel fibers also reduces the autogenous shrinkage as well as dry shrinkage of concrete by resisting the development of micro-cracks.
- Use of Dramix 3d steel fibers reduce the autogenous shrinkage up to 72.09%, which makes concrete very much durable.
- The maximum percentage of steel fibers used for reducing autogenous shrinkage is 2%. Increasing the percentage reduces workability but have no effect on autogenous shrinkage.
- Incorporation of discrete steel fibers into concrete can significantly reduce the autogenous- shrinkage, this is mainly due to the bond stress between the fibers and concrete matrix.
- Hooked end steel fibres serve the purpose in very efficient way. Comparing same quantity of micro or plain fibers and hooked fibres, hooked fibers provide maximum tensile strength and minimum shrinkage.

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