e-ISSN:2582-7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 5, Issue 6, June 2022

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.54

6381 907 438 6381 907 438 ijmrset@gmail.com www.ijmrset.com

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.54||Monthly, Peer Reviewed & Referred Journal |

| Volume 5, Issue 6, June 2022 |

| DOI:10.15680/IJMRSET.2022.0506098 |

Comparative Study of Drying Shrinkage in Mortar with Different Cement-To-Fly Ash Ratios

Dr. Parth Verma[1*], Manish Tiwari[1], Vaibhav Hoonka[1], Dr. Arun Kumar Khare[1], Guru Sharan Mishra[1], Bhupendra Sirbaiya[1]

Department of Civil Engineering, Baderia Global Institute of Engineering and Management, Jabalpur, Madhya Pradesh, India[1]

ABSTRACT: The reduction in volume of concrete due to internal factors, unaffected by external forces, is termed as shrinkage. Drying shrinkage occurs after concrete hardens, often leading to cracks, which significantly impact the strength and durability of concrete by increasing its permeability and susceptibility to aggressive substances. Apart from chemical and autogenous shrinkage, drying shrinkage is particularly critical. This study examined how alternative cementitious materials like fly ash affect water absorption in concrete samples. Additionally, it explored the influence of factors such as water-cement ratio (w/c) and curing time on drying shrinkage in mortar specimens. The study also investigated the impact of cementitious materials on crack formation and propagation. Significant reductions in shrinkage were observed with optimized fly ash content, which also contributed to enhanced concrete strength.

KEYWORDS: Drying Shrinkage, Fly Ash, Mechanical Strength, Mortar

I. INTRODUCTION

Concrete has been the predominant building material for a century. Following its casting and setting, concrete undergoes various dimensional, physical, and mechanical changes, including drying. Despite its mechanical implications, drying is primarily a physical process. As concrete hardens, it dries, resulting in significant dimensional changes that often manifest as cracks. The susceptibility to cracking is influenced by factors such as concrete's tensile strength and extensibility, which limit the deformation induced by shrinkage stresses.

These cracks impact the durability of concrete structures, especially those exposed to environmental conditions where moisture diffusion causes fluctuations in concrete moisture content across time and space, leading to uneven moisture distribution within concrete cross-sections. This differential drying induces tensile stresses on exposed concrete surfaces, potentially resulting in cracks.

Drying shrinkage refers to the contraction of concrete due to moisture loss during drying. Shrinkage-compensating concrete techniques are employed to minimize cracks and structural movements caused by drying shrinkage. The extent of drying shrinkage in concrete structures depends on constituent materials, mix proportions, curing methods, drying environments, and restraints.

Globally, annual fly ash production exceeds 900 million tons, with significant outputs from countries like China (580 million tons), India (169.25 million tons), the United States (43.5 million tons), and Australia (14 million tons). However, only about 53.5% of fly ash is effectively utilized, leading to challenges in waste disposal, often ending up in landfills or oceans. Similarly, global annual blast furnace slag production reaches about 530 million tons, with only approximately 65% being recycled.

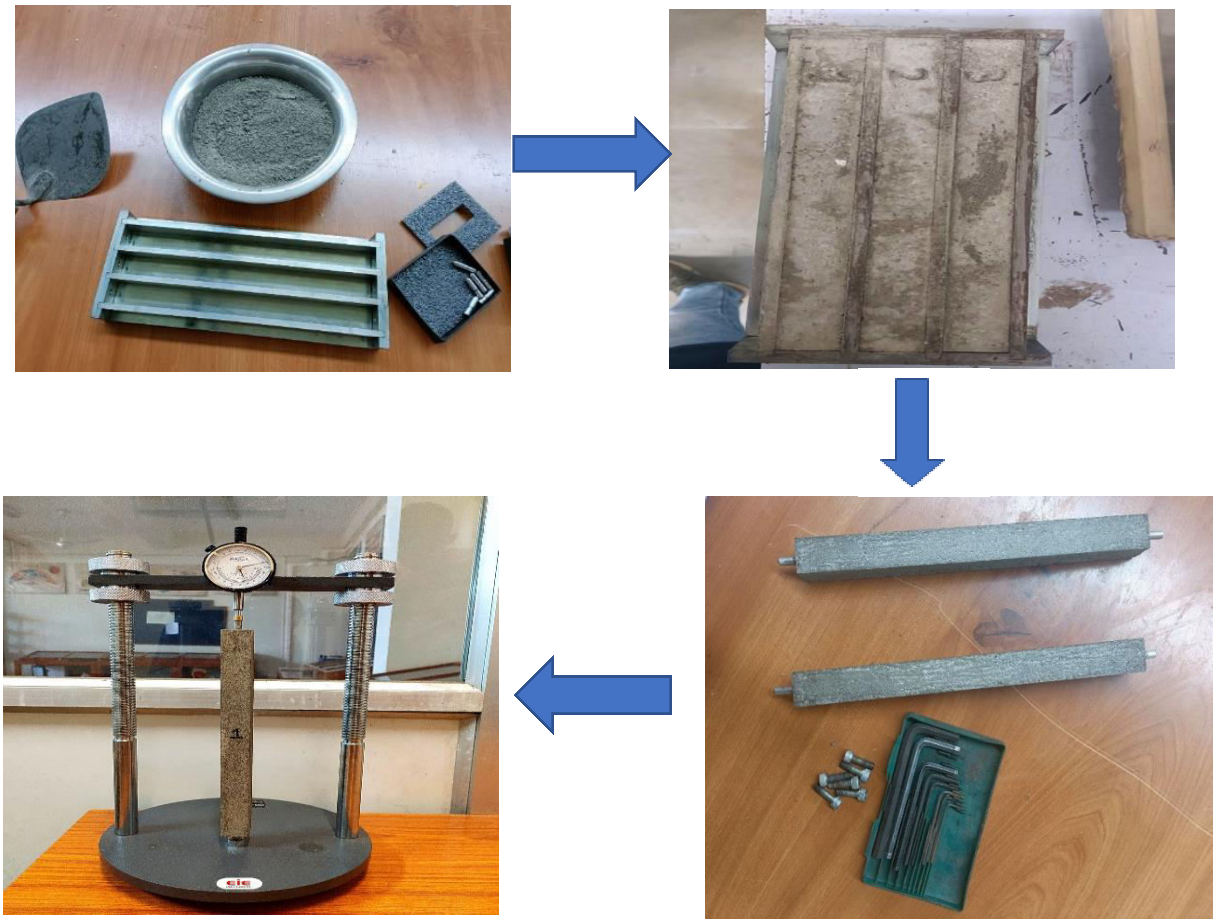
| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.54||Monthly, Peer Reviewed & Referred Journal |

| Volume 5, Issue 6, June 2022 |

| DOI:10.15680/IJMRSET.2022.0506098 |

II. EXPERIMENTATION

The drying shrinkage test for concrete, as per IS:1199 (1959), involves determining the difference between the original wet measurement and the dry measurement of a rectangular molded sample. Required apparatus include a mould, oven, curing tank, and length comparator. The process begins with preparing the specimen mould using two layers of compaction, typically sized at 7.5cm x 7.5cm x 15cm or 7.5cm x 7.5cm x 30cm.
After removing the specimen from the mould, it is submerged in water maintained at 25°C to 29°C for 24 hours or as specified. Following this initial period, the specimen is removed from water, and its length (L1) is measured. The specimen is then immersed in water again for another 24 hours. After removing it from water, the length of the specimen (L2) is measured. This cycle is repeated until a constant length is achieved.



Calculation:
The percentage in difference of final length to the initial length i.e. (L1-L2) is the drying shrinkage.
Dry Shrinkage % = (L1-L2)/L2 x 100%

1. Percentage of Cementitious Material

In this test, the cement employed is ASTM Type I Ordinary Portland Cement, along with Fly Ash (Type F) and river sand as the fine aggregate. Table 1 details the oxide content of the Fly Ash. Additionally, specific mix proportions are used (with a water-cement ratio of 0.45) for the cement and Fly Ash to ensure optimal workability, as outlined in Table

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.54||Monthly, Peer Reviewed & Referred Journal |

| Volume 5, Issue 6, June 2022 |

| DOI:10.15680/IJMRSET.2022.0506098 |

2. Table 1 Chemical Composition of the Fly Ash

SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	SO_3	P_2O_3	Others	LOI
61.8	17.80	6.97	1.34	3.19	0.95	2.00	0.88	0.79	0.20	0.49	3.61

Table 2. Mix proportions of mortar

Mortar	Cement (%)	Fly Ash (%)
M1	100	0
M2	95	5
M3	90	10
M4	85	15
M5	80	20

III.TESTING PROCEDURE

For Grade M20 mortar-1, the cement constitutes 100% by weight of the cementitious material with a mix ratio of 1:1.5. For mortar-2, the cement makes up 95% and fly ash 5%, maintaining the same mix ratio. For mortar-3, the cement is 90% and fly ash 10%, also with the same mix ratio and a water-cement ratio of 0.45. After preparing the mix proportions, the samples are placed in moulds for 24 hours. Mortar-1 and mortar-2 are then removed from the moulds, and their lengths are measured using a length comparator. After recording the measurements, the samples are submerged in water for another 24 hours. The expansion and contraction in the length of the mortar samples are detailed in Table 3.

Table 3 Readings of length of dial gauge

Days	Mortar 1(mm)	Mortar 2(mm)	Mortar 3(mm)	Mortar 4(mm)	Mortar 5(mm)
Day 1	10.37	9.73	7.30	5.994	6.834
Day 2	10.15	9.412	7.412	5.812	6.841
Day 3	10.23	9.51	7.40	5.801	6.826
Day 4	10.524	9.746	7.32	5.816	6.832
Day 5	10.37	9.984	7.29	5.818	6.842
Day 6	10.15	9.660	7.43	5.828	6.856
Day 7	10.23	9.330	7.44	5.942	6.968
Day 14	10.6	9.40	7.42	5.82	6.90
Day 28	10.72	9.42	7.438	5.85	6.858

For Grade M20 mortar-3, the cement constitutes 90% and fly ash 10% by weight of the cementitious material, with a mix ratio of 1:1.5. For mortar-4, the cement is 85% and fly ash 15%, maintaining the same mix ratio. For mortar-5, the cement makes up 80% and fly ash 20%, also with the same mix ratio and a water-cement ratio of 0.45. After preparing the mix proportions, the samples are placed in moulds for 24 hours. Mortar-3, mortar-4, and mortar-5 are then removed from the moulds, and their lengths are measured using a length comparator. After recording the measurements, the samples are submerged in water for another 24 hours, noting any expansion and contraction in length.

IV. RESULT AND DISCUSSION

The drying shrinkage percentages for the cementitious materials are presented in Table 4. L1 represents the length of all samples on day 1, and L2 represents their length on day 7. It was observed that as the percentage of cement decreased and the percentage of fly ash increased, drying shrinkage reduced. The relative humidity of the drying environment is roughly inversely proportional to shrinkage. For mixtures made with regular Portland cement at a W/C ratio of 0.45,

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.54||Monthly, Peer Reviewed & Referred Journal |

| Volume 5, Issue 6, June 2022 |

| DOI:10.15680/IJMRSET.2022.0506098 |

this ratio had a negligible impact on shrinkage. The test results also indicate that shrinkage of cementitious materials is directly related to the percentage of materials used.

Table 4 Drying Shrinkage % of mortar

	Mortar 1	**Mortar 2**	**Mortar 3**	**Mortar 4**	**Mortar 5**
Drying Shrinkage %	8.72	4.28	1.88	0.87	1.9

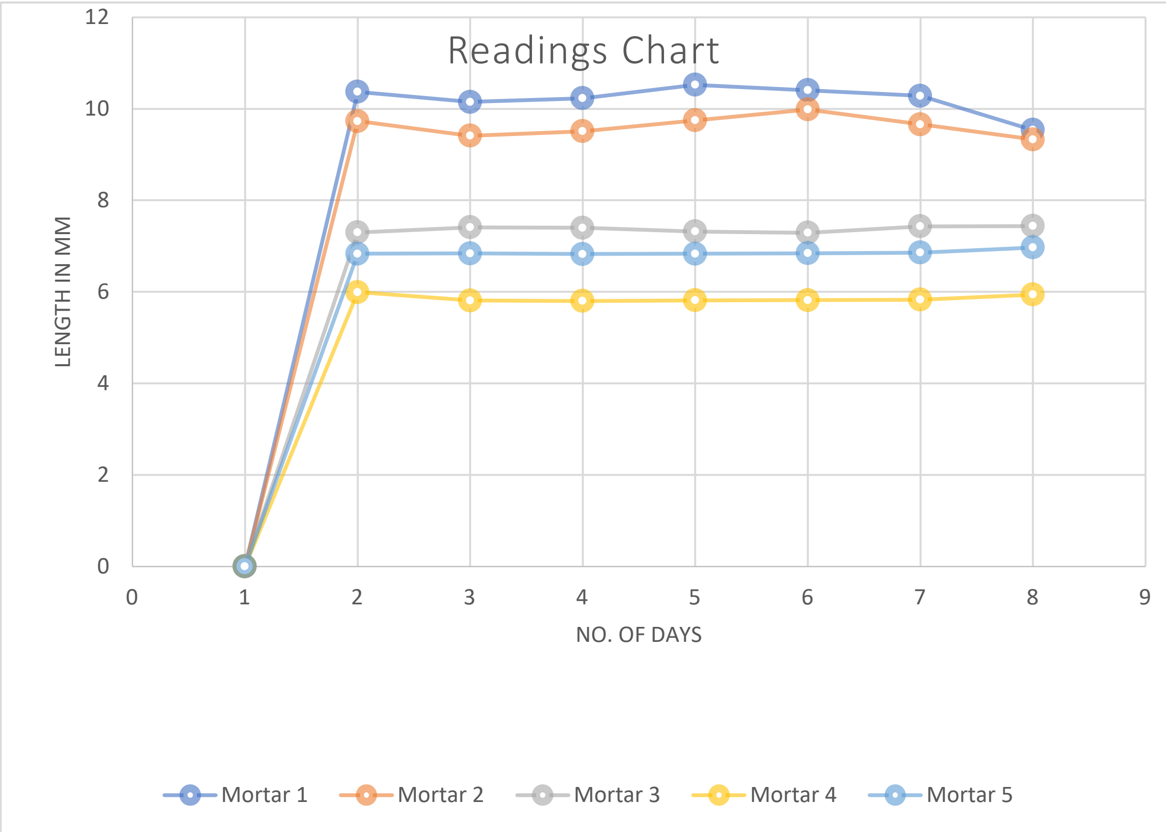


Figure 1 Drying Shrinkage

V. CONCLUSION

The expansion and contraction of cementitious material are due to the absorption and expulsion of water. The irreversible part of shrinkage occurs due to the formation of additional physical and chemical bonds in the cement gel when adsorbed water is removed. When concrete dries, free water in the capillaries, which is not physically bound, is lost first. This process creates internal relative humidity differences within the cementitious material, causing it to contract. However, the volume reduction is not equal to the volume of water removed, as the initial loss of free water does not significantly affect the volumetric contraction of the paste.

Through comparative analysis of drying shrinkage in mortar with varying ratios of cement and fly ash, we can reduce crack width, thereby increasing the strength and longevity of the structure. Table 3 shows that decreasing the percentage of cement and increasing the percentage of fly ash can help reduce drying shrinkage. Figure 1 provides a graphical representation of the number of days and the corresponding length measurements of the mortar samples.

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.54||Monthly, Peer Reviewed & Referred Journal |

| Volume 5, Issue 6, June 2022 |

| DOI:10.15680/IJMRSET.2022.0506098 |

REFERENCES

1. Bissonnette, B., Pierre, P. and Pigeon, M., 1999. Influence of key parameters on drying shrinkage of cementitious materials. *Cement and Concrete Research*, *29*(10), pp.1655-1662.
2. Verma, P., Dhurvey, P., & Sundramurthy, V. P. (2022). Potential Assessment of E-Waste Plastic in Metakaolin Based Geopolymer Using Petrography Image Analysis. Advances in Materials Science and Engineering, 2022(1), 7790320.
3. Kim, J.K. and Lee, C.S., 1998. Prediction of differential drying shrinkage in concrete. *Cement and Concrete Research*, *28*(7), pp.985-994.
4. Verma, P., Dhurvey, P., & Sundramurthy, V. P. (2022). Structural Behaviour of Metakaolin Geopolymer Concrete Wall-Type Abutments with Connected Wing Walls. Advances in Materials Science and Engineering, 2022(1), 6103595.
5. Fujiwara, T., 2008. Effect of aggregate on drying shrinkage of concrete. *Journal of Advanced Concrete Technology*, *6*(1), pp.31-44.
6. Verma, P., Dhurvey, P., & Gour, C. P. (2023). Utilization of E-Waste as Coarse Aggregates in Geopolymer Concrete. In Sustainable Approaches and Strategies for E-Waste Management and Utilization (pp. 224-238). IGI Global.
7. Li, J. and Yao, Y., 2001. A study on creep and drying shrinkage of high performance concrete. *Cement and Concrete Research*, *31*(8), pp.1203-1206.
8. Sahu, B., Dhurvey, P., Verma, P., Raheem, J., & Bhargava, A. (2022, November). Behaviour Analysis of Layered Beam Using ANSYS. In International conference on Advances in Materials and Manufacturing (pp. 135-142). Singapore: Springer Nature Singapore.
9. Shariq, M., Prasad, J. and Abbas, H., 2016. Creep and drying shrinkage of concrete containing GGBFS. *Cement and Concrete Composites*, *68*, pp.35-45.
10. Dhurvey, P., Panthi, H., Verma, P., & Gaur, C. P. (2023). Utilization of Waste Ceramic Tiles as Coarse Aggregates in Concrete. In Waste Recovery and Management (pp. 291-302). CRC Press.
11. Maruyama, I. and Sugie, A., 2014. Numerical study on drying shrinkage of concrete affected by aggregate size. *Journal of Advanced Concrete Technology*, *12*(8), pp.279-288.
12. Kioumarsi, M., Azarhomayun, F., Haji, M. and Shekarchi, M., 2020. Effect of shrinkage reducing admixture on drying shrinkage of concrete with different w/c ratios. *Materials*, *13*(24), p.5721.
13. Yuan, J., Lindquist, W.D., Darwin, D. and Browning, J., 2015. Effect of slag cement on drying shrinkage of concrete. American Concrete Institute.
14. Hooton, R.D., Stanish, K., Angel, J.P. and Prusinski, J., 2009. The effect of ground granulated blast furnace slag (slag cement) on the drying shrinkage of concrete–a critical review of the literature. *Slag Cement Concrete*, pp.79-94.
15. Abdalhmid, J.M., Ashour, A.F. and Sheehan, T., 2019. Long-term drying shrinkage of self-compacting concrete: Experimental and analytical investigations. *Construction and Building Materials*, *202*, pp.825-837.
16. Benboudjema, F., Meftah, F. and Torrenti, J.M., 2005. Interaction between drying, shrinkage, creep and cracking phenomena in concrete. *Engineering structures*, *27*(2), pp.239-250.
17. Almudaiheem, J.A., 1992. An improved model to predict the ultimate drying shrinkage of concrete. *Magazine of concrete research*, *44*(159), pp.81-85.

SJIF Scientific Journal Impact Factor

Impact Factor 7.54

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

NISCAIR

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com