International Journal of Scientific Research and Engineering Development-– Volume 7 Issue 3, May-June 2024
Available at www.ijsred.com

RESEARCH ARTICLE OPEN

An Experimental Investigation on Strength and Durability Characteristics of Silica Fume Based Blended Cement Concrete

Avinash Kumar [1], Mithun Kumar Rana[2],Pushpendra Kumar Kushwaha[3]
[1]P.G. Student, Civil Department, RKDF College of Engineering, Bhopal (M. P.),402026 India
[2,3]Assistant Professor, Civil Department, RKDF College of Engineering, Bhopal (M. P.), 402026 India

Abstract:

Because the raw materials are readily available, Ordinary Portland Cement (OPC) is most commonly employed as the principal binder in the production of concrete. The amount of carbon dioxide emitted during the calcination of limestone and the burning of fossil fuels during the manufacture of OPC is one of the well-known environmental challenges related to OPC production. Because of its exceptional strength and durability, concrete is one of the materials utilised in construction projects all over the world. Significant emissions of greenhouse gases have resulted from the growing demand for cement. A single tonne of cement produced generates a comparable quantity of CO2, or roughly 5-7% of all carbon emissions worldwide. This is exceedingly dangerous and contributes to global warming. The next few decades should see an even greater rise in this number. This is primarily due to the rapid infrastructure development that many emerging nations are undergoing in order to fulfil the rising demand brought on by their expanding populations. The primary cause of the carbon footprint is the increased need to produce concrete using natural resources in order to meet the rising demand for infrastructure. In addition to maintaining sustainability, the use of Supplementary Cementitious Materials (SCMs) in blended concrete can lower the quantity of CO2 released into the atmosphere.
The lime sludge-based concrete's mechanical qualities, such as its compressive, split tensile, and flexural strengths, were assessed and contrasted with the control mix at 7 and 28 days.Due to its high calcium concentration, the results showed that lime sludge was beneficial when used in place of certain cement. Additional research is done in order to prepare blended concrete.

Key Word-Strength and durability, Sludge, compressive, split tensile, and flexural strengths

I. INTRODUCTION

Across the globe, the issue of industrial waste disposal is becoming more and more significant. Because so much paper is used nowadays, most industrialised countries produce enormous amounts of sludge from paper mills from the burning of coal in thermal power plants. One of our biggest environmental issues is the need for electrical energy. The use of paper mill sludge as a material for other industrial purposes is somewhat limited. The paper mill sludge and other waste cellulosic fibre are simply thrown away due to their lack of use, which poses a serious disposal issue. The technology used to pulp, cut wood, and make paper, as well as the kind of effluent treatment used, the kind and supply of coal, and the ash collecting technique, all have a direct impact on the characteristics of bio-solids. Industrial solid wastes have a wide range of compositions, from organic (made in sectors making basic consumer goods) to inert inorganic (produced in mines and collieries), and sometimes even containing hazardous materials (as in the pesticide industry). It was anticipated that the Asia-Pacific area would become a significant producer of paper mill sludge as a result of a global shift in the production of paper and paperboard. Over the next 50 years, it was estimated that the world's production of paper mill waste will increase by 48–86% over current levels. The raw materials utilised in the various unit operations have a major impact on the type of waste produced by parent industries. There are several components in these wastes produced by industrial sources, some of which are hazardous. Both large and small categories of plants produce solid waste. The manufacturing of paper involves multiple steps, where solid waste is generated. For example, sludge from effluent treatment facilities is generated in the raw material handling and preparation sections, and lime sludge is produced in the causticizing portion of the chemical recovery unit. Solid garbage is typically disposed of in landfills, while incineration is growing more and more common. It must be regularly shown that the amounts of chemicals of concern are below practicable regulatory limits before any solid residues are applied to the soil. This study's goal was to investigate how these industrial wastes might be used in the building sector as pozzolanic or cementitious materials. From traditional rural economies, modern industrialization has elevated living standards to extremely sophisticated ones. Even while it is a sign of progress, the everyday generation of dangerous industrial waste has resulted in a dire ecological situation. Of them, lime sludge (LS) is one of the industrial wastes produced in India annually by the paper and pulp industries in about 4.5 million tonnes . The paper industry is the primary producer of LS waste; other sources are the fertiliser, sugar, carbide, and soda ash industries. The kraft process at the paper mill's chemical recovery division produces lime sludge. Green liquor is created by dissolving the smelt in water during the chemical recovery process. Caustic soda (NaOH) and calcium carbonate (lime sludge) are produced when the calcined lime (CaO) and smelt or green liquor (Na_2CO_3) react through the causticizationprocess . Researchers these days are concentrating on exploiting industrial waste as a raw material source for other sectors. The world population is expanding, and with it, so is the need for building materials. This is where LS enters the picture. Primarily composed of $CaCO_3$, it can serve as a substitute raw material for lime stone in the cement industry. The use of LS in cement manufacturing has been the subject of numerous research publications and papers published [4-6]. Using fly ash and lime sludge, Vasistha et al. created an eco-Portland cement clinker with the following composition: C_3S, C_2S, C_3A, and C_4AF . Furthermore, the mortar that has been made satisfies the specifications of masonry cements. In a study conducted by Wei et al., the addition of lime sludge increased the clinker's burning capacity, which lowered the temperatures required for the decomposition of calcium carbonate ($CaCO_3$) and the production of the liquid phase [5]. According to a study by Kumar et al., 28-day strength can be increased in cement mortar by replacing LS and FA by up to 25% [6]. To comprehend the impact of lime sludge on concrete, other studies have also been conducted. Numerous investigations utilising M20 and M30 grade aggregate in concrete with a 10%–20% replacement of lime sludge demonstrated an improvement in compressive strength . According to Srinivasan et al., replacing lime sludge in M30 grade concrete can boost the concrete's compressive strength by up to 30%. The compressive strength sharply declined after this LS replacement limit . Pitroda et al. proposed replacing up to 10% of the cement in M40 grade concrete with lime sludge without compromising its strength . Therefore, LS may be a good substitute material for the cement and building sectors

II. LITERATURE SURVEY

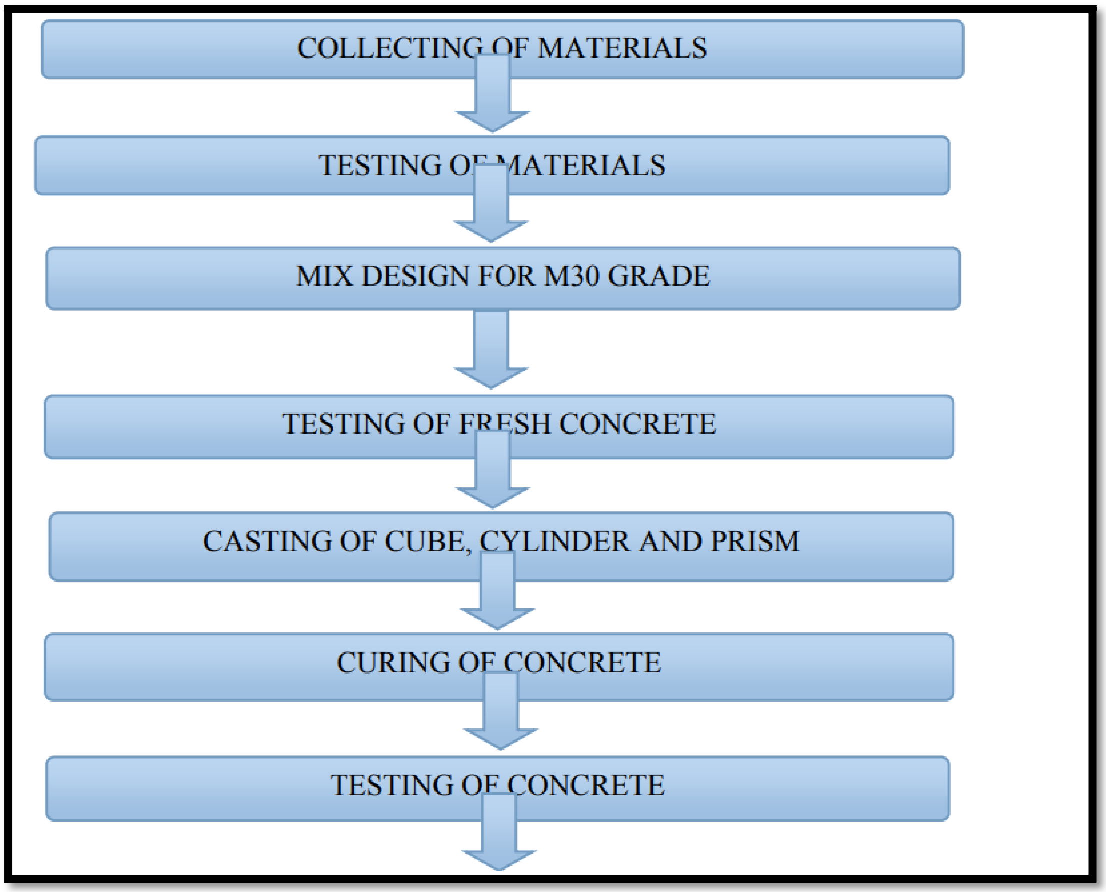
Sumith S P Raut; A Balwa Lk (2019) Paper mill pulp was looked into as a potential substitute for land fill disposal in concrete formulations. According to the weight of the M30 mix, waste paper sludge has been substituted for cement in the amount of 5% to 20%. Concrete mixtures were created and compared with standard concrete in terms of slump and strength, utilising a sufficient amount of waste paper pulp and water.

Udoeyo et al. (2020) evaluated the strength of binary mixed cementitious composites using coal fly ash and blast furnace slag, Pitroda and Umrigar (2021) explored the use of fly ash and lime sludge as partial replacements for cement in blended concrete, observing increased flexural strength with their addition

III. OBJECTIVE

- Obtaining the ideal amounts of lime sludge, fly ash, and silica fume while making a blended cement concrete mix.
- To determine the strength and durability properties of concrete by varying the quantities of fly ash, silica fume, and lime sludge

IV. METHODOLOGY FOR THE PRESENT STUDY



V. RESULTS AND DISCUSSIONS

5.1 Workabilty test

That's a concise summary of the limitations of the slump test for measuring concrete consistency. While it's a widely used method and provides valuable insights into workability, it's not without its drawbacks. Very wet or very dry concrete can skew the results, and it may not capture all the factors influencing workability. Additionally, it might not always accurately represent the concrete's placeability on-site. These points highlight the importance of considering multiple testing methods and practical observations when assessing concrete quality and workability.

Table 1**variation of slump due to Silica Fume**

SN	**Sample Designation**	**Slump (mm)**
1	Normal Mix (SF-0)	117
2	SF-20	118
3	SF-4	120
4	SF-6	125
5	SF-8	127
6	SF -10	129

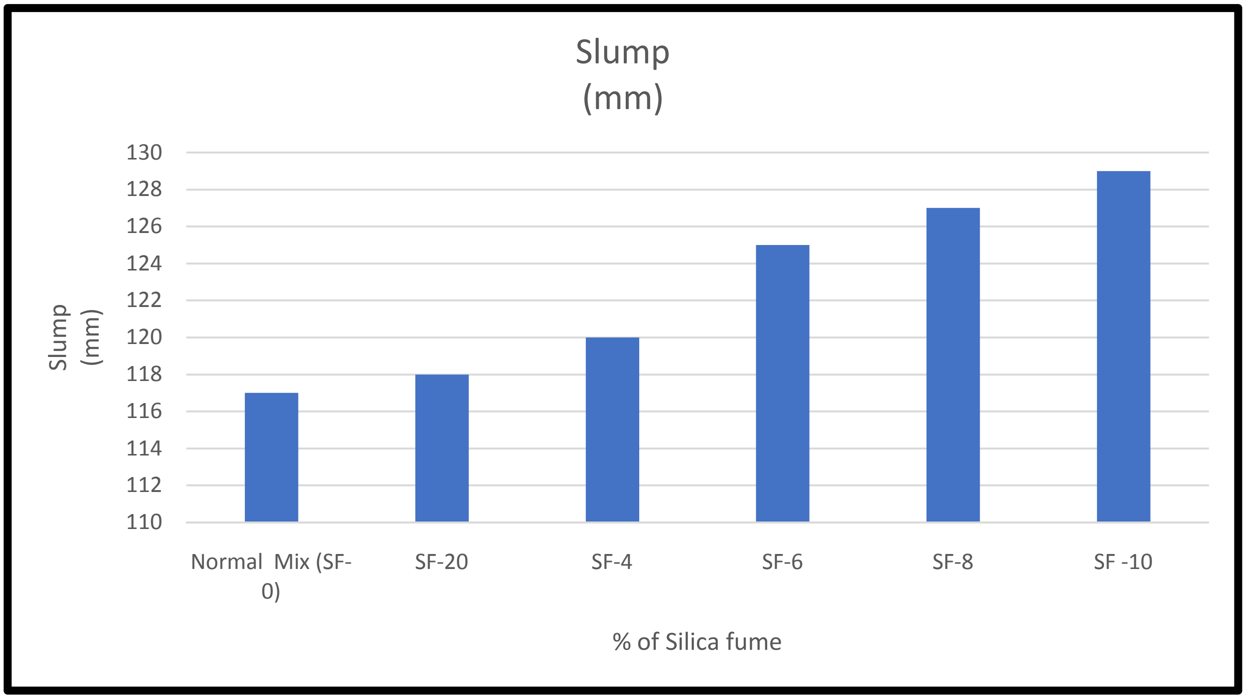


Figure 1 variation of slump due to Silica fume

COMPRESSIVE STRENGTH RESULTS

Effect of silica fume ON Compressive strength

SN	Sample Designation	compressive strength in N/mm2			Variaation of compressive strength
		7 days	**21 day**	**28 day**	
1	Normal Mix (SF-0)	18.91	25	30.5	
2	SF-20	20.45	27.25	32.2	5.57
3	SF-4	22	29.2	34.9	14.43
4	SF-6	23.45	31	35.2	15.41
5	SF-8	24.34	32	38.2	25.25
6	SF -10	24	31	35.2	15.41

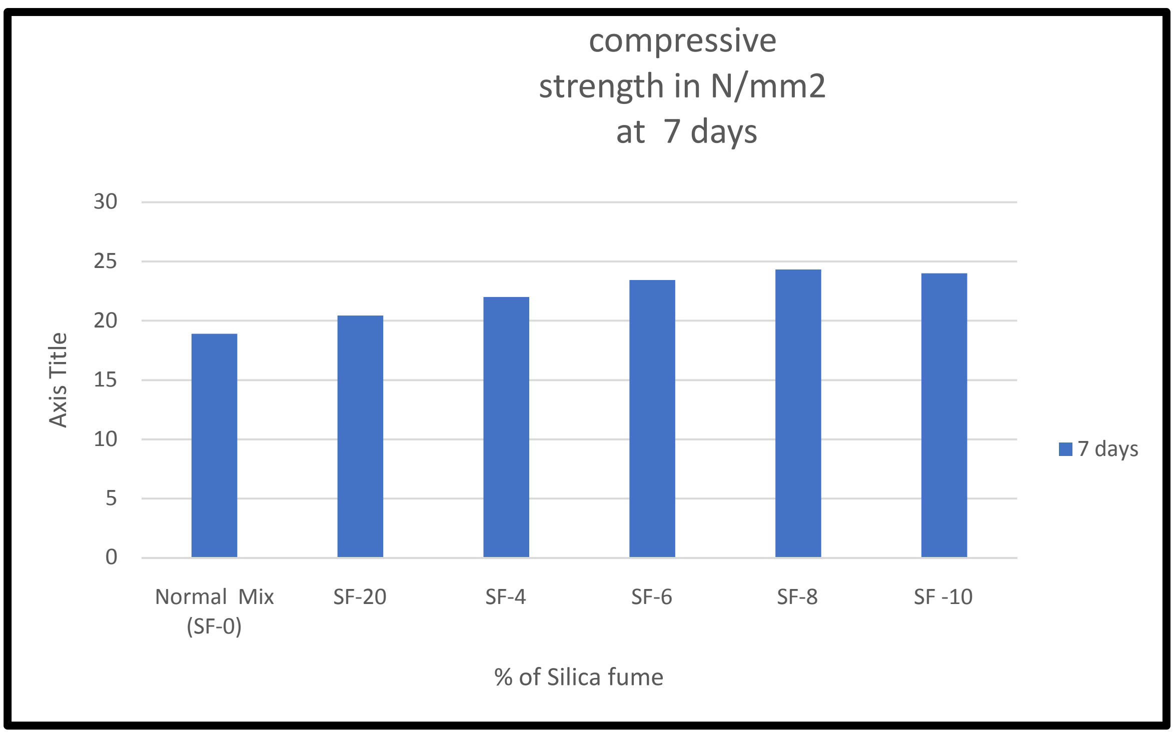


Figure 2 Effect of Silica Fume oncompressive strength in N/mm2 at 7 days

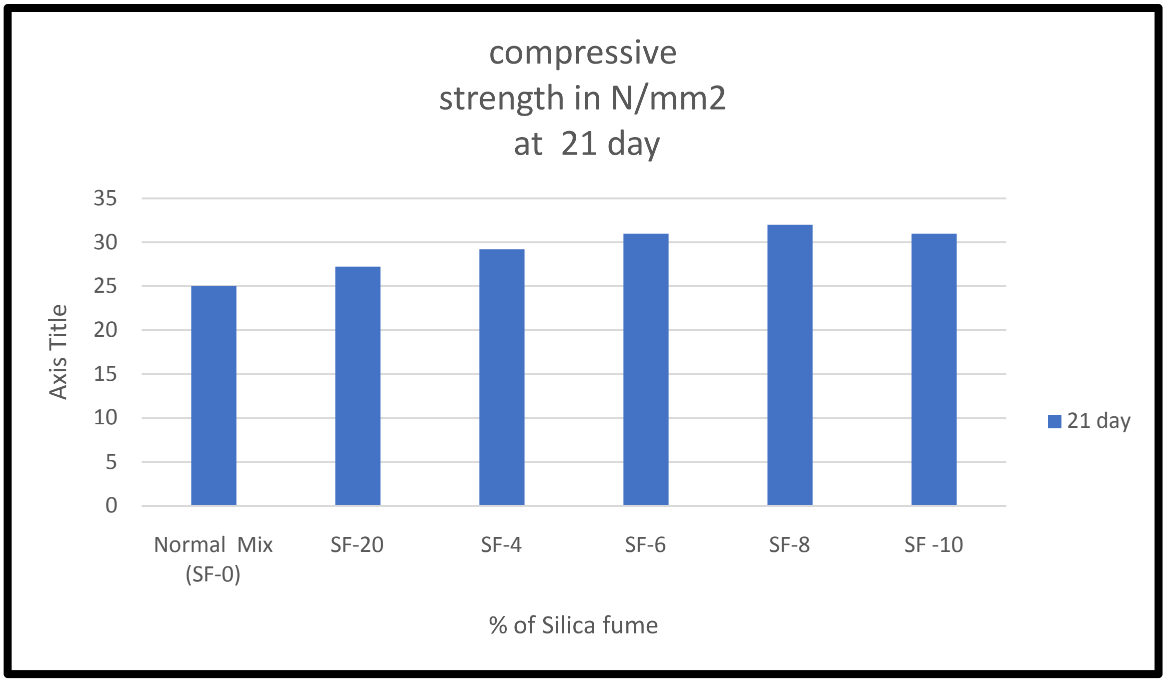


Figure 3 Effect of Silica Fume on compressive strength in N/mm2 at 21 , days

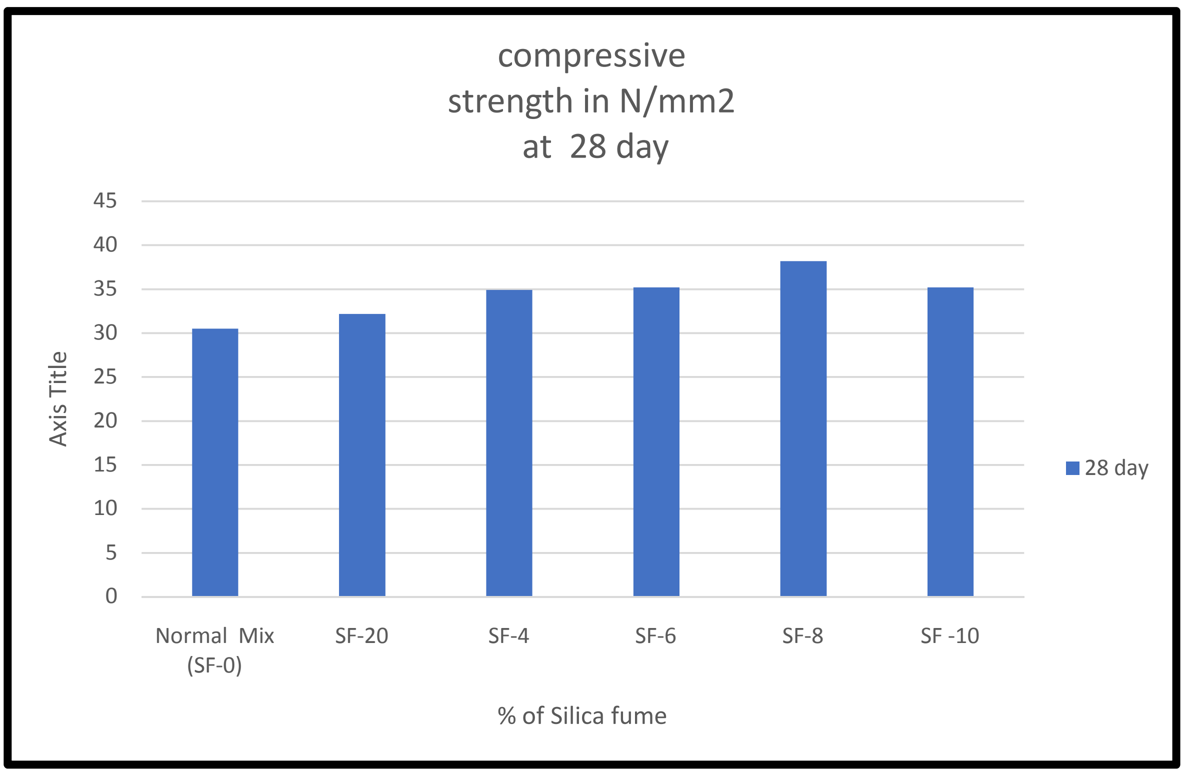


Figure 4 Effect of Silica Fume on compressive strength in N/mm2 at28 , days

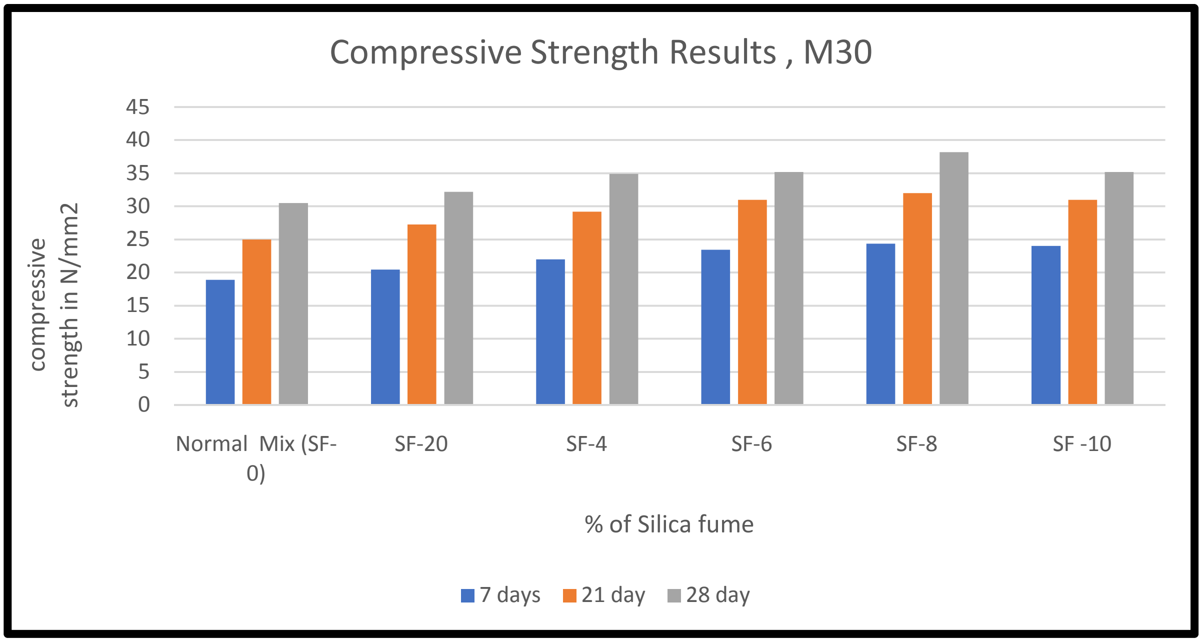


Figure 5 Effect of Silica Fume oncompressive strength in N/mm2 at 7 ,21,28 days

Based on compressive strength, 8% silica fume content was found to be optimal. The primary cause of the significant increase in strength is the ultra-fine particle size distribution of silica fume, which densifies the interfacial transition zone to produce the micro filler effect. The extra C-S-H gel produced by the pozzolanic reaction between silica fume particles and calcium hydroxide is another factor contributing to the strength gain. In all three grades of concrete, the blended concrete mix—which consists of cement, fume—has demonstrated a higher compressive strength than the control mix. Table displays the impact of silica fume replacement on 28-day compressive strength for various concrete classes.

6. CONCLUSION

- The compressive strength of concrete increases up to 8% and decreases on adding 10% SF but is still more than conventional concrete.
- The compressive strength of concrete decreases on adding 10% of Silica Fume.

Reference

[1] Joshaghani, A., Moeini, M.A. and Balapour, M. (2017) "Evaluation of incorporating metakaolin to evaluate durability and mechanical properties of concrete", Adv. Concrete. Constr., 5(3), 241-255.
[2] Juengera, M.C.G. and Siddique, R. (2015), "Recent advances in understanding the role of supplementary cementitious materials in concrete", Cement Concrete Res., 78(1), 71-80.
[3] Naik, T.R., Singh, S.S. and Hossain, M.M. (1995), "Properties of high-performance concrete systems incorporating large amounts of high-lime fly ash", Constr. Build. Mater., 9(4), 195-204.
[4] Pandey, S.P. and Sharma, R.L. (2000), "The influence of mineral additives on the strength and porosity of OPC mortar", Cement Concrete Res., 30(1), 19-23
[5] Rahman, M.A., Sarker, P.K., Shaikh, F.U.A. and Saha, A.K. (2017), "Soundness and compressive strength of Portland cement blended with ground granulated ferronickel slag", Constr. Build. Mater., 140(1), 194-202
[6] Sata, V., Jaturapitakkul, C. and Kiattikomol, K. (2004), "Utilization of palm oil fuel ash in high-strength concrete", J. Mater. Civil Eng., 16(6), 623-628.

[7] Shi, X., Xie, N., Fortune, K. and Gong, J. (2012), "Durability of steel reinforced concrete in chloride environments: An overview", Constr. Build. Mater., 30(1), 125-138
[8] Thompson G, Swain J, Kay M, Forster C (2001) The treatment of pulp and paper mill effluent: a review. Bio resource Technology, Vol. 77, pp. 275–2
[9] Srinivasan R, Sathiya K, PalanisamyM (2010) Experimental investigation in developing low cost concrete from paper industry waste.Bul. Inst. Polit. Iaşi, t. LVI (LX), f. 1, 2010
[10] Pitroda J, Zala LB, Umrigar FS (2013) Innovative use of paper industry waste (hyposludge) in design mix concrete. IJAET/Vol. IV/ Issue I/Jan.-March., 2013/31-35
[11] Furlani E, Tonello G, Maschio S, Aneggi E, Minichelli D, Bruckner S, Lucchini E (2011) Sintering and characterisation of ceramics containing paper sludge, glass cullet and different types of clayey materials. Ceramics International, Vol. 37, pp. 1293–1299
[12] Balwaik SA, Raut SP (2011) Utilization of waste paper pulp by partial replacement of cement in concrete. International Journal of Engineering Research and Applications (IJERA), 1(2): 300-309

