International Journal of Innovative Research in Computer Science & Technology (IJIRCST)
ISSN: 2347-5552, Volume-10, Issue-3, May 2022
https://doi.org/10.55524/ijircst.2022.10.3.48
Article ID Article ID IRP1196, Pages 292-298
www.ijircst.org

Glass Waste Powder as Partial Replacement of Cement for Sustainable Concrete

Rashid ul Islam[1], Manish Kaushal[2]

[1]M. Tech Scholar, Civil Engineering Department, RIMT University Mandi, Gobindgarh, India
[2] Assistant Professor, Civil Engineering Department, RIMT University Mandi, Gobindgarh, India

Correspondence should be addressed to Rashid ul Islam; parrayraashid123@gmail.com

ABSTRACT- The common assets (aggregate and cement) for the concrete business are un-existent, the examination is to research the chance of utilizing glass powder in concrete as incomplete concrete substitution and doesn't adversely influence the properties of the subsequent cement. Furthermore, the natural advantages of the disposal of the waste glass from the landfill is another objective. Requirement for elective assets is indispensable. The reusing of waste comprises a positive path for the solid business as elective materials to supplant concrete and totals. The fundamental goal of this exploration is to examine the chance of utilizing glass squander powder in concrete as incomplete concrete substitution and doesn't contrarily influence the properties of the subsequent cement. Likewise, the natural advantages of the end of the waste glass from the landfill is another objective.

Numerous endeavors have been made to utilize squander glass in concrete industry as a substitution of coarse aggregate, fine aggregate, and cement. Its exhibition as a coarse aggregate substitution has been discovered to be non-palatable due to quality relapse and development because of soluble base silica response. The exploration shows that there is quality misfortune because of fine aggregate replacement too.

In the research, cement was replaced by glass waste powder in the range of 0% to 30% by weight.

The solid blends were created, tried and looked at regarding workability, thickness, ingestion, and mechanical tests. Another blending strategy was utilized in blending concrete in with glass powder to improve its effectiveness, which the glass powder was broken up in water before adding to cement and aggregate. The impact of various restoring temperatures (23°C, 40°C) at ages (7, 28,52 days) was likewise concentrated on mechanical properties and strength of cement containing glass powder. The present study shows that waste glass if ground finer than 100μm shows a pozzolanic behavior.

The yield results acquired from this research center program demonstrated that the functionality of cement increased as the glass powder substitution increased because of the presence of all the more free water in the structure, which prompted having lower thickness and higher water assimilation. Afterward, following 28 days, the most noteworthy compressive strength was gotten for the 30% Glass powder.

Finally, this research has attempted to provide an interesting approach to introducing glass powder as a cement replacement in concrete, aiming to improve the pozzolanic activity. The Experimental results for the new mixing method verified the feasibility of this approach.

KEYWORDS- Waste glass; Recycling; Supplementary cementitious material; Environment; Sustainability.

I. INTRODUCTION

It is notable that cement is the central constituent that makes concrete, however, the assembling of Portland concrete has a fundamental negative effect, which creation of one ton of Portland cement clinker make around one ton of carbon dioxide and other ozone depleting substances (GHGs)[1]. Thus the discharge of this note worthy measure of carbon dioxide ought to be reduced by a reasonable advancement arrangement inside the cement and concrete industry [2]. Regularly glass doesn't hurt the climate in any capacity since it doesn't radiate poisons, yet it can hurt people just as creatures if not managed cautiously and it is less agreeable to climate since it is non-biodegradable [3]. In this manner, the advancement of new innovations has been required. The term glass contains a few substance varieties including soda lime silicate glass, alkali-silicate glass and borosilicate Until now, these kinds of glass powder have been broadly utilized in cement and aggregate blend as pozzolana for civil works [4]. The presentation of waste glass in concrete will expand the alkali substance in the cement. It likewise helps in blocks and ceramic manufacture and it preserves crude materials, diminishes energy utilization and volume of waste shipped off landfill [5]. As valuable reused materials, glasses and glass powder are essentially utilized in fields identified with structural designing, for instance, in cement, as pozzolana (supplementary cementitious materials), and coarse aggregate. Their recycling ratio is close to 100%, and it is also used in concrete without adverse effects in concrete durability [6]. Therefore, it is considered ideal for recycling. Meanwhile, concrete is the most commonly used building material in the world (the world's production in 2012 amounted to 7 million m3 per year, i.e., three times more than wood and seven times more than steel per year) [7]. According to industry statistics published in The Global Cement Report, 13th Edition , the consumption of cement in the world increased by 2.8% percent to 4.08 million tones in 2019 [8]. Therefore, there is a need to look for materials as a replacement for cement or aggregate. Recycled materials are used to limited energy consumption by the concrete industry and the production of concrete as an environmentally friendly material [9]. However, review study showed that previous studies with glass addition were not conclusive considering workability and strength while the chloride resistance of glass added concrete was found to be similar with control condition[10]. This research examined the potential of waste glass powder to produce sustainable concrete. Experimental work was carried out on the performance of glass in mortar and concrete[11]. Mortar samples were prepared to evaluate the flow and strength properties [12]. Further more, compressive strength of concrete cube samples were also determined by crushing it. In addition, the study discussed the packing and pozzolanic effect of glass by using superplasticizer in selected mortar samples[13].

II. Objective Of Study

The obective of the study is to increase the workability and comressive strength of the concrete. By this we can also control the environmental pollution, produce ow cost concrete, economical and profitabe substitute to landfills, incinerator.

III. Materials

The materials used in this work are glass powder, ordinary Portland cement, fine and course aggregates.

A. Glass Powder

The glass powder used in the present study is brought from Indian market. This material replaces the cement in mix proportion. Sample of glass powder shown below in fig.1 Particle size distribution graph and XRD analysis of glass powder were done and shown in Fig.2 and Fig.3 respectively.

Figure1: Glass powder particles

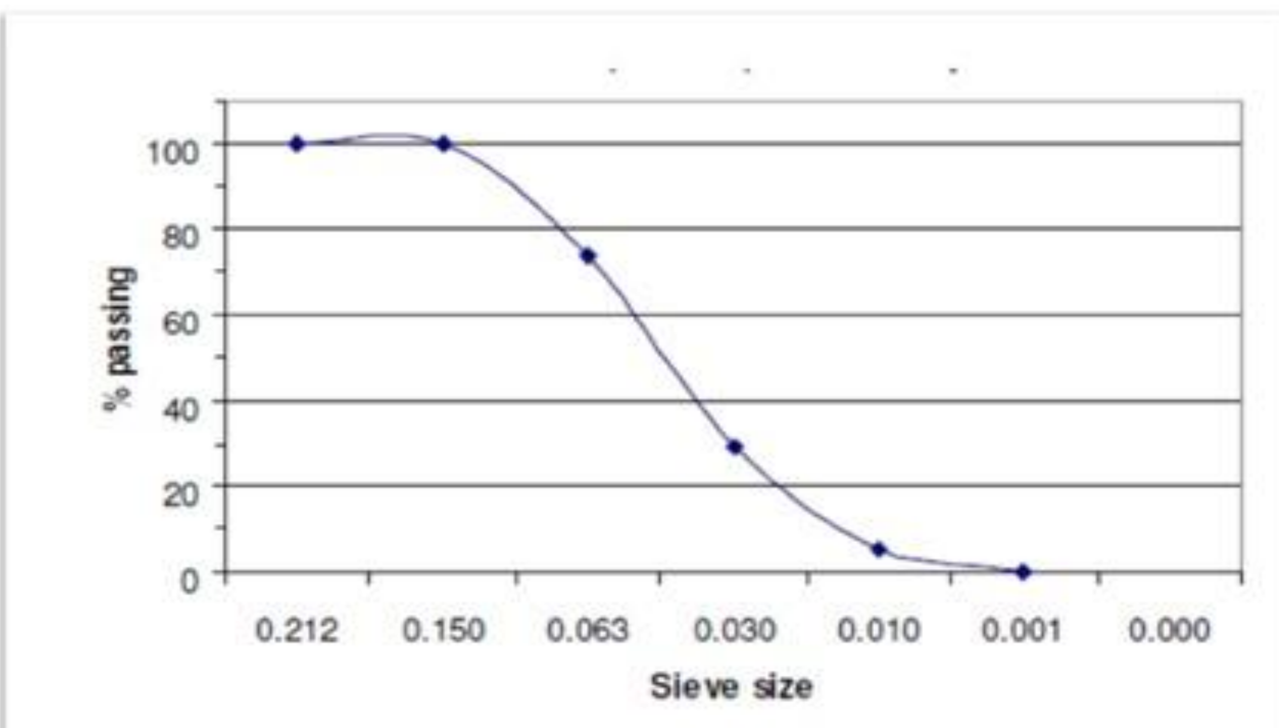

Figure 2: Particle size distribution of glass powder

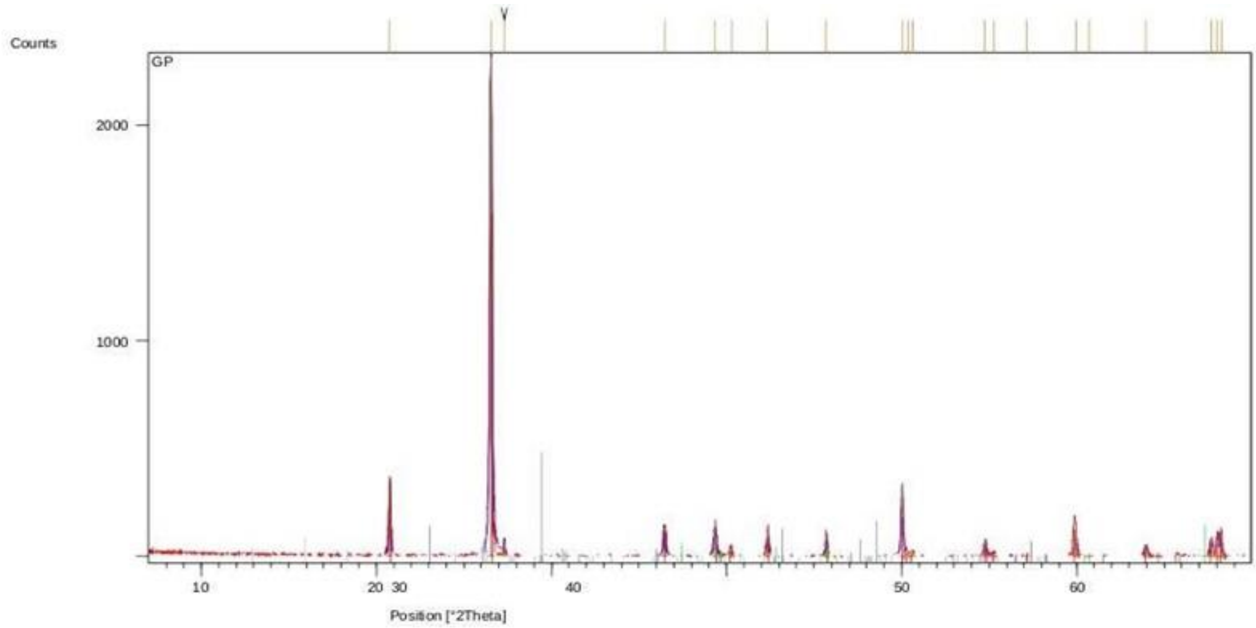

Figure 3: XRD Analysis of glass powder

B. Ordinary Portland Cement

The OPC(43 grade) used in the present work is of Ultratech brand. This is used as main binder in the mixes [14]. The table 1 presents the chemical analysis of the pozzolanic cement used in this study.

Table 1: Chemical Properties of Cement And Glass Powder

Composition	Cement (%)	GP (%)
SiO_2	38.06	64.32
Al_2O_3	8.88	2.90
Fe_2O_3	2.83	-
CaO	40.92	18.18
SO_3	2.33	-
MgO	1.59	-
Na_2O	1.75	13.03
K_2O	1.62	1.53

C. Fine Aggregate

Naturally available sand from river bed is used as fine aggregate in the present work. The most common constituent of sand is silica, usually in the form of quartz, which is chemical inert and hard. Hence used as a fine aggregate in concrete. The sieve analysis of sand is shown in table 2. As per IS383 the sand falls under zone2.

Table 2: Sieve Analysis of Sand

Sieve size (mm)	Aggregate wt. retained (Kg)	%Wt. retained	Cumulative % Wt. retained	100-cumulative % passing
4.25	0.039	3.9	3.9	96.1
2.36	0.27	2.7	6.6	93.4
1.18	0.088	8.8	15.4	84.6
0.6	0.176	17.6	33	67
0.3	0.416	41.6	74.6	25.4
0.15	0.234	23.4	98	2
Pan	.014	1.4	99.4	0.6

D. Coarse Aggregate

The coarse aggregate, available in structural engineering lab of the civil engineering department. The sieve analysis of 20mm and 10mm down size is shown in Fig.4.

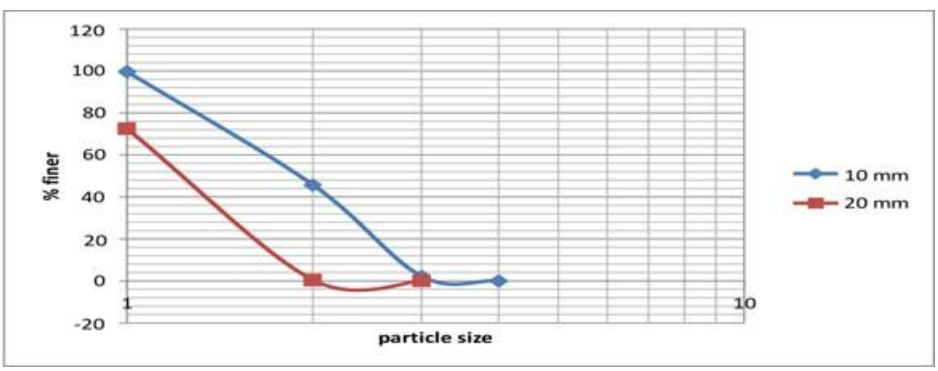

Figure 4: Sieve Analysis of Coarse aggregate

Table 3 represents the physical characteristics of Material

Table 3: Physical Characteristics of Materials

Description	Specific gravity
Cement (OPC)	3.09
Glass Powder	3.01
Coarse Aggregate	2.9
Fine Aggregate	2.62
Water	1

IV. METHODOLOGY

A design mix of M30 was received for the current investigation. The primary blend MC1 is control blend having just cement as blinder [15]. The MCG arrangement had glass powder as substitution of cement. The compressive strength test were led to screen the quality improvement of concrete containing 0% to 30% of these pozzolana as cement substitution [16-17]. The molecule size impact of glass powder concentrated by utilizing glass powder of size (150-100)µ and (50-100)µ. Capillary absorption test is led to consider the impact of alkali aggregate reactions. The tests were conducted in series [18-20]. Eleven numbers of standard cubes (150x150x150 mm) were cast to measure the compressive strength after 07 days and 28 days. Two cube were retained to measure capillary absorption after 07 days and 28 days respectively. To study the characteristics following tests were conducted

- Normal Consistency test
- Compressive Strength test
- Capillary Absortion test
- Slump test

V. RESULT AND DISCUSSION

A. Normal Consistency of Binder Mixes was Tabulated Below

Normal consistency of different binder mixes determined by using the procedure referring to IS 4031: part 4(1988): Fig. 5 shows the apparatus for Normal consistency.
300 gram of sample coarser than 150µ sieve is taken.
Approximate percentage of water added to sample and mixed methodically for 2-3 minutes.
After applying oil to the surface of mould, paste was filled in the vicat's mould and was placed under the needle of vicat's apparatus.
Release quickly the needle allowing it to sink in the paste and note down the penetration reading when the needle becomes stable.
If the penetration reading is less than 5 to 7 mm, prepare the paste again with more water and repeat the above procedure until the needle penetrates to a depth of 5 to 7mm.
The percentage of the water with which the above situation is satisfied is called normal consistency.

Figure 5: Normal consistency equipment

B. Workability Of Concrete

The final output results for different sample groups regarding slump values for fresh concrete are listed in table .The slump test was also conducted after 15 minutes to measure the slump loss from the time of original batching. The values of slump test are given in Table 4.

Table 4: Value of slump test Slump Test

	Slump Test	
GP Group	At 0 min	At 15 min
0 %	11 cm	09 cm
15 %	14 cm	12 cm
20%	17 cm	16 cm
25 %	19 cm	17 cm
30%	20 cm	18 cm

The results show that workability increases gradually by the increase of glass powder.

C. Compressive strength

For each series, five-set were cast to determine compressive strength. Each set comprises of eleven standard cubes out of which nine cubes were cast to measure the compressive strength after 07 days and 28 days. The size of the cube is as per the IS code 10086 – 1982. Fig. 6 shows the Testing of cube:

Figure 6: Testing Cube

The results of compressive strength testing of laboratory-cured cubes are presented below for First series with 30% cement replacement, Second series with 25% cement replacement ,third series 20% and fourth series 15% respectively. The strength values reported are the average of three test results. Fig. 7 shows the compressive strength of mortar specimen without admixture & Fig. 8 shows the graphical representation.

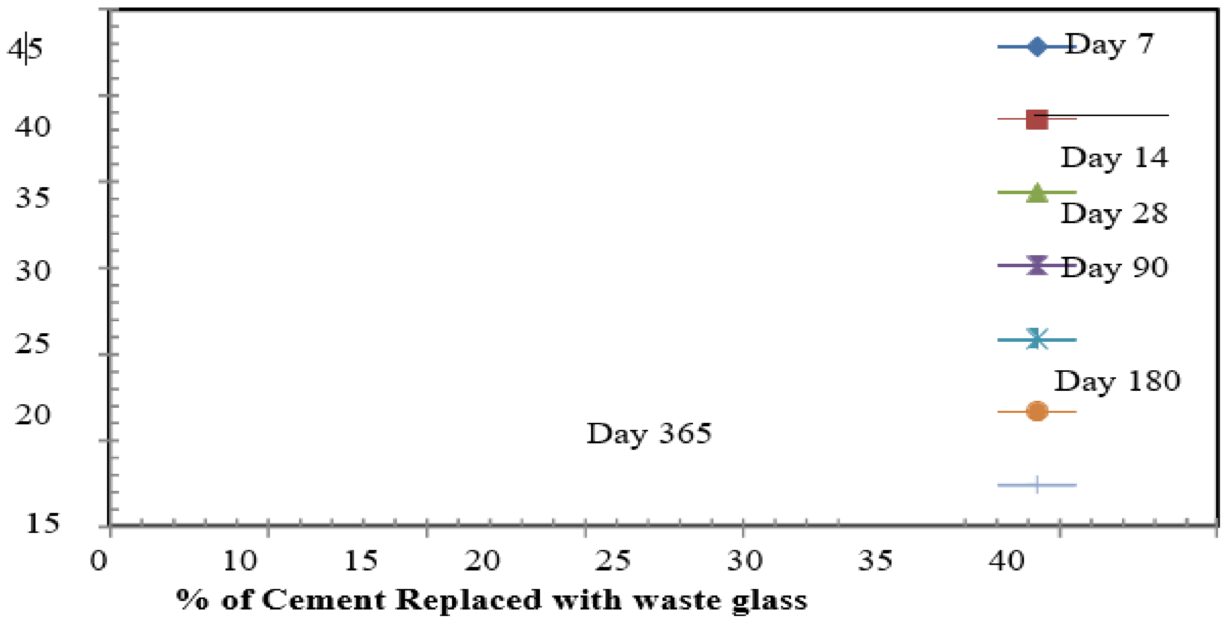

Figure 7: Compressive strength of mortar specimen without admixture

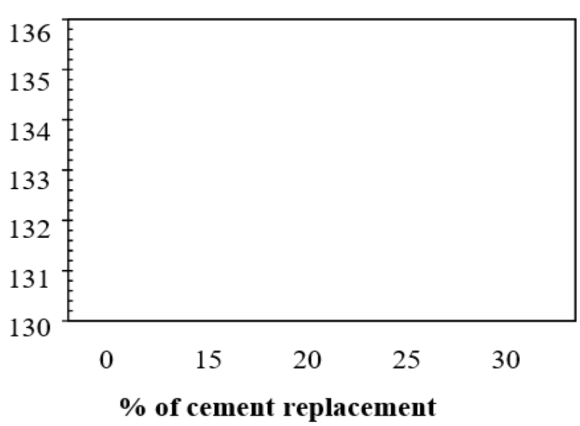

Figure 8: Glass quantity vs flow in cement mortar

VI. Effect of Admixture on Compressive Strength

Admixture on compressive strengths of glass added mortars (0–30% addition) at various ages. Early age i.e. in 7 and 14 days compressive strength of mortar specimens, which clearly depicts the positive effect of admixture on compressive strength of mortar. Though the trend of compressive strength was decreasing with the addition of glass powder, use of admixture always gave higher compressive strength at early ages. For control mortars adding 1% admixture dose gave compressive strength as high as 43% and 35% at 7 and 14 days, respectively. With the addition of glass the difference in compressive strength became lower at these ages. This indicates that the super plasticizing effect on ground glass is lower compared to the Portland cement as cement starts diluting and reacting as soon as water is added to the mix but glass requires a longer period to start pozzolanic reaction. Similar trends were obtained among the compressive strengths at 28, 56 and 90 days . The effect of admixture became less significant than previous ages. However, a different behavior was noted for control concrete compared to the glass added concrete. With the increase in glass content the difference between compressive strengths decreased and the difference was almost eliminated at 30% replacement level. This indicates progression of pozzolanic reaction at this age as the compressive strength is the combined effect of packing (compaction), cement hydration and pozzolanic reaction. At earlier ages very little/no pozzolanic reaction occurs and thus only effect of superplasticizer are visible and the packing effect gave higher compressive strength of mortar. The effects of admixtures at 180 and 365 days are similar to those of early age effects The effect of admixture and therefore, difference in compressive strength was within a narrow band of 14–20% at 180 days and that was 16– 21% at 365 days. It is expected that pozzolanic reaction would mostly occur in between 28 and 91 days. Therefore, only the effect of admixture, i.e. packing is visible again at latter ages (180 and 365 days)

VII. Conclusion

Waste glass, if ground finer than 100µm shows a pozzolanic behavior.The smaller particle size of the glass powder has higher activity with lime resulting in higher compressive strength in the concrete mix. Compared to fly ash concrete, finer glass powder concrete had slightly higher early strength as well as late as strength. The coefficient of capillary absorption test also indicates that incorporation of finer glass powder improves durability. Glass powder of size 150µm - 100µm exhibit initiation of alkali-aggregate reaction. The presence of ettringite confirms this. The results obtained from the present study shows that there is great potential for the utilization of best glass powder in concrete as replacement of cement. The fine glass powder can be used as a replacement for expensive materials like silica fume and fly ash. It can be concluded that 30% of glass powder of size less than 100μm could be included as cement replacement in concrete without any unfavorable effect.

ACKNOWLEDGEMENTS

There are people without whom this dissertation might not have been possible and to whom I am greatly thankful. Therefore, I would like to acknowledge.

My supervisor ER Manish Kaushal, Assistant Professor and Project Guide, Department of Civil Engineering, RIMT University who was not simply supervisors, but also friends and mentors. Without him and his wealth of knowledge, patience and reliability; I could not reach this far. I express my heartfelt gratitude to Dr Sandeep Singla, Professor and Head, Department of Civil Engineering, RIMT University for his consistent encouragement in completing the project. The administrative technical and academic staff of the Departments of Civil Engineering, RIMT University for their valuable support. I express my deep love and warm regards to my parents and my friends for their support, constant encouragement and timely help.

CONFLICT OF INTEREST

I declare that the submission is the original work and is not under review at any other publication.

REFERENCES

[1] Thanongsak,N.,Watcharapong,W.,andChaipanich.A.,(2009),"Utilizationoffly ash with silica fume and properties of Portland cement-fly ash-silica fume concrete". Fuel, Volume 89, Issue 3, March 2010, Pages768-774.

[2] Patel, A, Singh, S.P, Murmoo, M. (2009), "Evaluation of strength characteristics of steel slag hydrated matrix" Proceedings of Civil Engineering Conference- Innovation without limits (CEC-09), 1 8th - 1 9th September"2009.

[3] Li Yun-feng, Yao Yan, Wang Ling, "Recycling of industrial waste and performance of steel slag green concrete", J. Cent. South Univ. Technol.(2009)16: 8−0773, DOI:10.1007/s11771-009-0128x.

[4] Velosa, A.L, and Cachim, P.B.," Hydraulic lime based concrete: Strength development using a pozzolanic addition and different curing conditions", Construction and Building Materials ,Vol.23,Issue5,May2009,pp.2107-2111.

[5] BarbhuiyaS.A.,Gbagbo,J.K.,Russeli,M.I.,Basheer,P.A.M." Propertiesofflyash concrete modified with hydrated lime and silica fume", a Centre for Built Environment Research, School of Planning, Architecture and Civil Engineering, Queen"s University Belfast, Northern Ireland BT7 1NN, United Kingdom Received 28 January 2009; revised 1 June 2009; accepted 3 June 2009. Available online 15 July 2009.

[6] Gonen,T. and Yazicioglu,S. "The influence of mineral admixtures on the short and long term performances of concrete" department of construction education, Firat University, Elazig 23119,Turkey.2009.

[7] Mateusz R.J. O. and Tommy N. " Effect of composition and Initial Curing Conditions of Scaling Resistance of Ternary(OPC/FA/SF) concrete", Journal of Materials in Civil Engineering © ASCE/October 2008, PP668-677.

[8] Chang-long, WQI, Yan-ming, HeJin-yun , "Experimental Study on Steel Slag and Slag Replacing Sand in Concrete", 2008, International Workshop on Modelling, Simulation and Optimization.

[9] Jigar P. Patel, "Broader use of steel slag aggregates in concrete", M.Tech thesis, Cleveland State University, December,2008. N.P.Rajamane*,J.Annie Peter ,P.S. Ambily," Prediction of compressive strength of concrete with fly ash as sand replacement material". Cement and Concrete Composites, Volume 29, Issue 3, March 2007, Pages 218-223. Abdullah A. Almusallam, Hamoud Beshr, Mohammed Masleh uddin, Omar S.B. Al-Amoudi,, "Effect of silica fume on the mechanical properties of low quality coarse aggregate concrete", Cement & Concrete Composites 26 (2004)891-900.

[10] Turkmen.I," Influence of different curing conditions on the physical and mechanical properties of concrete with admixtures of silica fume and blast furnace slag", Materials Letters 57 (2003), pp.4560-4569.Article/ View Record in Scopus/Cited by in Scopus(9).

[11] Tasdemir,C, "Combined effects of mineral admixtures and curing conditions on the sorptivity coefficient of concrete", cement and concrete research 33(2003), pp. 1637-1642.

[12] IS 2720(III/SEC-I): 1980 Methods of Test for Soils, Determination of specific gravity. IS 2720(IV):1985 Methods of Test for Soils, determination of grain size analysis.

[13] Thomas , M. D. A. and Shehata, M. H. " Use of ternary cementitious systems containing silica fume and fly ash in concrete"; cement and concrete research 29 (1999).Bijen,J."Benefits of slag and fly ash "construction and building materials, vol.10, no.5,pp. 309-314, 1996.

[14] Kumar, A., Singla, S., Kumar, A., Bansal, A. and Kaur, A., 2022. Efficient Prediction of Bridge Conditions Using Modified Convolutional Neural Network. Wireless Personal Communications, pp.1-15.

[15] Singh, A., Singla, S. and Garg, R., 2020, November. Performance analysis of Papercrete in presence of Rice husk ash and Fly ash. In IOP Conference Series: Materials Science and Engineering (Vol. 961, No. 1, p. 012010). IOP Publishing.

[16] Ashraf, S., Kaur, S. and Singla, S., 2022. Water Quality Assessment of Anchar Lake, Srinagar, India. Civil and Environmental Engineering Reports, 32(1), pp.88-115.

[17] Ahmad, Uzair. (2018). A Study on Effect of Polymers on the Properties of Vg-10 Grade Bitumen. International Journal for Research in Applied Science and Engineering Technology. 6. 2572-2576. 10.22214/ijraset.2018.4433.

[18] Singh, J., Singh, B. and Singla, S., Enhancement of Expensive Soil by Addition of Stone Dust and LDPE Fibre.

[19] Singh, P. and Singla, S., 2023. Estimation of Land Surface Temperature of Srinagar City, India Using Landsat 8 Data. Sustainability, Agri, Food and Environmental Research, 12(1).

[20] Irshad, U and Singla, S.,2019 "Impact of Road Conditions on Traffic Management-A Case Study of Chenab Valley." International Journal of Scientific & Technology Research 8 1179-1186.