Influence of Shredded Latex Gloves Addition on Concrete Properties

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Abstract **To address environmental concerns in the concrete industry, alternative materials and waste materials are being utilized. In this research, silica fume and shredded latex gloves are being studied. Silica fume is a common byproduct of the silicon industry, while shredded latex gloves pose a disposal challenge. The aim is to investigate the effects of adding shredded latex gloves at different percentages with silica fume as a partial replacement for cement. Five concrete mixes were prepared and tested for workability, mechanical strength, and durability properties. The results showed positive outcomes, especially with 0.3% shredded latex gloves and 10% silica fume replacement, compared to the normal concrete in the control sample.**

Index Terms **Compression Test, Rapid Chloride Penetration Test, Shredded Latex Gloves, Silica Fume, Natural Rubber Latex.**

I. INTRODUCTION

Cement plays a crucial role in construction but raises environmental concerns due to greenhouse gas emissions. Cement production is the second-largest source of pollution globally. The demand for cement continues to grow, contributing to carbon dioxide emissions. Furthermore, the extraction of natural resources for concrete production has adverse environmental effects. Sustainable concrete research focuses on finding cement alternatives and utilizing waste materials to conserve resources and manage industrial waste.

Medical Rubber Waste

The disposal of waste, including rubber waste, from hospitals and manufacturers is a growing problem exacerbated by the COVID-19 pandemic. Sustainable waste management strategies are being sought globally, such as incorporating waste materials like rubber into concrete production. This helps with waste disposal and improves concrete properties. Urgent measures are needed to manage rubber waste, especially due to increased PPE use. Research on utilizing latex gloves in concrete can contribute to sustainable waste management and eco-friendly construction materials.

Silica Fume. Silica fume (SF) is a valuable addition to concrete, obtained during silicon metal processing. It enhances concrete strength and durability. SF can be easily incorporated into the production process and is effective in combating building deterioration caused by thaw and marine salts. It resists chloride ion penetration and is commonly used in bridge construction and retrofitting to enhance durability and mitigate corrosion.

Another way of overcoming this is to add some waste material as component of concrete to study the effects of properties and utilizing the materials, such as Rubber, Medical Gloves, Husk, Glass, etc. in this research work latex surgical gloves have been used.

Latex Gloves. Latex is a natural substance derived from the Hevea tree, also known as the rubber tree. The cispolyisoprene, the primary constituent of natural rubber. Latex, comprising detrimental organic compounds, poses a hazardous waste challenge, necessitating appropriate disposal to prevent groundwater contamination and protect wildlife. However, a viable solution lies in the incorporation of latex products into concrete, as the polymer content in waste latex has been shown to enhance concrete characteristics

Studying concrete with shredded latex gloves helps address waste. Factors like workability, mechanical properties, and durability are examined to assess their potential use and waste management benefits.

II. LITERATURE REVIEW

Shredded Latex Gloves (SLG) substitution by 10% showed compressive values of the rubberized concrete reduced by 86% [1]. This paper indicates that shredded nitrile gloves in blended concrete composites can lead to significant improvements in compressive strength. Importantly, substituting up to 0.2% nitrile gloves (shredded) resulted in a ~22% increment in compressive vales at 28 days test. The SEM-EDS stated a strong bond formed in between the gloves and the paste of cement matrix [2]. The addition Natural Rubber Latex (NRL), resulted in higher compressive strength attributed to two main factors, the polymerization of latex monomers and NRL particles in the mixture that helped in filling the pores of the concrete, resulting in a denser and more compact structure. This also uplifted the tensile and flexural strength of the concrete due to the reduction in brittleness caused by the presence of the polymer in the modified phase. As a result, the concrete becomes more ductile and better able to bear tensile and flexural forces [3]. At 10% SF dosage, significant improvements in compressive, split tensile, and flexural strength was observed, with increases of 15.4%, 6.62%, and 56.47% respectively. Silica fume enhances the bonding and packing of the concrete matrix. Casting up of NRL up to 6% by weight of cement can increase the compressive strength by 16.1%. Higher NRL content, particularly around 8%, leads to significant improvements in split tensile (38.48%) and flexural strength (73.59%) [4]. The strength over a span of 7, 14 and 28 days, when cement is substituted with 20% SF (Mix-06), the flexural strength experiences a 20%, 25.39% and 22.10% increase respectively . Whereas the percentage of SF is further increased, the strength begins to decline. [5]. The optimal amount of silica fume replacement for achieving enhanced flexural strength in M40 concrete was found to be 12% [6]. The rubberized concrete exhibited lower compressive, flexural, and penetration compared to the control mix (concrete without rubber tyre waste). However, the concrete demonstrated improved resistance to abrasion and water soaking capability to 10% substitution when compared to the control mix [7]. The substitution of crumb rubber as a replacement for sand has detrimental effect on strength properties as percentage of crumbed rubber increases, by 4% and 5.5% the compressive values decline by 3.79% and 17.8% respectively rubber particles might not have effectively bonded with the cement matrix, leading to reduced resistance against wear and abrasion [8]. The utilization of waste rubber tire particles in concrete, involving various compositions ranging from 3% to 12% as replacements for cement resulted that the partially swapping of rubber with cement led to a negative result in both compressive and split tensile strength. [9]. Waste rubber tires were partially swapped by fine aggregate as rubber ash. The amalgamation of rubber's ash with rubber fibres was also studied. The findings unveiled, decline in flexural values with increment in rubber ash content, the mixture containing fibre unveiled increment in flexural strength with increment in rubber fibre [10]. Silica fume increment, lead to increment of consistency by 40% . In terms of strength properties, the findings indicate that the optimum 7-day and 28-day compressive and flexural value is achieved when the silica fume is replaced in the range of 10-15% [11]. Substituting 15% of the cement content with SF led to enhanced resistance against chloride penetration [12]. The influence of SF and SBR latex on the ITZ among aggregates and Portland cement have been explored by SEM and EDX, favourable results were obtained in concrete containing both silica fume and SBR latex, with an ITZ thickness of 20-25 mm [13]. The ultimate compressive strength decreased significantly with higher rubber concentrations [14]. Previous studies indicate that incorporating shredded latex gloves as a partial replacement for coarse aggregate in concrete led to poor strength. However, combining natural latex with silica fume showed positive results in terms of strength. Limited research exists on the impact of silica fume on concrete with shredded latex gloves and the durability properties. This study aims to fill this gap by investigating the effects with silica fume and durability of such concrete.

III. MATERIAL AND THEIR PROPERTIES

A. Cement

In this study, OPC grade 43 from Ultratech was used, conforming to the specifications of IS 269:2015 which was purchased from a local vendor near Arora Place, Ludhiana, having consistency 30% and specific gravity 3.12.

B. Fine Aggregate and Coarse Aggregate

The sand was bought from a shop at Arora Palace, Gill Road, Ludhiana of Zone II, modulus of fineness 2.61,specific gravity 2.55, and water absorption 1.24% was tested as per IS:383-2016. Coarse aggregate was also sourced from the same place. These aggregates were of the crushed variety, and their size was determined to be was 10mm and 20mm with specific gravity of 2.67 and 6.72 respectively, they were used by weight as 60% of 20 mm and 40 % of 10 mm.

D. Silica Fume

The Silica Fume shown in figure 3.3 was purchased from KGR Agro Ltd. at Humbran, Humbran-Ludiana Road, of Grade 92 – D with specific gravity of 2.12.

E. Latex gloves

Figure 1: Shredded Latex Gloves

New latex gloves were preferred in order to avoid infection and contamination, the Gloves were of Kanam Latex: Kaltex Plus, specified in table 3., the glove used were Powdered Non- Sterile Examination Gloves ambidextrous in shape was taken from Raju Medicals near CMC Hospital. The gloves were of creamy white Color. The gloves were then manually cut in size less than 10 mm as shown in figure 1. The specifications such as tensile strength, ultimate elongation %, Force were 18 Mpa, 650 min and 6 N min, with stress at 500% elongation was 5.5 max, these were taken from manufacturer.

IV. SAMPLE PREPARATION

A. Mix Design

In this research, the designed mix for grade M30 concrete following the guidelines and procedures outlined in IS 10262:2009. After conducting several trials, the ratio for the design mix was obtained, and the details are presented in the Table 1.

B. Molds, Mixing and Casting

Figure 2: Dry Mix of Sample

Concrete cubes of size 150mm were casted for compression tests, while sliced cubes (dia. 100mm x depth 50mm) were used for the Rapid Chloride Permeability Test. Beams of length 100mm were prepared for flexural tests. Components including aggregates, cement, silica fume (10% replacement), and shredded latex gloves were mixed uniformly. Three samples were cast for each test set, and evaluations were conducted at 7 and 28 days.

Table 1: Mix Design for M30 Grade in Kg/ m³

S. No	Cement	Water	FA	CA	SF	Weight of Concrete	SLG
CSI	426.67	192	624.6	1134.4	--	2377.67	--
CSI I	384	192	624.6	1134.4	42.67	2377.67	--
SI	384	192	624.6	1134.4	42.67	2377.67	2.83
SII	384	192	624.6	1134.4	42.67	2377.67	4.76
SIII	384	192	624.6	1134.4	42.67	2377.67	7.13

C. Testing of Specimens

Slump Test: This a measure concrete's workability, indicating consistency and ability to flow. It provides an indication of the ease of placing and compacting the concrete. The test was performed as per IS 7320:1974 Reaffirmed 2018.

Compression Strength Test: The compression strength test determines the maximum load-beard compressive forces. It helps assess the overall strength and structural integrity of the concrete. The test was performed ad per IS 516 (Part 1/ Section 1):2019.

Flexural Strength Test: This judges the capability of the concrete to bear flexural stresses. It accounts the atmost bending moment that the concrete bears before it starts to crack or fail. The test was performed ad per IS 516 (Part 1/ Section 1):2019.

Rapid Chloride Penetration Test: It provides an idea about concrete's aversion regarding penetration of chloride and that's important for assessing its durability and susceptibility to corrosion. The test was performed as per ASTM C 1202-14, Using PROOVE it apparatus of German Instrument.

IV. RESULTS AND DISCUSSIONS

A. Slump Test Result

As shown in figure 3, the CSI slump came to 78 mm. Other mixtures attained lower workability by adding silica fume and shredded latex gloves. Inclusion of SF filled the gaps and absorbed more water reducing the workability to 68 mm, correspondingly the addition of latex gloves in SISII, SIII reduced the Slump values to 44 mm, 42 mm and 33 mm. Comparing CS I with S I, S II, S III, the drop in slump value is by 12.3 %, 44%, 45.7%, and 57.6 % respectively. Which clears that the stiffness of the Samples in SI, SII and S III is low as compared to the CSI. The addition of shredded latex gloves may have disrupted the cementitious matrix, leading to decreased strength. It interfered with cement hydration and binding properties, reducing workability and slump values. This interference resulted in a decrease in overall strength [1,7].

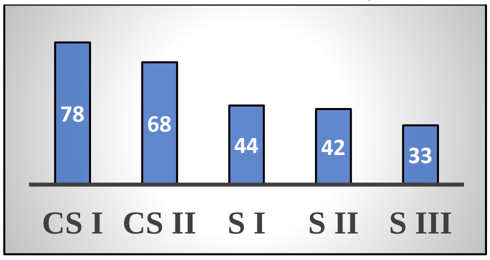

Figure 3: Slump Test Results

B. Compression Strength Result

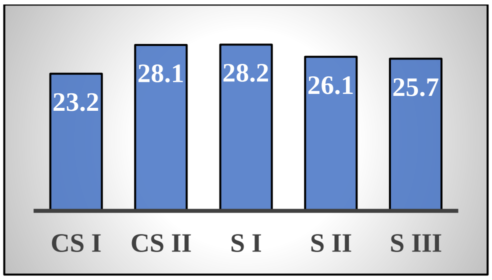

Figure 4: Compression Strength at 7 Days

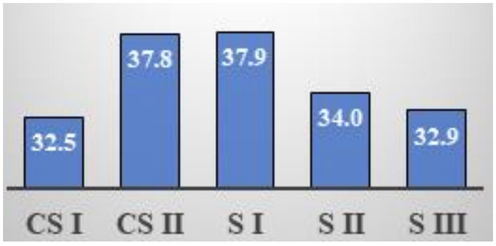

Figure 5: Compression Strength at 28 Days

From figure 4 and 5, Comparing SI, SII, and SIII with CS I, there were improvements in compressive strength by 21.23%, 12.30%, and 10.89% respectively. Similarly for the 28-day samples, there were improvements in compressive strength of 16.30%, 4.78%, and 1.36% respectively. SI performed well due to the crack-bridging effect of shredded latex gloves [3], while SII and SIII had decreased strength due to increased air content and improper bonding [4].

C. Flexural Strength Result

From the upshot conveyed in Figure 6 and 7, Comparing the flexural strength of SI, SII, and SIII with CS I, there was an increase in flexural strength of 29.84%, 36.82%, and 35.65% respectively at 7 days, similarly for 28 days there was an increase in flexural strength of 17.42%,17.71%, and 12% respectively. Overall, the optimal addition of 0.2% SLG (Shredded Latex Gloves) resulted in good performance at both 7 days and 28 days. The irregular shape and size of the shredded latex gloves

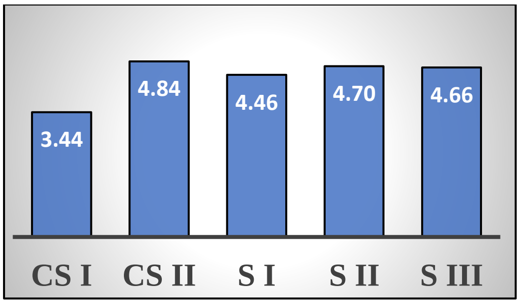

Figure 6: Flexural Strength at 7 Days

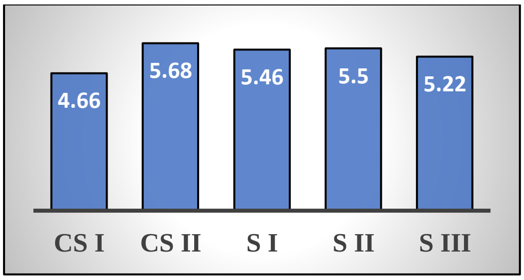

Figure 7: Flexural Strength at 28 Days

hindered the bonding between the cement paste and the gloves, leading to a gradual decrease in flexural strength latterly[10]. Previous Microscopy analysis revealed the presence of microcracks where the rubber was present, further decreasing the flexural strength. The non-uniform interface and smooth finish of the shredded latex gloves caused voids, water trapping, and weaker bonding with the cement paste.[7]

D. Rapid Chloride Penetration Test

From the above figure 8, can see that the normal concrete CS I have moderate class of permeability, whereas SI, SII, SIII have lower class of permeability, improvement happened as the packing of concrete get more compacted due to size of silica particles giving the desired properties, where as in the rest of the cases SI, SII, SIII doesn't shows any significant change to addiction of shredded latex glove in the permeability class, but as from results it can be seen that after the addition of latex gloves the Charge passed kept on increasing in SI, SII and SIII by 0.58 % from S I to S II and by 14.96 % from SI to SIII, and 14.29 % from SII to SIII. This increase in charge is due to the increase in the voids as the increasing the amount from 0.1 % shredded latex gloves to 0.3 % shredded latex gloves the cement paste and shredded glove's bond gets weakened and increase on air voids in SEM analysis [4].

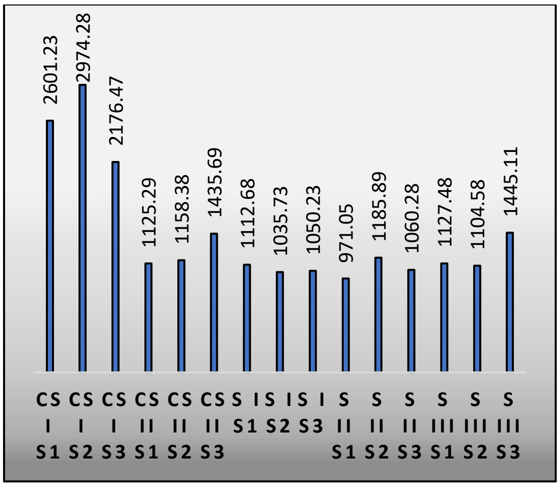

Figure 8: Rapid Chloride Penetration Test

V. CONCLUSION

1. The addition of shredded latex gloves had a noticeable impact on the workability and slump values. Shredded latex gloves significantly decreased the slump values. These results indicate more stiffness in the samples incorporating shredded latex gloves.
2. SI, SII and SIII exhibited good performance as by maintaining the compression strength with increment by 16.30%, 4.78% and 1.36% respectively, whereas the flexural strength was maintained by increment of 17.42%, 17.71% and 12% respectively when compared to the Control Sample I.
3. Addition of shredded latex gloves in SI, SII and SIII by 0.1 %, 0.2%, and 0.3% with 10% silica fume replacement by cement gave good outcomes as the permeability class moved moderate to low with comparison to the Control Sample I.

   The addition of shredded latex gloves can be done up to 0.3% with silica fume by 10% replacement of cement. With the mentioned combination the strength both compressive and flexure are more than that of Control Sample I, while the two wastes the shredded latex gloves and silica fume have been used in an effort to make sustainable concrete.

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