Spectrum of Engineering Sciences
ISSN (e) 3007-3138 (p) 3007-312X
Volume 3, Issue 9, 2025

EVALUATING THE EFFECT OF AMMONIUM NITRATE ON THE MECHANICAL PROPERTIES OF CONCRETE INCORPORATING WASTE GLASS AS A PARTIAL REPLACEMENT

[1]Umer Shahzad, [2]Farah Naz*, [3]Shiraz Baloch, [4]Aalia faiz, [5]Dr. Shimza Jamil

[1]Department of Civil Engineering, Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan, Punjab, Pakistan.
[2]Department of Civil Engineering, Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan, Punjab, Pakistan.
[3]Department of Civil Engineering, Khwaja Fareed University of Engineering and Information Technology, Rahim Yar Khan, Punjab, Pakistan.
[4]Department of Building and architectural engineering, faculty of engineering and technology BZU MULTAN.
[5]Assistant Professor Building and Architectural Engineering
farah.naz@kfueit.edu.pk , umer.shahzad@kfueit.edu.pk , meershiraz17@gmail.com , Aliafaiz2006@gmail.com, shimzajamil@bzu.edu.pk

DOI: https://doi.org

Keywords Eco-friendly environment, Waste glass reinforcement concrete, Tensile strength, Compressive Strength, Environmental sustainability.

Article History
Received on 08 July 2025
Accepted on 25 July 2025
Published on 16 August 2025

Corresponding Author: *
Farah Naz*

Abstract

The requirement for infrastructure is growing as a result of the world's population growth, which fuels everyday construction activity. In comparison to non-reinforced concrete, fiber-reinforced concrete has a higher tensile strength, which increases its durability. Recycled glass is added to concrete to increase its stress resistance and lessen the chance of cracking. Moreover, it minimizes damage by strengthening the concrete's resistance to extreme weather, like freezing and thawing. It can also be used to lower the water content of the concrete, improving its early strength, and it successfully keeps the concrete workable for longer periods of time. The project is to examine the effects of adding recycled glass as reinforcement to concrete and to assess the impact of ammonium nitrate on the material, with an emphasis on the mechanical characteristics that follow. Tests evaluating compressive and tensile strengths will be conducted on a range of concrete samples containing varying proportions of waste glass. The study's findings will provide insightful information about how waste glass may be used as an affordable and environmentally beneficial substitute for conventional reinforcing materials. The results of this study may have a big impact on environmental sustainability and the building sector. Its goal is to increase building sustainability. Additionally, it looks into how ammonium nitrate affects the strength and durability of concrete. The study assesses the impact of these alterations on the performance of concrete, emphasizing the enhancement of environmental results and material efficiency. The findings shed light on the possible advantages and restrictions of these substitute materials in concrete applications.

INTRODUCTION

Three powder-like materials ground up sand, baking soda, and dusty limestone combine to form glass. It is easily disposed of with little damage to the environment and is reusable [1, 2]. Glass is an incredibly useful and age-old product, but keep in mind that when it breaks, it can cause painful [3,4]. Due to their mass domination and generally homogeneous chemical composition-soda lime-silica glass makes up almost the entire manufactured flat and container glass-the container and flat glass industries have the greatest potential for glass recycling [5]. For the vast majority of people, glass is an everyday object. It is essentially a transparent frozen liquid made of silica, calcium carbonate ($CaCO_3$), and soda ash that has been liquefied at extremely high temperatures [6,7]. The resources needed to produce glass are abundant. Glass can break, is difficult to recycle, and is more expensive to transport due to its weight. Despite being recyclable, there are problems associated with using glass. Carbon dioxide (CO_2) emissions occur during the glass manufacturing process due to the use of fossil fuels and the depletion of raw materials [8,9,10]. We used waste glass as a cement replacement with different percentages. Glass is utilized in concrete to avoid cracking resulting from both plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete, which reduces water leaking through the concrete [11]. They increase the concrete's impact, ductility, strength, abrasion resistance, and shatter resistance. The glass strengthens the mortar component of the concrete, preventing the creation and spread of fractures. The majority of people utilize glass on a daily basis; it is essentially a transparent, frozen liquid composed of ($CaCO_3$), soda ash, and silica that liquefies at extremely high temperatures [12,13]. Concrete is a versatile building material that comes in a range of forms to suit the requirements of various projects. One of the most common types of concrete is Portland cement concrete, which is composed of cement, water, and aggregates like sand and gravel [14,15]. Ammonium nitrate (NH_4NO_3) is a chemical compound widely used in various industries, primarily as a fertilizer and also as an explosive material [16 ,17]. Because ammonium nitrate has a high nitrogen concentration, it is a commonly utilized fertilizer in agriculture. Ammonium nitrate gives plants an easy-to-access supply of nitrogen, which is a necessary ingredient for plant growth [18].

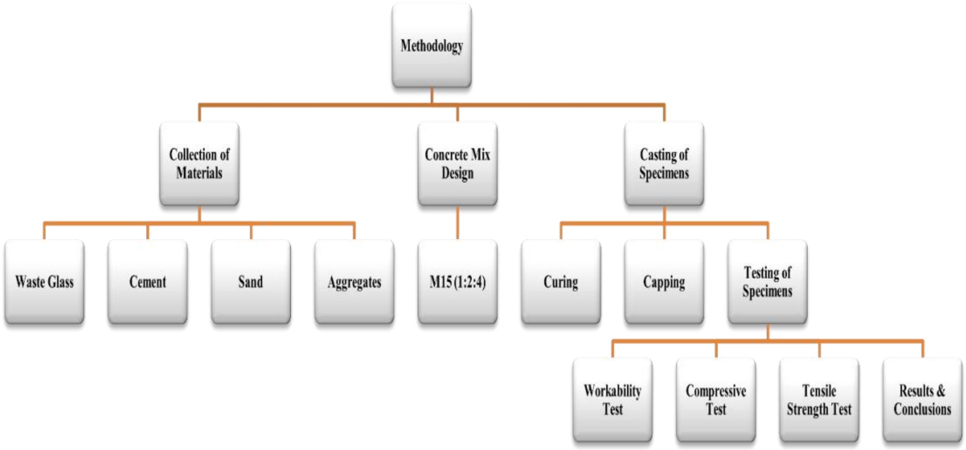
Ammonium nitrate is an explosive substance that can be used when combined with fuels or other compounds. It is essential to the manufacturing of many explosives, such as water gels and ANFO (ammonium nitrate/fuel oil) [19 ,20]. If ammonium nitrate is handled or stored incorrectly, there is a considerable chance of an explosion. When it comes into contact with organic compounds or extreme heat, the risk goes up [21]. Although ammonium nitrate is not flammable in and of itself, it can quicken the burning of other substances when it comes into contact with fuels or other reducing agents [22 ,23]. However, skin and respiratory irritation can result from prolonged exposure to dust or fumes. Excessive consumption or inhalation can result in symptoms such as nausea, vomiting, and in more serious situations, methemoglobinemia, and a disorder that impairs the blood's ability to carry oxygen [24 ,25]. As a result of the concrete industry's ongoing expansion, new concrete classes had been created and older concrete classes are had been improved. Jamshadi et al [26] studied that a new type of concrete called waste glass concrete was distinguished from conventional concrete by its superior durability and flexibility as well as its mechanical qualities, which are significantly better. The cement and concrete industries have demonstrated a long-standing dedication to continuous innovation and improvement [27,28]. Innovative, cutting-edge, and developing technologies have been brought to light in recent business trends in areas such as digital construction, high-rise construction, 3D innovation, and advances in concrete technology [29]. To achieve this, though, major decision-making processes must center on collective action and carbon reduction.

Paul [30] studied the reason behind using waste glass instead of cement is the best replacement ratios and how they affect the durability and strength of concrete over time. The majority of current research focuses on short-term strength gains and falls short in addressing long-term performance, environmental effects, or the interactions between waste glass and other components of the concrete mix. MA Alaraj [31] suggested that used waste glass as a cement replaced increases compressive strength, tensile strength and flexural strength. Rajadesingu et al [32] studied that the effects of ammonium nitrate on the strength, longevity, and long-term stability of concrete, which represents gap in the field. Its effects on the hydration process and overall mix performance, as well as how it interacts with other concrete additives, are not covered in the majority of current research. On the safety and environmental effects of adding ammonium nitrate to concrete mixtures, there is also a lack of information. Filling these inconsistencies may offer vital information about how to guarantee sustainable practices and maximize concrete performance. As a result of the concrete industry's ongoing expansion, new concrete classes had been created and older concrete classes are had been improved. A new type of concrete called waste glass concrete was distinguished from conventional concrete by its superior durability and flexibility as well as its mechanical qualities, which are significantly better. Examine the effects on concrete's compressive strength by partially substituting discarded glass for some of the cement. A cylindrical object's tensile strength is determined by applying a compressive load along its longitudinal axis. Find out how strong the beam is flexural. Flexural testing quantifies the force needed to bend a plastic beam and assesses a material's stiffness or resistance to bending. It shows how long concrete can withstand breaking under bending pressures. The cement and concrete industries have demonstrated a long-standing dedication to continuous innovation and improvement. Innovative, cutting-edge, and developing technologies have been brought to light in recent business trends in areas such as digital construction, high-rise construction, 3D innovation, and advances in concrete technology.

1. Methods and Materials

The process for a tangible research study is depicted in the flowchart shown in figure 1. The first step is gathering the necessary supplies, which include aggregates, sand, cement, and leftover glass. After that, an M15 (1:2:4) ratio concrete mix design is created. The specimens are cured and capped after they are cast, which is the next step in the process. These specimens go through a number of tests, including compressive, tensile, and workability tests. Ultimately, conclusions are drawn from the analysis of the data.

Figure: 1 Methodology Chart



2.1. Materials Properties

Ordinary Portland cement (OPC), water, natural coarse aggregates, fine aggregates and glass powder have been utilized in the experimental study. OPC have passed from sieve # 100 having specific gravity 3.12 and standard consistency 6mm. The initial and final setting of OPC is 95 minutes and 320 minutes respectively. Properties of OPC are described in the table 1.

Table 1. Physical Properties of OPC

No	Property	Description
1	Specific Gravity	3.12
2	Standard Consistency	6mm
3	Initial Setting Time	95 Minutes
4	Final Setting Time	320 Minutes
5	Compressive Strength	
7	7 Days	28.6 N/sq.mm
8	14 Days	37.1 N/sq.mm
9	28 Days	46.8 N/sq.mm

The majority of fine aggregate is made up of small particles that are collected on a 75 m (No. 200) screen after passing through a 4.75 mm (No. 4) sieve. We used harrow sand in the project because they have a greater strength than the other all sand. Harrow sand have fineness modulus 2.675 and specific gravity is 2.64.

Table 2 clearly shows the physical properties of fine aggregate. Coarse aggregates are crushed stone, gravel, or recycled concrete components whose particle sizes are greater than 4.75 mm. we used Sargodha aggregate in the project, black brownish color having size 19 mm to 25mm. Fineness modulus of coarse aggregate is 6.85 and water absorption is 0.59%. They also increase the workability of concrete by using less cement paste and physical properties of coarse aggregate shown in table 3.

Table 2. Physical properties of Fine Aggregate

Source	Harrow Sand
Fineness Modulus	2.675
Specific Gravity	2.64 (SSD)
Water Absorption	1.76%
Loose Bulk Density	1.64g/cm^3
Compacted Bulk Density	1.76g/cm^3

Table .3. Physical properties of coarse aggregates

Physical Property	Coarse Aggregate
Source	Sargodha Crush
Max. Size	19mm
Fineness Modulus	6.85
Specific Gravity	2.768 (SSD)
Water Absorption	0.59%
Impact Value	4.82%
Crushing Value	12.52%
Los Angeles Abrasion	19.31%
Air Void %	0.50%
Compressive Strength	19.8 Mpa
Average Unit Weight	1680 Kg/m^3

Figure 2 show the crushing of waste glass in los Angeles Abrasion machine. We will place waste glass in Los Angeles abrasion machine for crushing by piece by piece. The revolution of Los Angeles is 500 rev/min. For first time the complete glass was not crushed, we will place glass in los Angeles's machine again for complete crushing of glass.

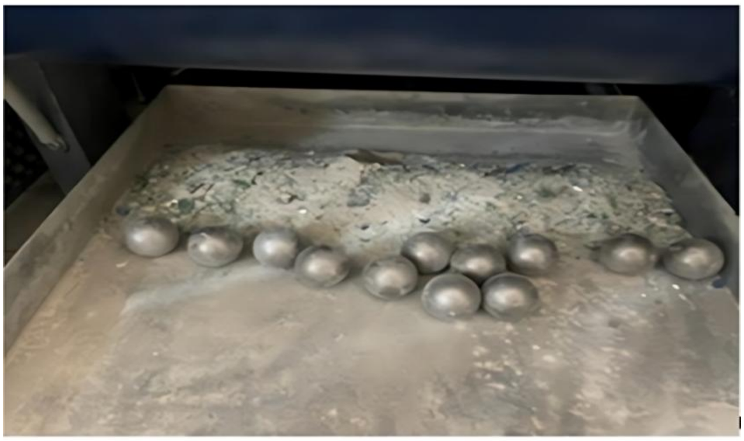


Figure: 02. Crushed Waste glass

Figure 3 show the sieve Analysis and the fineness modulus (sum of retained % of sieves / 100) of the sand was determined using ASTM C136/136M-16 standards. We used sieve include (#4, #8, #16, #30, #50, #100 and #200) to find FM of sand. Add up all of the cumulative percentage values and divide the result by 100 to find the fineness modulus value. The sample was dried for 24 hours in an oven at 105 degrees Fahrenheit. Mechanical sieves were employed to measure the sand's fineness modulus.

Figure: 03. Fineness Modulus of sand

Figure 4 show the specific gravity and water absorption apparatus. The specific gravity test determines the fine aggregates' density in respect to water, per ASTM C128. The specific gravity value of a dry aggregate sample is determined by first measuring its mass in air and then again in water, and then calculating the difference between the two masses It is specified as a percentage of the aggregate's dry weight.

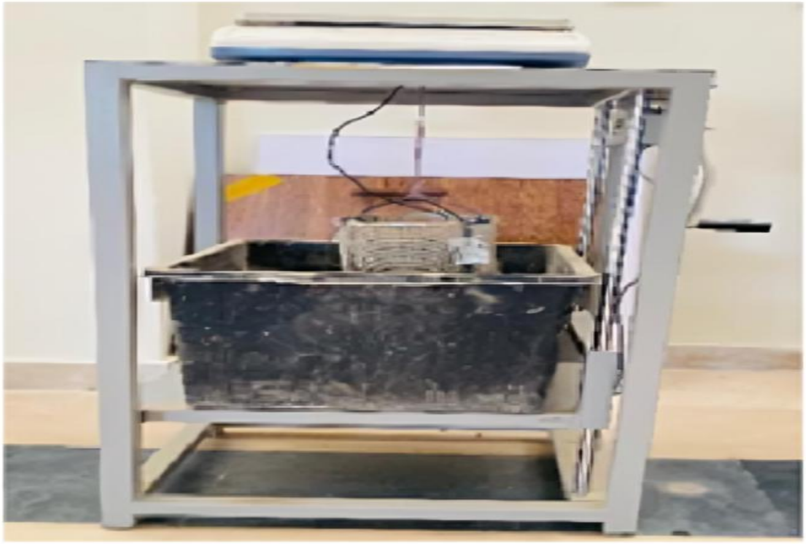


Figure: 04. Specific gravity and water absorption apparatus

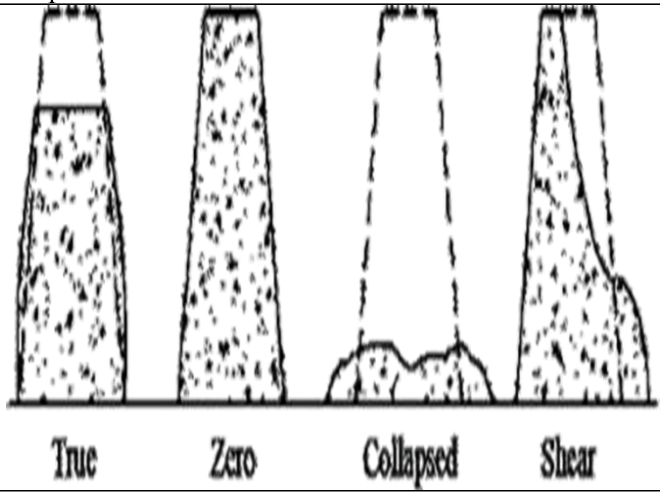
Figure 5 show the relative density of sand having the degree of compaction of a given sample is ascertained using the relative density and % compaction. The sample was dried in an oven that was heated to between 103° and 105° C for a full day.

Figure: 05. Relative density of Sand

Testing of Specimens

Slump Cone Test

Figure 6 (a), (b) and (c) show the different types of slumps and performing slump cone test and it is a widely used method to assess the consistency and workability of freshly mixed concrete. There are four distinct varieties according on the form that was left behind when the cone was taken out of the drop. In this state, there is no distortion and no change in droop. The second is the real slump. This type of slump is brought on by the material being somewhat disturbed from the top when the cone is removed. The next type is a shearing slump. After the cone is removed, shear slump occurs when material from one side is driven out of the slump. The last one gets destroyed. The word "collapse" refers to the complete distortion of the recession.



(a) Types of Slumps

(b) Concrete fill in Slump cone

(c) Concrete show zero slump

Figure: 06 Types of Slumps and performing Slump Cone test

Casting and capping of Concrete Cylinders

Figure 7 show casting of concrete cylinders and after the waste glass is substituted with cement and combined with the concrete, the mixture is transferred into molds that have a cylindrical shape. The cylinder has diameter of 6 in and length is 12 in. To create concrete cylinders of conventional size, the molds are sized suitably. To obtain the ideal density and remove any air gaps, the concrete is compacted inside the molds using vibration or other compaction techniques. First, waste glass is not added to the control sample, which is made in accordance with the predicted concrete mix design. Different amounts of cement are substituted for the glass, and various cylinders are cast in its stead.

Figure: 7 Casting of Concrete Cylinder

Figure 8 elaborate the capping of concrete cylinders and the process of capping is used to polish and flatten the ends of concrete cylinders before testing their compressive strength. Capping helps ensure uniform load distribution during testing and prevents abnormalities or defects from affecting the test results. Usually, a capping material, such as neoprene pads or sulfur cement, is applied to the ends of the cylinders and allowed to cure.

Figure: 8. Capping of Cylinders

2.1.1.Compressive Strength of Cube's

Figure 9 elaborate compressive strength (Load / Area) of cubes and after giving the mounds a thorough cleaning, oil the cube's frame. Layer molds should be filled with concrete. To compact each layer, use a tamping rod with at least 35 strokes each layer. It is necessary to trowel the top surface into position. After being cured for 24 hours, mortar cubes are usually taken out of the molds in 16 to 72 hours. Reduce the sample size to the closest 0,2 mm when the cube's cure period has passed, then insert the model into the machine to start loading on the other side. Apply the load at a rate of 140 kg/cm2/min without providing any shock until the sample breaks. Pay attention to the maximum load.

Figure: 9. Compressive Strength of Cubes

2.1.2.Split Tensile Strength of Concrete Cylinders

Figure 10 show the performing of split tensile test and the standard-sized concrete cylinders can be cast and healed in a period of 28 to 56 days. Draw diametric lines at both ends to ensure that the lines are in the same axial position. Next, take note of the sample size. The equipment used for compression testing was set to the appropriate range. On the bottom plate, arrange the plate strip and the sample. The specimen should be positioned vertically in the center of the ends of the foundation plate. On top of the specimen, place the second fly wood strip. After it only touches the strip, lower the top plate. Apply the load steadily and shock-free at a pace of 0.7 to 1.4 KN/sec.

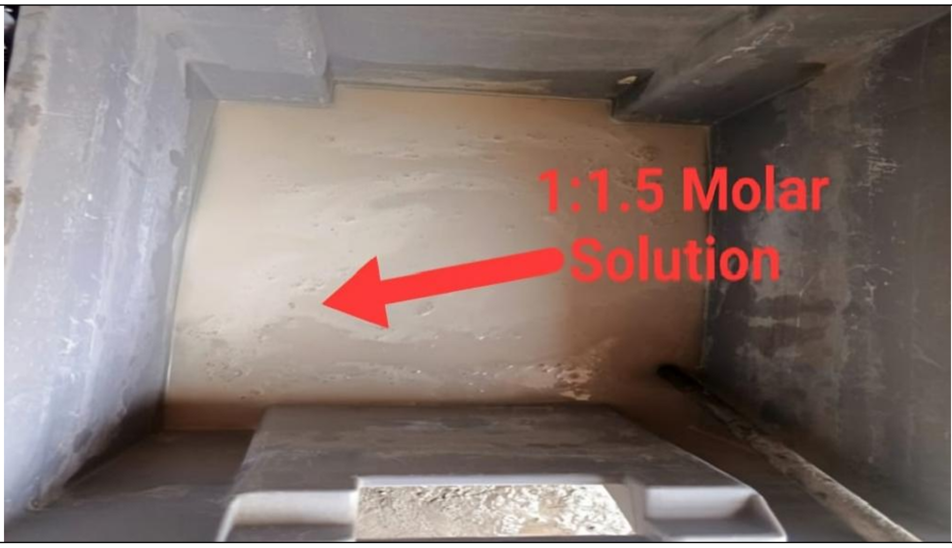
Figure: 10. Split tensile Strength test

2.2.Ammonium Nitrate and its Solution

Figure 11 (a) show the ammonium nitrate which can be used in concrete primarily as an additive to enhance certain properties of the mixture. Its inclusion helps accelerate the setting time of concrete, which is particularly beneficial in cold weather conditions where curing rates are slowed. This additive also contributes to reducing the porosity of concrete, leading to increased durability and resistance to freeze-thaw cycles. However, careful control of dosage is critical, as excessive amounts can lead to unwanted expansion and cracking.

Figure 11 (b) show to prepared a molar solution of ammonium nitrate (NH_4NO_3) using 1 kg of ammonium nitrate and 1.5 kg of water, the process begins by determining the molar mass of ammonium nitrate, which is approximately 80.04 g/mol. Given 1 kg (1000 g) of ammonium nitrate, this equates to 12.5 moles (1000 g / 80.04 g/mol). The water used as the solvent has a mass of 1.5 kg (1500 g). For the solution preparation, the ammonium nitrate is gradually added to the water while stirring continuously to ensure complete dissolution. These results in a solution with a molarity calculated as moles of solute per liter of solution. Since the solution's volume increases upon dissolution, precise molarity determination requires measuring the final volume. Assuming a negligible volume change for simplicity, the approximate molarity is 12.5 moles in 1.5 liters of water, yielding around 8.33 M (moles per liter).

(a) Ammonium Nitrate



(b) Ammonium Nitrate Solution

Figure: 11 Ammonium nitrate and ammonium nitrate solution

Results and Discussions

Fineness Modulus of Fine aggregate

The fineness module is the index value that represents the average size of sand particle. It is found by performing a typical sieve seven analysis. The aggregate rate of each filter is added and subtracted to determine the value of the fineness modulus. We have determined the fine modulus of sand and the result of the sand modulus are shown i n table 4 which is 2.67%.

Table 4: Result of fineness modulus of Sand

Sieve Size	Wt Retained(g)	Cum Retained(g)	Wt.Cum Retained(g)	%ageCum Passed(g)	%ageSpecification
3/8"	-	-	-	100	100
No. 4	23	23	3.3	96.7	95-100
No. 8	52	75	10.8	89.2	80-100
No 16	152	227	33.6	66.4	50-85
No. 30	156	383	55.1	44.9	25-60
No. 50	117	500	71.9	28.1	10-30
No. 100	145	645	92.8	7.2	0-10
No. 200	7	652	96.4	3.6	0-5
Pan	43	695	100	0	0
			Sum=267		
F.M of Sand		=267/100		=2.67%	

3.2.Specific Gravity and water absorption of Fine Aggregate

Specific gravity is determined by dividing the weight of a certain volume of aggregate by the weight of a similar volume of water. The results of specific gravity and water absorption are shown in Table 5. It is a tool for figuring out a material's strength or quality. Fine aggregate absorbs water at a rate of 1.72%. Lower specific gravities tend to make aggregates weaker than higher specific gravities.

Table 5. Sand's Specific Gravity and Water Absorption

Description	Sample 1	Sample 2	Average
Mass of Saturated Dry Sample (A)	511.9	524.7	518.3
Mass of Oven Dry Sample in Air (B)	503.3	515.8	509.55
Mass of Pycnometer Filled with Water (C)	653.4	661.2	657.3
Mass of Pycnometer with Saturated Surface Dry Sample and Water (D)	964.2	993.2	978.7
Water Absorption %age (A-B/B) *100	1.71	1.72	1.72

Specific Gravity			
A) Bulk Oven Dry (B/A) +C-D	2.502	2.676	2.591
B) Bulk Saturated Surface Dry (A/A) +C-D	2.547	2.722	2.632
C)Apparent (B/B) +C-D	2.614	2.806	2.708

1.1. Unit Weight of Fine Aggregate

Table 6 show the outcomes of unit weight of fine aggregate that the unit weight of sand, sometimes called the density or specific weight, is the amount of sand per unit volume that it occupies. Sand that has been moistened can weigh anywhere from 1,900 to 2,100 kg/m^3, while dry sand typically weighs between 1,500 and 1,700 kg/m^3.

Table 6. Unit Weight of Fine aggregates

Description	Results
Mold Volume	5005g
Mold Weight	3680g
Loose Weight of Sand in Mold	11910g
Compacted Wt. in 3 layers	12400g
Loose Bulk Density	1.64g/cm^3
Compacted Bulk Density	1.74g/cm^3

Specific Gravity and water absorption of Coarse Aggregate

Table 7 presents the specific gravity that a particular total volume's specific gravity is determined by comparing it to an equivalent volume of water. Water has a specific gravity of 1 when it is 23 °C. Any water vacuum volume is not included in the volume estimate; it just takes into consideration the aggregate's volume. The mass estimation includes only the aggregate particle. Calculations have been made for the apparent specific gravity, dry oven gravity, and specific SSD gravity.

Table 7. Specific Gravity and Water Absorption of Coarse Aggregate

Description		Sample 1	Sample 2	Average
Mass of Saturated Dry Sample	A	4221	4267	4244
Mass of Oven Dry Sample in Air	B	4198	4245	4221.5
Mass of Sat. Surface Dry Sample in Water	C	2726	2734	2773.5
Water Absorption %age	(A-B/B) *100	0.55	0.54	0.53
Specific Gravity				

A) Bulk Oven Dry	B/A-C	2.81	2.77	2.87
B) Bulk Saturated Surface Dry	A/A-C	2.82	2.79	2.89
C) Apparent	B/B-C	2.85	2.81	2.92

3.5. Crushing Value of Coarse Aggregate

A comparative assessment of the aggregate's crush force under increasing compression loads is given by the crush value test shown in Table 8. The strength of the aggregate is indicated by the index in route construction, and the aggregate crush is the percentage by weight of the crushed material attained when the trial aggregate has been put to a specified load under standard conditions which is 20.87%.

Table 8. crushing Value of Coarse Aggregate

Description	Calculations
Total weight of aggregate	2769 g
Aggregate passing through sieve # 8	578 g
Crushing value of Coarse Aggregate	20.87 %

1.2. Compressive Strength of Concrete Cubes

The figure 12 clearly show days in horizontal (x-axis) and compressive strength in vertical (Y-axis) when curing days increase the compressive strength Increases and also when percentage of waste glass as a cement replacement increases up to certain limit the compressive strength increases and after that the compressive strength decreases. Up to a certain point, using WGP in place of cement improves concrete; but, as the percentage of WGP increases, the effect becomes negative. It is evident that when the percentage of waste glass increases, the compressive strength usually decreases. The compressive strength of all samples increases with time, although there is still a tendency for strength to drop as waste glass content rises. Throughout the whole testing period, the sample with 15% waste glass outperforms the ones with 5% and 25% waste glass. When waste glass % increases the strength decreases and the line of graph gradually down with increases in days.

According to the results of the compressive test, at 28 days, the percentage of waste glass replaced by cement increased to 7.64% and 13.41% at 5% and 15%, respectively, compared to the normal concrete. The percentage of WGP replaced by cement decreased to 17.55% at 25% and below 15%, which is not appropriate. Using WGP in place of cement at 56 days had a positive effect on the concrete up to a certain point and a negative influence as the fraction of

Spectrum of Engineering Sciences
ISSN (e) 3007-3138 (p) 3007-312X Volume 3, Issue 9, 2025

WGP rose, based on the compressive strength values of the concrete at that time as reported by the compressive test results. When 5% and 15% of waste glass are replaced with cement, the compressive strength increases to 9.77% and 17.51%, respectively, compared to normal concrete. When 25% of WGP is replaced with cement, the compressive strength drops to 25.01%. According to the compressive test results, employing WGP in place of cement at 90 days had a positive effect on the concrete up to a certain point and a negative impact as the amount of WGP rose. In comparison to regular concrete, the compressive strength rises to 7.33% and 17.33%, respectively, when 5% and 15% of the waste glass is substituted with cement. Cement replaces 25% of WGP, resulting in an 11.95% reduction in compressive strength.

In summary, the use of 15% glass as a replacement for cement consistently improves the compressive strength of the concrete, whereas using 25% glass significantly reduces the strength. The 5% replacement shows moderate performance, better than the 25% but lower than the 15% replacement.

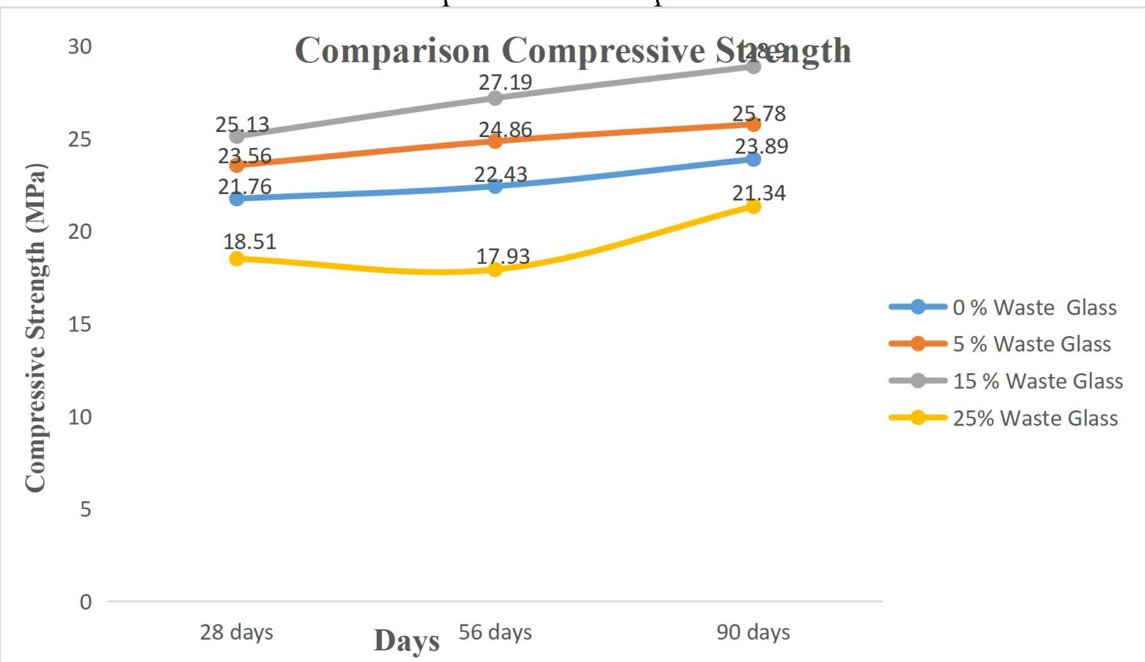


Figure: 12. Compressive Strength of Concrete

3.7.Split Tensile Strength of Concrete

The figure 13 clearly demonstrates the relationship between curing days and split tensile strength, with days represented on the horizontal (x-axis) and split tensile strength on the vertical (Y-axis). As the curing days increase, the split tensile strength of the concrete also increases. Additionally, the figure shows that when the percentage of WGP as a cement replacement increases, the split tensile strength initially increases up to a certain point but then decreases beyond that limit. However, when the percentage of WGP exceeds this optimal range, the split tensile strength begins to decrease, indicating a negative effect. This observation highlights the importance of optimizing the amount of WGP in concrete mixtures to achieve the best performance. The split tensile strength first declines with increasing waste glass content; the sample with 25% waste glass had the lowest strength at 28 days. On the other hand, all samples show an increase in split strength over time. Interestingly, the sample containing 15% waste glass regularly exhibits the strongest results across the whole testing period, peaking at 90 days. According to the results, replacement levels with 15% waste glass were shown to be the most successful, while initially having more waste glass lowers the material's split strength. However, over time, the material gains strength.

At 28 days, the splitting tensile strength values rose; however, as the waste glass addition was raised further, the strength values fell. The splitting tensile strength increased by 14.87% and 20.9%, respectively, when the used glass was replaced by 5% and 15% of it; however, the splitting tensile strength decreased by 18.26% when the waste glass was replaced by 25%. According to the results, at 56 days, the splitting tensile strength improved by 4.93% and 14.24%, respectively, when the used glass was replaced by 5% and 15%. Nevertheless, the splitting tensile strength was reduced by 18.93% when the waste glass was replaced by 25%. When waste glass was used in place of cement for 90 days, the splitting tensile strength values improved, but only to the extent that the amount of waste glass was increased. However, when the amount of waste glass was raised further, the strength values dropped. The results showed that replacing the utilized glass by 5% and 15%, respectively, increased the splitting tensile strength by 10.93% and 17.94%. Nevertheless, a 25% replacement of the waste glass resulted in a 17.80% loss of splitting tensile strength.

In summary, the splitting tensile strength of concrete increased with 5% and 15% waste glass replacement, showing the highest gains at 15%. However, replacing 25% of the cement with waste glass consistently resulted in a significant decrease in tensile strength across all curing periods (28, 56, and 90 days).

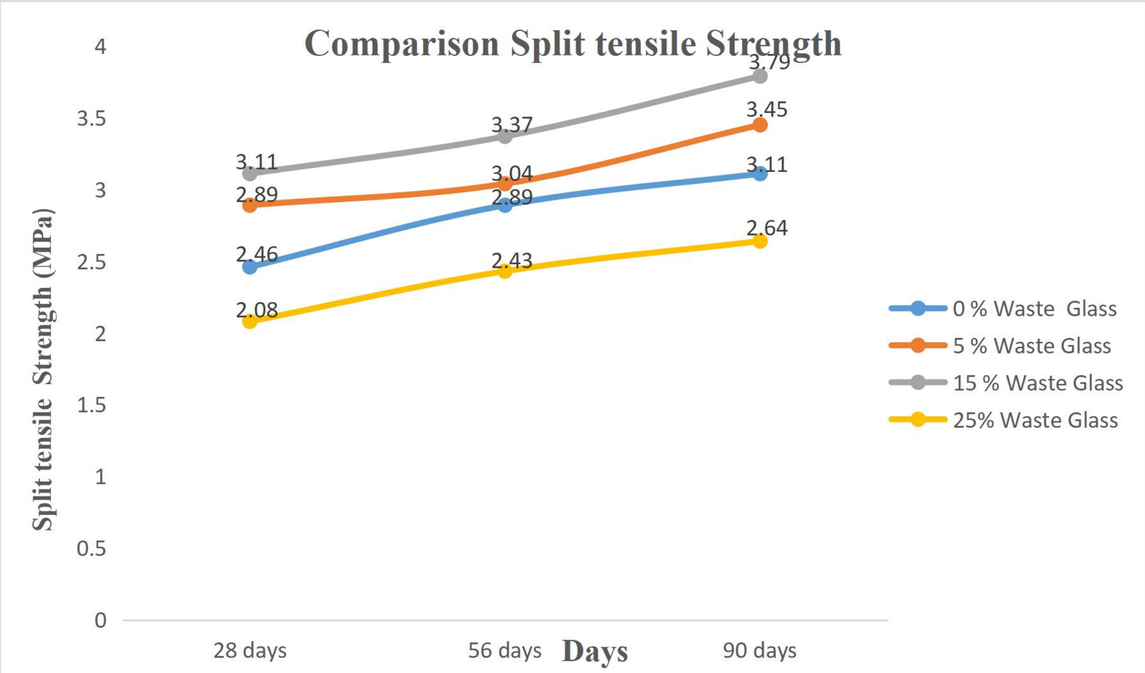


Figure: 13. Split tensile strength of Concrete

3.8.Flexural Strength of Concrete

Figure 14 clearly shows how flexural strength is affected by curing days, with days shown on the horizontal (x-axis) and flexural strength on the vertical (Y-axis). The flexural strength of the concrete increases as the curing time extends. The figure also illustrates that adding WGP as a cement replacement boosts flexural strength up to a certain point, but beyond that point, the strength starts to drop. This indicates that using too much WGP can have a negative impact, emphasizing the need to carefully determine the right amount of WGP in concrete mixtures for the best results. Concrete's flexural strength can be increased by substituting waste glass for cement because of the enhanced bonding and pozzolanic reaction. The waste glass's replacement ratio and particle size, however, determine how effective it is.

After 28 days, flexural strength rose by 10.92% and 19.30% for waste glass substitutes of 5% and 15%, respectively, whereas it fell by 10.01% for waste glass substitutes of 25%. The graph descends after 15%, indicating that replacing cement after 15% is inappropriate due to a drop in strength. Only to the extent that the amount of waste glass increased did the addition of cement in lieu of waste glass improve the flexural strength. At 56 days, the flexural strength of waste glass substitutes of 5% and 15% increased by 10.55% and 19.27%, respectively, while the flexural strength of waste glass substitutes of 25% decreased by

7.55%. The flexural strength improved at 90 days when waste glass was replaced with cement, but only to the extent that the amount of waste glass increased. Flexural strength rose by 8.73% and 19.30% for waste glass substitutions of 5% and 15%, respectively, but fell by 7.88% for waste glass substitutes of 25%. The graph unequivocally demonstrates that the 15% waste glass substituted for cement has a stronger bond than the other. The flexural strength of waste glass substituted with 5% and 25% cement is lower than that of waste glass substituted with 15% cement.

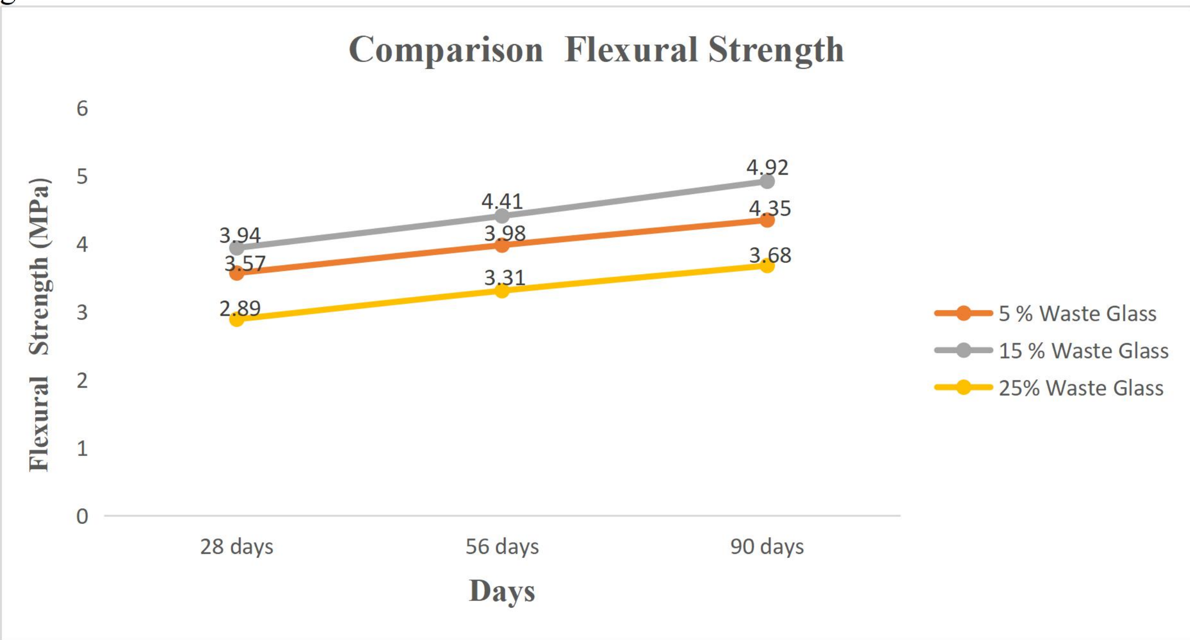


Figure 14. Flexural Strength of concrete

1.3. Compressive Strength of concrete after dip in Ammonium Nitrate compared with Normal Concrete

The corrosive interaction between ammonium nitrate and the concrete matrix causes a considerable loss in compressive strength when concrete cylinders constructed with waste glass as a partial replacement for cement are cured in ammonium nitrate. Because ammonium nitrate is so soluble, it seeps into the concrete and combines with the cement paste's calcium hydroxide to cause leaching. Ammonium nitrate also reduces the load-bearing capacity of concrete by causing internal expansion and microcracking. The concrete's strength has significantly decreased as a result of the exposure to ammonium nitrate, as demonstrated by the compressive strength test. This weakens the concrete's internal structure, leading to a decrease in compressive strength compared to normal concrete.

Figure 15 shows variation in compressive strength due to different percentages of glass. Results showed that the concrete with 5%, 15%, 25% glass replacement concrete decreases the strength 8.68%, 17.18% and 28.81% at 28 days respectively compared with Normal concrete. Concrete's compressive strength is significantly impacted when glass is partially replaced with cement as ammonium nitrate compared with normal concrete. It also demonstrates variance in compressive strength as a result of varying glass percentages. According to the results, the concrete with 5%, 15%, and 25% replacement glass reduces the strength at 56 days by 22.06%, 1%, and 36.75%, respectively compared with normal concrete. At 90 days, when 5%, 15%, and 25% of the waste glass is replaced with cement, the compressive strength drops to 10.37%, 22%, and 60.2%, respectively, compared to standard concrete.In summary, that compressive strength of concrete dip in ammonium nitrate decrease day by day. Immersing concrete in liquids containing ammonium nitrate gradually weakens it. The chemical attack on the cement matrix causes this degradation, which weakens the structure of the concrete by causing calcium compounds to dissolve.

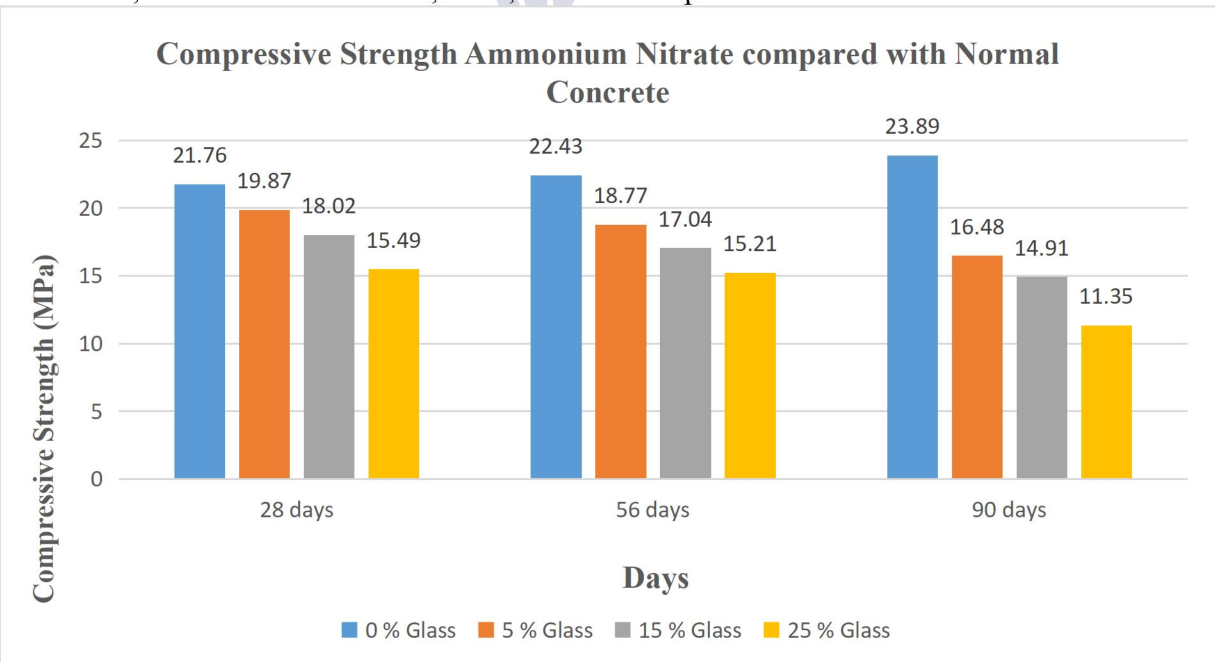


Figure: 15. Compressive Strength Ammonium Nitrate

3.10.Split Tensile Strength of concrete after dip in Ammonium Nitrate compared with Normal Concrete

Figure 16 elaborate when concrete cylinders made with waste glass as a partial replacement for cement are cured in ammonium nitrate, the strength decreases due to the aggressive chemical reaction between ammonium nitrate and the cement matrix. Ammonium nitrate is highly soluble and can penetrate the concrete, leading to the leaching of calcium hydroxide from the cement paste. This results in the dissolution of essential binding components like calcium silicate hydrate (C-S-H), which is crucial for the strength and durability of concrete. The reaction also causes internal expansion, cracking, and the formation of voids, further weakening the concrete. The split tensile test, which measures the tensile strength of concrete, thus reveals a significant reduction in strength due to these detrimental effects.

The findings of the Split Tensile Test showed that using WGP instead of cement at day 28 in ammonium nitrate was detrimental. When 5%, 15%, and 25% of the waste glass is replaced with cement, the Split tensile strength falls to 34.12%, 75.77%, and 166.98%, respectively, compared to standard concrete. When 5%, 15%, and 25% of the waste glass is replaced with cement, the split tensile strength drops to 24.87%, 65.13%, and 148.51%, respectively, compared to standard concrete at 56 days. It was harmful to use WGP at 90 days in ammonium nitrate rather than cement. In comparison to ordinary concrete, the split tensile strength decreases to 21.13%, 64.33%, and 164.04%, respectively, when 5%, 15%, and 25% of the waste glass is substituted with cement.In summary, the use of waste glass powder (WGP) as a cement replacement in concrete exposed to ammonium nitrate significantly reduces split tensile strength over time, with greater WGP content leading to more substantial strength losses at 28, 56, and 90 days. The detrimental effects increase with both the percentage of WGP and the duration of exposure.

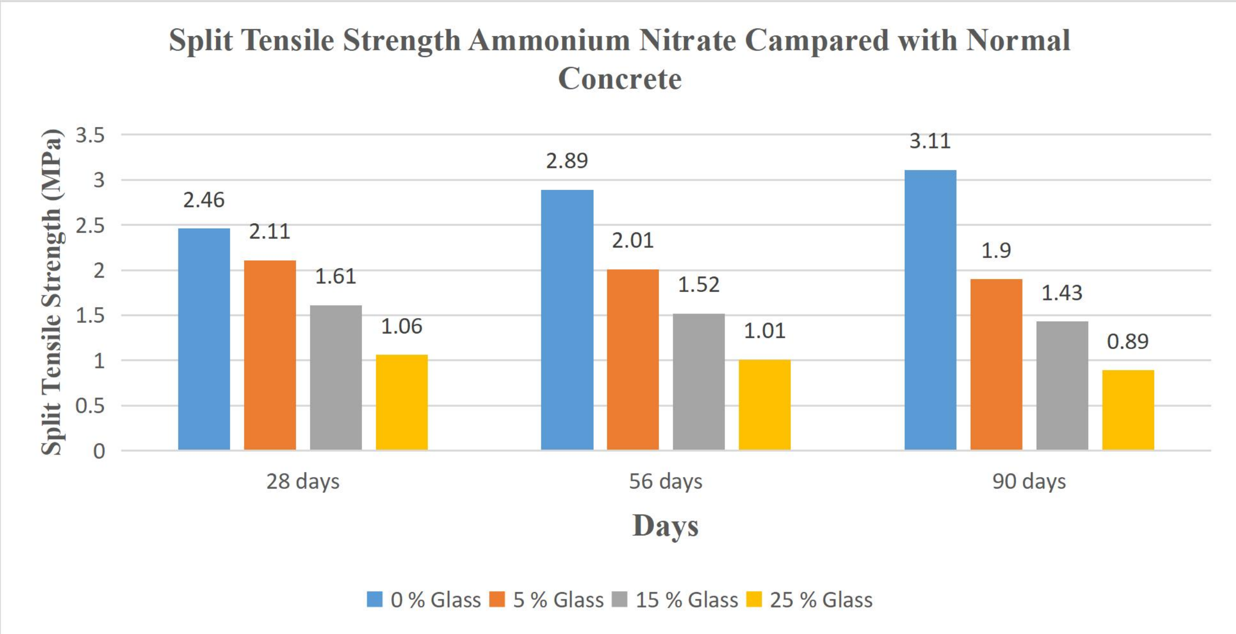


Figure: 16. Split Tensile Strength Ammonium Nitrate

1.4. Maximum Compressive Strength Comparison without Ammonium nitrate and with ammonium nitrate.

Figure 17 shows, at 28, 56, and 90 days, the compressive strength of concrete that has 15% waste glass added as a cement substitute. Ammonium nitrate-containing and non-ammonium nitrate-containing curing conditions were compared. After 28 days, the compressive strength without ammonium nitrate is 25.13 MPa, a considerable increase over the 18.02 MPa recorded during ammonium nitrate curing. Strength without ammonium nitrate rises to 27.19 MPa while strength with ammonium nitrate marginally falls to 17.04 MPa as the curing time reaches 56 days. After ninety days, the sample cured with ammonium nitrate reaches 14.91 MPa, while the sample cured without ammonium nitrate reaches 28.9 MPa. This indicates a significant difference in compressive strength. These findings imply that over time, ammonium nitrate has a detrimental effect on the development of compressive strength in concrete that contains waste glass. The lack of ammonium nitrate tends to result in a more consistent and higher strength development, indicating the possible negative impact of ammonium nitrate on the performance and durability of certain concrete mixtures.

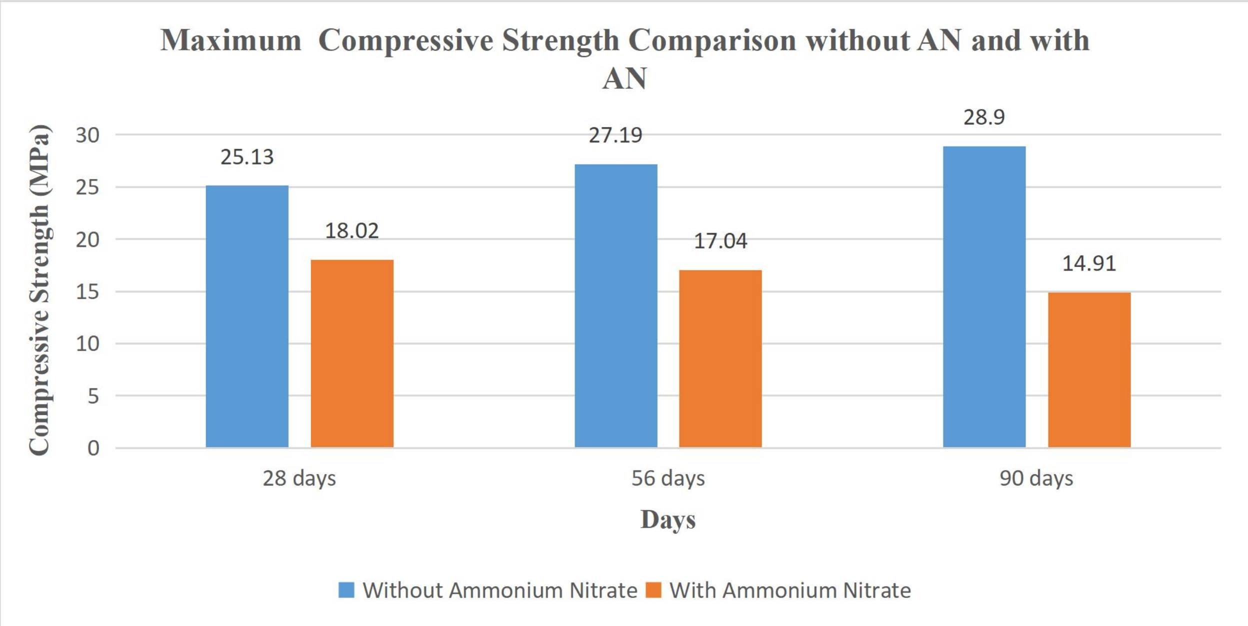


Figure: 17. Compressive Strength Comparison with ammonium nitrate and without Ammonium Nitrate

Maximum Split tensile Strength Comparison without Ammonium nitrate and with ammonium nitrate.

Figure 18 displays the split tensile strength at 28, 56, and 90 days for concrete that contains 15% waste glass as a cement replacement. The two curing conditions are the same: no ammonium nitrate and ammonium nitrate. Without ammonium nitrate, the split tensile strength at 28 days is 3.11 MPa, almost twice as high as the 1.61 MPa noted for concrete cured with ammonium nitrate. The strength without ammonium nitrate rises to 3.37 MPa during the course of the 56-day curing period, while the strength with ammonium nitrate falls to 1.52 MPa. Ninety days later, the split tensile strength without ammonium nitrate still increases to 3.79 MPa, whereas the strength with ammonium nitrate drops even further to 1.43 MPa. These findings show that ammonium nitrate consistently reduces the split tensile strength of concrete containing waste glass. This effect is strong and long-lasting. On the other hand, the tensile strength of concrete that has not been cured with ammonium nitrate keeps becoming better, suggesting that ammonium nitrate might be bad for the structural integrity of these concrete mixtures.

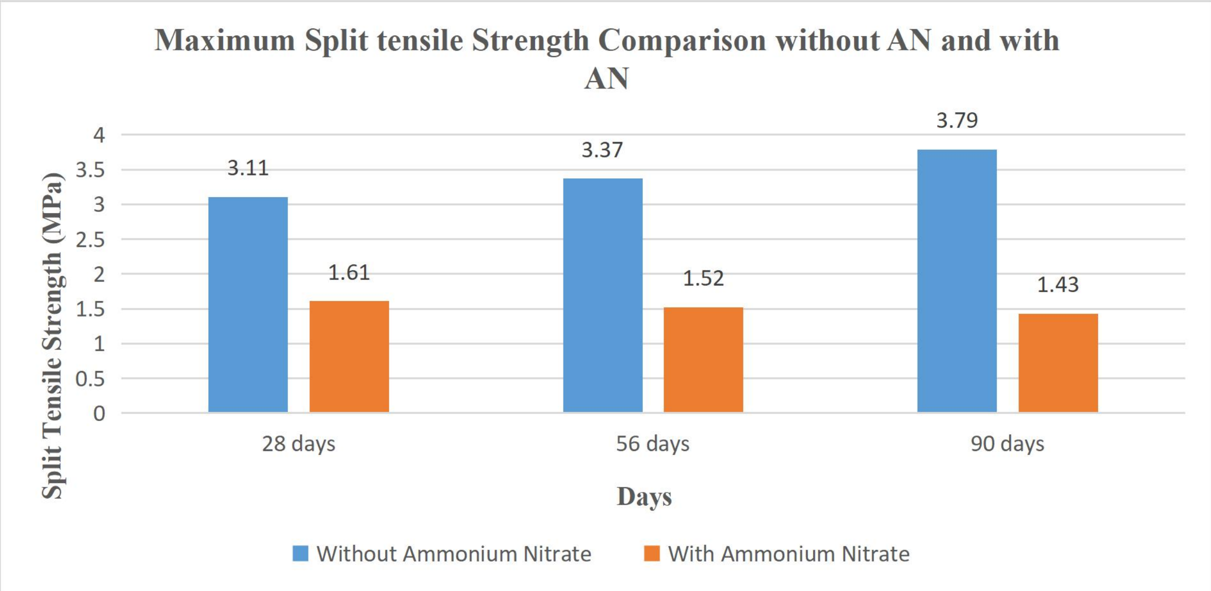


Figure: 18. Split Tensile Strength Comparison with ammonium nitrate and without Ammonium Nitrate

Conclusion

The findings of this study allow for the formulation of several conclusions that advance our understanding of concrete technology and construction techniques. The tensile and compressive properties of concrete are enhanced when discarded glass is substituted for cement. The addition of 5% and 15% waste glass to concrete mixes improves compressive, tensile, and flexural strengths, with 15% showing the most significant enhancements. However, exceeding 15% waste glass content leads to a decrease in strength, making higher concentrations unsuitable for construction. Optimal performance is achieved with 15% waste glass, balancing improved mechanical properties with effective fiber dispersion and bonding.

Ammonium Nitrate has adverse impacts on concrete. The Concrete Cylinders dip in ammonium nitrate has less Compressive and Tensile Strength. Ammonium nitrate can deteriorate concrete over time by reacting with the calcium hydroxide in the cement paste, leading to the formation of calcium nitrate and causing expansion, cracking, and weakening of the concrete structure. Proper handling and storage are essential to prevent such damage. Recycled glass can be used to replace cement in concrete constructions, increasing their lifetime and durability.

In this context, sustainability refers to the recycling of waste materials and the reduction of traditional cement consumption by the partial replacement of cement in concrete with waste glass. Construction companies can reduce their dependency on non-renewable resources and the carbon emissions that come with producing cement by integrating used glass. This methodology fosters the advancement of environmentally conscious and sustainable construction methods in addition to aiding in the efficient management of waste.

Experiments with various % of waste glass as a cement replaced may be used to discover the ideal reinforcing concrete, and they can also help develop standards for practical application. Investigating several surface treatment methods is indicated to improve the bonding of waste glass to the cement matrix. Chemical surface alterations or coatings may increase the inter-facial bonding and improve the mechanical performance of reinforced concrete. It is recommended that concrete structure and buildings should be avoided from ammonium nitrate chemicals because ammonium nitrate hollows the concrete structure.

References

1. Britannica, T. Editors of Encyclopaedia (2024, May 13). glass. Encyclopedia Britannica. https://www.britannica.com/technology/glass.
2. Ibrahim, K. A. (2016). An Investigation of Historical Chemical Industry Ash and Lime Waste, and Local Catchment Chemistry, From Near Northwich in Cheshire, United Kingdom. The University of Manchester (United Kingdom).
3. Del Rio, D. D. F., Sovacool, B. K., Foley, A. M., Griffiths, S., Bazilian, M., Kim, J., & Rooney, D. (2022). Decarbonizing the glass industry: A critical and systematic review of developments, sociotechnical systems and policy options. Renewable and Sustainable Energy Reviews, 155, 111885.
4. Eskilson, S. (2018). The age of glass: A cultural history of glass in modern and contemporary architecture. Bloomsbury Publishing.
5. Spirrett, F. (2021). Investigations into glass additive manufacturing by selective laser melting and directed energy deposition (Doctoral dissertation, University of Nottingham).
6. Richet, P. (2021). A History of Glass Science. Encyclopedia of Glass Science, Technology, History, and Culture, 2, 1413-1440.

7. Sedrick Yeih, N. (2021). Role and Effects of Silica sand on the quality of glass.
8. Berger, G., Raonic, Z., Forthuber, D., Raupenstrauch, H., & Hermann, R. (2022). Energy and Material Flow Evaluation with CO2 Emissions in the Glass Production Process. Advances in Materials Physics and Chemistry, 12(05), 82-105.
9. Gür, T. M. (2022). Carbon dioxide emissions, capture, storage and utilization: Review of materials, processes and technologies. Progress in Energy and Combustion Science, 89, 100965.
10. Adesina, A. (2020). Recent advances in the concrete industry to reduce its carbon dioxide emissions. Environmental Challenges, 1, 100004.
11. Jing, G., Huang, G., & Zhu, W. (2020). An experimental study on water permeability of architectural mortar using waste glass as fine aggregate. Materials, 13(5), 1110.
12. Olsen, J. C., & Direnga, O. G. (1941). Settling rate of calcium carbonate in the causticizing of soda ash. Industrial & Engineering Chemistry, 33(2), 204-218.
13. Shelby, J. E. (2020). Introduction to glass science and technology. Royal society of chemistry.
14. Sunarno, Y., Tjaronge, M. W., & Irmawaty, R. (2020). Preliminary study on early compressive strength of foam concrete using Ordinary Portland Cement (OPC) and Portland Composite Cement (PCC). In IOP Conference Series: Earth and Environmental Science (Vol. 419, No. 1, p. 012033). IOP Publishing.
15. Rahla, K. M., Mateus, R., & Bragança, L. (2019). Comparative sustainability assessment of binary blended concretes using Supplementary Cementitious Materials (SCMs) and Ordinary Portland Cement (OPC). Journal of Cleaner Production, 220, 445-459.
16. Shah, K. D. (2018). Ammonium nitrate--decomposition, fire and explosive behaviour. Loss Prevention Bulletin, 263, 3.
17. Han, Z. (2016). Thermal stability studies of ammonium nitrate (Doctoral dissertation).
18. Lee MJ, Chung YH, Choi HY, Cha HG. Evaluation of subchronic repeated administration toxicity of ammonium nitrate in rats. Toxicol Res. 2019 Dec 2;36(2):115-122. doi:

10.1007/s43188-019-00022-4. PMID: 32257923; PMCID: PMC7099116.
19. Jackson, S. I. (2017). The dependence of Ammonium-Nitrate Fuel-Oil (ANFO) detonation on confinement. Proceedings of the Combustion Institute, 36(2), 2791-2798.
20. Fabin, M., & Jarosz, T. (2021). Improving ANFO: effect of additives and ammonium nitrate morphology on detonation parameters. Materials, 14(19), 5745.
21. Babrauskas, V. (2016). Explosions of ammonium nitrate fertilizer in storage or transportation are preventable accidents. Journal of hazardous materials, 304, 134-149.
22. Pittman, W., Han, Z., Harding, B., Rosas, C., Jiang, J., Pineda, A., & Mannan, M. S. (2014). Lessons to be learned from an analysis of ammonium nitrate disasters in the last 100 years. Journal of hazardous materials, 280, 472-477.
23. Oluwoye, I., Dlugogorski, B. Z., Gore, J., Oskierski, H. C., & Altarawneh, M. (2017). Atmospheric emission of NOx from mining explosives: A critical review. Atmospheric Environment, 167, 81-96.
24. Ashwini, K., Dhanraj, M., & Sivasamy, V. (2020). Knowledge and awareness of the prevalence of ammonium nitrate in water bodies. Drug Invention Today, 14(4).
25. Lee, T. J., & Borgman, M. A. (2022). Toxic Inhalations. In Management of Chest Trauma: A Practical Guide (pp. 367-385). Cham: Springer International Publishing.
26. Jamshidi, A., Kurumisawa, K., Nawa, T., & Igarashi, T. (2016). Performance of pavements incorporating waste glass: The current state of the art. Renewable and Sustainable Energy Reviews, 64, 211-236.
27. Mullett, P. (2022). Challenges to Innovation in Construction. Innovation in Construction: A Practical Guide to Transforming the Construction Industry, 89-115.
28. Zalesski, B. (2023). Time for concrete solutions. Chronicle of international cooperation.
29. Szolomicki, J., & Golasz-Szolomicka, H. (2019). Technological advances and trends in modern high-rise buildings. Buildings, 9(9), 193.

30. Paul, S. C., Šavija, B., & Babafemi, A. J. (2018). A comprehensive review on mechanical and durability properties of cement-based materials containing waste recycled glass. Journal of Cleaner Production, 198, 891-906.
31. Alaraj, M. A. (2018). Effects of waste glass as a partial replacement of coarse aggregate on concrete performance (Master's thesis, Eastern Mediterranean University (EMU)-Doğu Akdeniz Üniversitesi (DAÜ)).
32. Rajadesingu, S., Mendonce, K. C., Palani, N., Monisha, P., Vijayakumar, P., & Ayyadurai, S. (2024). Exploring the potential of bacterial concrete: A sustainable solution for remediation of crack and durability enhancement–A critical review. Construction and Building Materials, 439, 137238.