WORKING WITH CONCRETE MIXTURES

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BOOKS ARCADE

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CONTENTS

CHAPTER 1

FINE AND COARSE AGGREGATE IN CONCRETE WITH RUBBER

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Disposing of damaged and unnecessary worn-out tyres is now one of the biggest environmental issues. Without a doubt, the growing heaps of old tyres raise environmental issues [1]. Recyclable projects are becoming more and more important as garbage builds up and landfill space becomes less and less available [2]. Concrete is commonly utilised to create most buildings, bridges, and other structures across the globe; as a result, it has earned the right to be called the foundation of a country's infrastructure growth. Concrete is made up of a variety of components, including water, coarse aggregate, fine aggregate, or cement as the binder[3]. Concrete use has been rising steadily. As a result, there are fewer natural resources available and no materials that might serve as this perfect material.

So, in order to meet the demands of the industries, People must completely or partly replace all the materials. The most extensively utilised construction material in the world is concrete, which requires 12.6 billion tonnes of natural resources to produce. Concrete's performance may be improved and costs may be decreased if recycled materials like rubber are used in lieu of aggregate as shown in Figure 1. The calcium hypochlorite ($Ca(ClO_2)$) solution produced the greatest results of the surface treatments evaluated to improve the hydrophilicity of the rubber surface. Compared to traditional bituminous mixes, rubberized bituminous layers demonstrated improved skid resistance, less fatigue cracking, or longer design lives. Before being used in concrete, the particles underwent a 72-hour surface treatment with ($Ca(ClO_2)$)-saturated aqueous solutions[4].

Figure 1: Illustrate the waste tire dumping.

Aggregates Made of Crumbed Rubber

CRC, a brand-new material in the building industry, shows promise. The substance, which is made by substituting rubber particles for sand while mixing concrete, promises to drastically lessen certain environmental effects, although structural research on it is still in its infancy. The rubber is between 100 and 230 mm broad and between 300 and 430 mm long. By cutting, its size is changed to 100-150 mm in the second step. If the shredding process is prolonged, particles with diameters ranging from 13 to 76 mm will be created. These particles are referred to as shredded particles. Large rubber sheets are cut into smaller, ripped pieces in special mills to create crumb rubber, which serves as a substitute for sand or cement as shown in Figure 2. Depending on the kind of mills utilized and the temperature created during this process, various sized rubber particles may be produced. A straightforward approach produces particles with a high degree of irregularity in the 0.425–4.75 mm range[5]**.**

Figure 2: Illustrate the Crumbed rubber.

Silica Fumes

Silica fumes are a by-product of making ferro silica alloys or silicon metal. The calcium hydroxide, which is created during Portland cement hydration, is easily reacted with the fumes because they are a highly fine, amorphous, and reactive mineral additive shown in Figure 3. Concrete with silica added has finer pore structure and greater mechanical strength. To enhance the qualities of Portland cement concrete, particularly its compressive strength, bond strength, and abrasion resistance, silica fume is added[6].

Figure 3: Illustrate the Silica fume.

Aggregate Excellence

- The durability of hardened concrete will undoubtedly enhance with the use of high-quality aggregates in the concrete mix.
- The aggregate particles should have a smooth, rounded form. The workability of new concrete is affected by particles that are flaky and lengthy.
- Rough-textured angular aggregates are advised for better ingredient bond formation, although they need more cement.
- To create a thick concrete mix, the aggregate must be properly graded.
- Before utilising, aggregates should have their moisture content checked. A very workable mix might result from aggregate with too much moisture.

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CHAPTER 2

AGGREGATE IN CONCRETE

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One of the most recent wastes to be researched for possible building use is rubber from old tyres. Tires have often been stacked, unlawfully discarded, or landfilled [1]. International research interest in the characteristics and possible applications of rubberized concrete (RC) has progressively increased over the last 20 years. Plastics and rubber in landfills are generally inert materials that take a long time to decompose, taking longer than metals but less time than ceramics. Therefore, research is being done on replacing rubber in concrete partially. In a concrete mix, aggregates are often regarded as inert fillers. However, a deeper inspection indicates that aggregate has a significant impact on the characteristics of both freshly-poured concrete and cured concrete. Changes to your concrete mix's gradation, maximum size, unit weight, and moisture level may all affect its personality and functionality [2].

Another justification for careful aggregate selection is the economy. By picking the largest permissible aggregate size, you may often save money. By lowering the amount of cement needed, the most expensive component, using greater coarse aggregate often decreases the cost of a concrete mix. If the water-to-cement (w/c) ratio is maintained, less cement will result in less water (within safe bounds for durability). Reduced shrinkage and cracking due to controlled volume change are possible with less water content. The key elements to take into account while choosing and adjusting the percentage of concrete aggregate [3].

Utilizing used tyres should have minimal negative effects on the environment and optimise resource preservation. Rubber particles added to cement-based products are one potential remedy for this issue. Hundreds of crumb rubber products may be made using raw materials that can be made from used tyres. The manufacture of aggregate for use in the building also contributes to the ongoing depletion of natural resources, which is another aspect of the issue. Additionally, some nations rely on imported aggregate, which is unquestionably extremely costly. For instance, the Netherlands must import aggregate because it lacks it. This worry fuels a rapidly expanding interest in the adoption of substitute materials that can take the place of natural aggregates. Therefore, the use of recycled waste tyres as an aggregate may provide a solution for two significant issues: the environmental issue caused by waste tyres as well as the depletion of natural resources by the manufacture of aggregates, which has led to a scarcity of natural aggregates in certain countries [4].

According to test findings, rubberized concrete's compressive strength would decrease when more rubber aggregate is added than 5% compared to unrubberized concrete. As the proportion of rubber aggregate grew, this decrease also increased. Compressive strength decreases are seen. The lack of adhesion at the rubber aggregate's borders, which causes the soft rubber particles to act as voids in the concrete matrix, is what causes the drop in strength [5].

- Rubberized concrete had a high capacity for absorbing plastic energy and showed no signs of brittle failure when subjected to compression or split tension stress.
- The results of the splitting tensile strength tests reveal that the compressive strength tests also reveal a drop in strength with increased rubber aggregate content. However, compared to the drop in compressive strength, the splitting tensile strength was reduced less.
- Concrete that contains more leftover tyre crumb rubber is lighter in weight.
- Rubber with a higher to medium workability level is discarded tyre crumb.
- Use of such mixes is advised in locations where high concrete strength is not as necessary since the long-term performance of these mixes is unknown in the field, particularly for pavement portions (e.g. sidewalls).

A sizable market exists for concrete products in which the incorporation of rubber aggregates would be practical and would make use of used rubber tyres, the disposal of which is a significant source of environmental pollution [6].

Examples of Aggregate Proportions

To achieve consistent concrete strength, finish ability, workability, or durability, aggregates must be carefully chosen to be durable, mixed for maximum effectiveness, or managed appropriately.

Advantages

- Temperature resistance.
- Lower expenses since it doesn't need to be mined.
- Less negative environmental effects.
- Less wasteful use of landfill space.
- Less dense.
- Greater impact resistance and durability.

Disadvantages

- If a lot of rubberized aggregates are utilized, the castings' structural integrity will break down, resulting in many flaws and fissures in the construction.
- Lower compressive strength would prevent it from being used in structural applications.
- Lowest high-water absorption. Can't be completely replaced (only partial replacement).

Applications

- Because the specific gravity of the rubber employed was lower than that of the fine particles, replacing some of the fine aggregates in the concrete mix with powdered rubber results in a drop in the density of the finished product.
- Non-load-bearing constructions could use it.

- High-strength rubberized concrete may be used in regions where an acid attack is a possibility.
- Tire disposal pollutes the land and atmosphere. Rubber's use in concrete is thus environmentally benign.

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CHAPTER 3

RUBBER FROM USED TYRES HAS AN IMPACT ON THE DURABILITY AND MECHANICAL QUALITIES OF CONCRETE

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In this experimental investigation, a total of 20 specified concrete mix designs were created, with rubber replacing fine particles to varying degrees (0, 5, 10, 15, and 20%). This research made use of ordinary Portland cement (OPC), which has a specific gravity of 3.15 [1]. The experiment's sand, which had a 1% water absorption rate, came from a nearby source. Crushed angular stone aggregates with a maximum size of 20 mm, a specific gravity of 2.67, and a water absorption rate of 0.5% were used as the coarse aggregate in the experiment [2]. The loss in compressive strength is steady and almost constant with the rise in the % of powdered rubber for design mix strengths between 30 MPa and 50 MPa. In comparison to a rubber replacement of fine aggregates at 5, 10, 15, or 20%, respectively, the compressive strength decrease is on average 30, 35, 50, and 63%. At all rubber percentages, the addition of powdered rubber resulted in a minor increase in the concrete's tensile strength, but this gain is still less than the compressive strength loss rate.

The Impact of Crumb Rubber Powder as a Partial Replacement of Fine Aggregate on Concrete's Mechanical and Durability Properties

When the quantity of crumbed rubber in the concrete increased, the compressive and flexural values steadily decreased. The mixes containing crumb rubber up to 7.5% replacement had a lower level of chloride penetration than the standard mix [3]. Compared to the control mix, the high-strength concrete containing crumb rubber exhibits greater abrasion resistance. Flexural strength was decreased as a result of replacing the rubber aggregates. Grade 43 ordinary Portland cement was used. A local business provided the crumb rubber. After the steel and textile fibres were removed, tyre rubber was crushed into three sizes (powder form of 30 mesh, 2–4 mm, 0.8–2 mm, and 8 to 20 mm) [4]. Concrete mix workability was increased by using a second-generation polycarboxylic ether-polymer based on a superplasticizer. Waste tyre rubber may be used as a partial replacement for fine aggregate up to 12.5% by weight when designing high-strength concrete.

Characteristics of concrete that contains rubber from old tyres

Rubberized concrete also offers several desired qualities including reduced density, stronger impact or toughness resistance, increased ductility, and better sound insulation, which may restrict its usage in some structural applications due to the loss of compressive strength [5]. The qualities mentioned in the previous line may be helpful for a variety of construction applications, including flowable fill used as subbase material and uses for roads and roadways. The features of concrete may be improved by adjusting the particle size, rubber content, type of cement, usage of mineral and chemical admixtures, or pretreatment techniques for rubber particles [6].

Rubber from Used Tyres May Be Used In Lieu Of Gravel and Filler In Concrete

Locally accessible Type II Portland cement (ASTM C 150, Type II) that complied with Iranian standard 389 was used to create a concrete sample. The strength of concrete mixes containing chipped rubber was decreased by curing and mixing with drinking water. Despite a 5% drop in cement content by weight, with a 5% substitution of powder rubber, the compressive strength was lowered by just around 5% in comparison to the control combination. When 7.5 and 10 of the powder rubber were substituted, the strength was decreased by 10 and 23%, respectively. These were mostly brought on by a decrease in the amount of cement in these combinations. The results of this study show that adding 5% by weight of tyre rubber to concrete will not significantly reduce its strength.

Evaluation of the Mechanical and Lasting Qualities of Concrete Including Scrap Tyres

For the concrete mixes in this investigation, regular Portland cement with a specific gravity of 3.12 and silica fume with a specific gravity of 2.18 were both utilised. The silica fume and cement chemical compositions. Fine aggregates were partially replaced with rubber fibres, which had tensile strengths of 22.8 MPa and an elastic modulus of 1.72 MPa. With a specific gravity of 1.07, these rubber fibres had dimensions of up to 20 mm in length and 2e5 mm in breadth (aspect ratio: 4e10). Rubber fibres ranging from 0% to 25% were used to partially replace the fine aggregate in concrete mixtures made using w/c ratios of 0.35, 0.45, and 0.55. In addition, cement was substituted in the rubber fibre concrete and the control concrete, ranging from 0% to 10%, with silica fume. Based on the results of the tests conducted, it can be concluded that the rubber fibres can be used as a partial replacement of sand for a replacement level of up to 10% without significantly reducing strength and durability properties when 10% cement is simultaneously replaced by silica fume. The mixes were first dry-mixed for 2 to 3 minutes in the mixer.

Recycling Of Used Tyre Rubber as Concrete Aggregate

The cement used was regular Portland cement grade 43 (specific gravity 3.15, normal consistency 34%, and initial setting time 99 minutes, final setting time 176 minutes). Concrete was created with a water-cement ratio of 0.3 to test the potential of used tyre rubber as a fine aggregate replacement. Crumb rubber was substituted for natural fine aggregates in multiples of 2.5% from 0% to 20%. The admixture utilised to achieve the requisite workability was a superplasticizer.

For the 28, 56, or 84-day acid attack tests, 15 concrete cubes of the same size were cast in each of these mixtures, along with 6 cubes of the same size for the carbonation and chloride penetration tests. At a temperature of between 25 and 30 °C inside, the mixes were produced and cast. After casting, moulds were covered with plastic sheets and removed from the moulds after 24 hours. Concrete was created following IS: 10262-2010 to research the characteristics of waste tyre rubber in high-strength concrete. Cement, fine aggregates, coarse aggregates, and water are distributed in the following proportions: 1:1.48:2.67:0. Natural sand was substituted with crumb rubber in increments of 2.5% from 0% to 20%. Comparing the control mix concrete specimens to the rubberized concrete specimens, there was a greater loss in compressive strength and weight. In rubberized concrete, only the water absorption displayed higher values.

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CHAPTER 4

IMPACT OF ADDING WASTE RUBBER TO COMPOSITE PORTLAND I CONCRETE

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Concrete waste rubber and regular concrete were used to create composite materials, with the water-to-cement ratio remaining constant. Rubber was used in place of some of the sand (fine aggregate) [1]. Rubber was utilised in weight percentages of 5% or 10%, with a particle diameters of 0.29 mm and 0.59 mm. Untreated and sodium hydroxide-treated scrap rubber was also utilised (NaOH). Rubber was also used in concrete mixtures, which 88% decreased slump values. Comparing the treated rubber to the untreated rubber concrete composite did not result in any appreciable improvements to the composites' compressive strength or splitting tensile strength. The addition of rubber, on the other hand, lowered this variable, with the impact becoming more pronounced as rubber content grew, as seen by the behaviour of the ultrasonic pulse velocity with time [2].

Aggregate Created From Recycled Tyres for Concrete

In this study, natural aggregate (NA) and rubber from old tyres (TA) were both utilised. Crushed gravel or rolled sand, both made from limestone, made up the NA fractions. A reference concrete and mixes with replacement ratios of 5%, 10%, and 15% of the total volume of NA by TA were among the thirteen concrete mixtures created. Concrete mixes were created for each ratio using the replacement of fines alone, coarse only, or fines but also coarse at the same time (in all mixes, NA were replaced by TA of the same size). Replacement of NA (natural aggregate) with TA (rubber from used tyres) has a significant impact on compressive strength, with a drop of around 50% for a replacement ratio of 15%. The replacement ratio of NA by TA causes an increase in concrete shrinkage, however, the variance is less pronounced for coarse aggregate. With the replacement ratio of NA to TA and particularly when the substituted aggregate's particle size grows, water absorption by immersion increases [3].

Aggregates Made From Resurfaced Old Rubber Tyres

Cement, water, fine aggregate, coarse aggregate, and various-sized rubber particles were the ingredients utilised to create the test specimens. A typical Portland cement has a 42.5 MPa characteristic strength. Pulverized fly ash, which was considered in the mix design process, makes up about 30% of this cement. The coarse material utilised was crushed gravel with a nominal maximum size of 10 mm. A portion of the fine aggregate was replaced using three distinct granular samples of old tyre rubber, RA (cut to 3 mm), RB (ground to 0.5 mm), or RC (grounded to 0.3 mm), obtained from a nearby recycling facility without any treatment or impurities.

New Characteristics of Fly Ash-Incorporated Self-Compacting Rubberized Concrete

All of the mixes included regular Portland cement. With a nominal maximum size of 16 mm, river gravel served as the coarse aggregate. A blend of natural river sand as well as crushed limestone with a maximum particle size of 5 mm was employed as fine aggregate [4]. With a constant water-to-cementitious material ratio of 0.35 and a total cementitious material content of 550 kg/m3, four distinct series of SCRC mixes were created. According to the test results for compressive strength, the usage of CR or FA significantly reduced SCRC's compressive strength. Additionally, when CR or FA concentration rose, the rate at which compressive strength decreased did as well.

Silica Fume-Containing High-Strength Rubberized Concrete for Building Long-Lasting Roadside Barriers

To lessen injuries and deaths during collisions, this study gives strength and durability test findings for rubberized concrete that incorporates silica fume (micro silica) for roadside barriers [5]. The testing procedure involves creating concretes with normal and high strengths from recycled scrap tyre rubber. 10%, 20%, 30%, and 40% of the weight of the fine mineral aggregate were replaced with tire-rubber particles made of a mixture of crumb rubber or fine rubber powder. The increased potential for segregation or bleeding is one of the key problems associated with the inclusion of chipped or crumb rubber aggregate. To get around the issue, the typical mixing process has undergone several unexpected changes [6].

According to some studies, water should be added gradually after all dry mix components have been well mixed for between one minute and five minutes, together with any necessary superplasticizer or SBR (styrene butadiene rubber) admixtures. Others have discovered that putting the rubber with sulphuric acid may enhance the modulus of elasticity for rubberized concrete (H_2SO_4). Before adding the rubber to the concrete mix, the rubber aggregate may be pre-coated with cement paste and allowed to solidify. This can boost compressive strength by 30% to 50%, with minor gains in flexural strength as well.

Properties of Concrete Made With Homogeneous and Varying-Sized Waste Tyre Rubber Particles

Here, the impact of tyre rubber particles on the mechanical and fracture characteristics of concrete of normal strength was examined. The coarse and fine aggregates were swapped out for pieces of chipped and crumbed tyre rubber, respectively. The replacement levels for the coarse and fine aggregates were 25, 50.00, 75, and 100% by volume. The tyre rubbers were broken into two sizes, measuring 5 to 10 mm and 10 to 20 mm, respectively. The two different-sized pieces of chipped tyre rubber were combined in a 1:1 ratio. The size of the crushed tyre rubber fragments varied from 1 to 5 mm. Crushed stone that complied with aggregate specifications made up the coarse aggregate (ASTM 2003). Instead of focusing on the deterioration of the link between the tyre particles and the cement paste, the examination of the mechanical characteristics included assessing the compressive strength at 7 and 28 days as well as the impact strength at 28 days of age. It also becomes clear that the tyre rubber particles provide additional energy-consuming toughening processes in the concrete, such as particle pull-out and rubber internal cracking that are not present in regular concrete.

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CHAPTER 5

ORDINARY PORTLAND CEMENT

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Hydraulic cement is used to make regular Portland cement. It is used to create concrete that can set and harden when its chemical qualities interact with water [1]. A tiny quantity of gypsum is added to the clinker and the combination is finely crushed to create the final cement powder since OPC does not dissolve in water as it sets and hardens to obtain the necessary setting properties in the end product [2]. This project makes use of OPC grade 53. Sand that is virtually riverbed pure and easily accessible locally is utilised as fine aggregate [3]. The sand particles pack to provide a minimal void ratio; a larger void content necessitates more water mixing. It is necessary to evaluate properties like void ratio, gradation-specific surface, and bulk density with the ideal cement content and minimal mixing water.

Coarse Aggregate

Concrete's coarse aggregate is a chemically stable component. The drying shrinkage as well as other dimensional changes brought on by moisture transport are lessened by the presence of coarse aggregate. The coarse aggregate used in traditional concrete leads to the cement concrete's heterogeneity, and the cement mix's interaction with the aggregate surface is weak. By limiting the maximum size of the aggregate, the cement becomes more uniform, and the strength and durability attributes of the concrete are significantly improved [4].

Crumb Rubber

Crumb Rubber is a rubber that has been mechanically or cryogenically processed into tiny granular or powdered particles [5]. During this procedure, the steel and fabric parts of the tyres are also taken out. Particles in crumb rubber range in size from 4.75mm to less than 0.075mm. There are typically three ways to turn discarded tyres into crumb rubber. Methods include:

- Process of a cracker mill.
- The granular procedure
- Micromilling technique.

People may produce particles with diameters ranging from 5 mm to 0.5 mm using the cracker mill method, which is also referred to as ground crumb rubber. We may conduct a granular procedure by obtaining particles of a size between 9.5mm and 0.5mm. Two sizes of tyre rubber were graded and utilised in the experiment. When doing a partial replacement, crumble rubber is utilised. The employed crumb rubber is 20 meshes in size. Rubber crumb has a specific gravity of 1.15.

The biggest problem facing industrialised and emerging nations today is waste materials produced by diverse physical and chemical processes. To reduce environmental harm, extensive waste recycling research is being carried out. Construction researchers have made strides in the use of these waste resources, much like other recycling and manufacturing sectors [6].

Used tyres from automobiles release one of the non-recyclable elements into the environment. Investigations have shown that old tyres are made of substances that are seriously contaminating and do not break down in the environment.

The compressive strength of concrete may be dramatically reduced if the fine aggregate is replaced with rubber particles due to localised stresses and bonding issues between the rubber particles and cement mixture. It is possible to handle used tyres as complete tyres, silt tyres, shredded tyres, ground tyres, or crumb rubber products. In this project, crumb rubber is utilised to replace some of the aggregates.

Concrete is a Versatile and Composite Substance

The steel industry produces ground-granulated blast furnaces (GGBS) as a byproduct. To move a vehicle's weight from the axle through the wheel to the ground, a rubber tyre is utilised. Additionally, it offers a flexible cushion that cushions shock when the tyre rolls over uneven surface characteristics.

The examination of recycled tyre rubber's possible usage in the concrete mixture is the focus of the current effort. It could make it easier to build concrete with less of an effect on the environment. As a result, differences in the concrete containing rubber material's values for compression strength, tensile strength, flexural strength, and durability may occur. Curing is the process of keeping newly cast concrete at a certain temperature and moisture content for a predetermined amount of time.

Because the specific gravity of the rubber employed was lower than that of the fine particles, partial substitution of the fine aggregates in the concrete mix with powdered rubber results in a drop in the density of the finished product. The modulus of elasticity is negatively impacted by the inclusion of rubber powder in the concrete mixture. The reduction in elasticity represents rubberized concrete's capacity to respond elastically to tension loads, which enhances how ordinary concrete fails.

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CHAPTER 6

FUTURE PROSPECT OF REPLACEMENT OF FINE AND COARSE AGGREGATE IN CONCRETE WITH RUBBER

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Waste rubber tyres have little potential for recycling and mostly wind up in landfills, which harms the environment. Rubber has a lot of potential for usage in concrete, which would save landfill waste and be environmentally benign [1]. Rubber is inexpensive compared to other components of concrete and is readily accessible in the form of old tyres. Therefore, if it is employed, the concrete will be more affordable. Comparing rubber to the natural rock particles used in traditional normal concrete, rubber is more flexible and lighter per unit [2]. Rubberized concrete will thus be highly beneficial in locations where more flexibility is needed. Rubberized concrete may further be used to make lightweight concrete [3]. A reduction in compressive strength and weight, an improvement in ductility, flexibility, impact and toughness resistance, as well as improved and better sound insulation, are the main findings of all past studies on this subject. However, the usage of untreated rubber is what led to these outcomes. The treated rubber that is being incorporated into the concrete has received very little attention [4].

Workability

The workability of rubberized concrete, whether treated or untreated, is shown to be worse than that of plain concrete and declines as the number of aggregate replacements rises [5]. The low workability of rubberized concrete (untreated) is a result of defective bonding and rubber aggregates that restrict the flow of concrete paste and natural aggregates. When NaOH treatment improves bonding, the rise in viscosity causes a reduction in workability. Workability reduces when rubber is treated with cement paste because cement particles stick to rubber particles, absorbing water from the concrete and reducing the amount of water available to provide workability [6].

Compression Power

NTR-10 is determined to have the strongest 7-day compressive strength of all the substituted mixes, however, it is still less than plain concrete. However, in this instance, ordinary concrete's 92.62% compressive strength is recovered, which is pretty excellent given the material utilised. The compressive strength after 28 days is also determined to be maximum for NTR-10 but again lower than regular concrete. It accounts for 92.57% of the standard normal concrete's compressive strength, which is regarded as adequate. When compared to NTR-10 or plain concrete, the compressive strengths of untreated as well as cement-treated rubberized concrete are shown to be much lower. Less compressive strength may be ascribed to large elastic module differences, poor bonding and limited adhesion between concrete ingredients and untreated rubber particles. Additionally, because of the low strength of the rubber particles compared to the surrounding concrete matrix, when force is applied, fractures initially occur in the area where the rubber or concrete matrix is in touch.

Flexural Strength

In the current investigation, there is a fluctuating pattern in flexural strength. NTR-5 is determined to have the greatest 28-day flexural strength of all replacement mixes and regular concrete. The flexure strength of untreated rubber concrete decreased, but the trend for treated rubber exhibited variation. The maximum flexural strength for treated rubberized concretes is equivalent to a 5% replacement level, while the lowest flexural strength is equivalent to a 15% replacement. When treated rubber replaces 5% of the usual conventional concrete, the strength improvement is determined to be around 13%. Less cement is used in combinations to make them less rigid. Less rigid specimens with rubber aggregates may sustain further stress after cracking because the rubber aggregates can bridge fractures brought on by a flexural force. The flexural strength is thereby increased by treated rubber aggregate content, but only up to a replacement range of 5%.

Tensile Strength in Splits

In every situation where treated rubber is employed, split tensile strength is found to be higher after 28 days, and it is shown to be maximum at NTR-15 (sodium hydroxide treated with 15% replacement). The split tensile strength is 2.67 times stronger than the strength of typical concrete at this replacement level, which is quite significant and promising. This increase in split tensile strength after treating rubber is caused by a synergistic interaction between the treatment's increased bonding and the concrete's acquired flexibility owing to the rubber particle.

- Rubber has a strong chance of joining the concrete family permanently because of its many good qualities, including greater flexibility, low weight, and ease of supply. Utilizing this trash in the building business may be highly environmentally beneficial.
- When compared to untreated rubberized concrete, treated rubberized concrete has greater compressive strength. However, only 92.57% of the compressive strength of typical conventional concrete is recovered, even after the rubber has had a surface treatment.
- Almost all replacement levels of treated rubberized concrete are found to have greater flexural and split tensile strengths than standard conventional concretes. The NTRs 5 and 15 are determined to have the greatest day flexural and split tensile strengths, respectively.
- This research sought to ascertain if the fundamental qualities of concrete might be improved by the use of waste products like used tyres. The information provided in this study demonstrates the significant potential for using tyres as aggregates. As used tyres may be used to replace more costly materials like rock aggregate, it is thought that they would provide far larger prospects for value addition and cost recovery.
- The workability of the final mix is decreased when rubber aggregates are used, however, this issue may be solved by using certain plasticizers.

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CHAPTER 7

INTRODUCTION TO CONCRETE

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A composite material that is essentially made of a limiting medium, such Portland concrete and water, with inserted particles or fragments of total within that are often a mixture of fine and coarse total [1]. The most adaptable and frequently used construction material worldwide is concrete. Contrary to other building materials like regular stone or steel, which often must be used as they are, it tends to be developed to meet a wide range of execution details. Since cement's stiffness is significantly lower than its compressive strength, supported concrete is often constructed using steel reinforcement bars [2]. The only significant building material that can be transported in a plastic condition to the job site is concrete. Due to its unusual ability to be molded into almost any form or shape, concrete is a desired building material [3]. Additionally, concrete is made to enable dependable, high-quality, expedited building. Concrete structures are stronger and may be designed to resist storms and earthquakes. Pavements, architectural constructions, foundations, motorways, bridges, multi-story parking buildings, walls, footings for gates and fences, even boats, are all made of concrete. Its greatest benefit is that it ties together bricks & stones more effectively than any other method now used by humans.

Fine and coarse aggregate are combined to form concrete, a composite material, which is then joined by a fluid cement (cement paste) that eventually solidifies (cure). Concrete is the most often used building material and the second most utilized substance in the planet after water. It is used more than twice as much globally than steel, wood, polymers, and aluminum combined. By 2025, it is anticipated that the ready-mix concrete market, the largest section of the global concrete market, would generate more than $600 billion in sales. This broad use has a variety of negative effects on the ecosystem. The manufacture of cement, in particular, generates a significant amount of greenhouse gases, accounting for 8% of all emissions globally [4]. Fine and coarse aggregate are combined to form concrete, a composite material, which is then joined by a fluid cement (cement paste) that eventually solidifies (cure). Concrete is the most often used building material and the second most utilised substance in the planet after water. It is used more than twice as much globally than steel, wood, polymers, and aluminium combined. By 2025, it is anticipated that the ready-mix concrete market, the largest section of the global concrete market, would generate more than $600 billion in sales. This broad use has a variety of negative effects on the ecosystem. The manufacture of cement, in particular, generates a significant amount of greenhouse gases, accounting for 8% of all emissions globally. When dry Portland cement, aggregate, and water are combined, the result is a fluid slurry that is simple to pour and shape. Through a process known as concrete hydration, the cement interacts with the water to create a tough substance that resembles stone and has a variety of purposes [5]. The hardening process takes several hours. Concrete may now be prepared in a number of tooled methods in addition to being cast in forms [6].

When making Portland cement concrete in the past, lime-based cement binders like lime putty were frequently used with other hydraulic cements (water-resistant cements), including a calcium aluminate cement (named for its visual resemblance to Portland stone). There are several more non-cementitious varieties of concrete that utilise other techniques to bind the aggregates together. Examples include asphalt concrete, which uses bitumen as a binder and is frequently employed for road surfaces, and polymer concretes, which use polymers as a binder. Mortar differs from concrete. While mortar serves as a binding agent to hold bricks, tiles, as well as other masonry units together, concrete is a construction material in and of itself. Concrete can be distinguished by the type of cement or aggregate used, by the characteristics it exhibits, or by the techniques employed to make it. In typical structural concrete, the ratio of cement to water greatly influences the concrete's characteristics. All other factors being equal, stronger concrete results from reduced water content. Just enough water must be added to the mixture to ensure that the cement paste fully surrounds each aggregate particle, fills any gaps between the aggregate, and makes the concrete liquid sufficient to be poured and distributed efficiently.

The force required to crush a sample of a specific age or hardness is used to determine the strength of concrete, which is expressed in pounds per square inch or kilograms per square centimeter. Environmental elements, particularly temperature and moisture, have an impact on the strength of concrete. It may encounter uneven tensile stresses if it is let to cure too quickly, and these pressures cannot be withstood in an imperfectly formed form. The concrete is kept moist for a while after it has been poured as part of the curing process to reduce shrinkage that happens when it hardens.. Its strength is likewise negatively impacted by low temperatures. An addition, such calcium chloride, is added to the cement to make up for this. As a result, the setting process proceeds more quickly, producing heat that can combat fairly low temperatures. Ice-cold temperatures are not used to pour concrete into large forms that can't be fully covered.

Ferroconcrete, often known as reinforced concrete, is concrete that is hardened over embedded metal (typically steel). Its creation is typically credited to Parisian gardener Joseph Moniker, who in 1867 was granted a patent and produced concrete garden tubs and pots reinforced with iron mesh. Tensile strength is contributed by the reinforcement steel, which might be in the style of rods, bars, or mesh. Plain concrete is not suited for many structural purposes because it cannot readily handle stresses like wind action, earthquakes, vibrations, and other bending force. Because of the tensile strength of the steel and the compression strength of the concrete, a part made of reinforced concrete is able to withstand significant lengths of time under tremendous strains of various types. The steel can be positioned at or close to the location where the maximum stress is predicted because to the flexibility of the concrete mix. Using prestressed concrete in masonry building is another breakthrough. Either pretensioning or posttensioning procedures are used to achieve it. Pretensioning involves laying lengths of steel wire, cables, or ropes within an empty mould before stretching and anchoring them. The anchors are released once the concrete has been poured and given time to cure, and when the steel tries to stretch back to its original length, it presses the concrete.

The steel is fed through ducts cut out of the concrete during the posttensioning procedure. When the concrete has dried, a gripping mechanism is used to secure the steel to the member's exterior. The amount of stress that is communicated to the concrete may be precisely controlled by exerting a certain amount of stretching stress on the steel. By compressing a part to the point where no tension is felt until the strength of the squashed section is overcome, restressed concrete neutralises the stretching forces that would rupture regular concrete. It has been effectively employed to produce lighter, cheaper, and more attractive structures like bridges and expansive roofs because it delivers strength without requiring cumbersome steel reinforcing. Concrete has become one of the most widely used building materials around the world due to its capacity to be extremely strong and its initial adaptability to almost any form.

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CHAPTER 8

HISTORY OF CONCRETE MATERIAL

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Depending on how one defines "concrete," one may determine when it was initially created. Rudimentary cements produced by crushing & burning gypsum or limestone are worn by historical materials. Lime also includes burnt and crushed limestone [1]. These cements created mortar, a plaster-like substance used to cement stones together, when sand and moisture were added to them. These elements were enhanced over thousands of years, blended with other materials, and eventually evolved into contemporary concrete [2]. Around 1300 BC, Middle Eastern architects and builders discovered that when they covered the exteriors of their pounded-clay fortifications and residential walls with a thin, moist layer of burnt limestone. It created a hard, impenetrable surface by chemical reactions with airborne gases. Although it wasn't concrete, this represented cement's early stages of development. When constructing with stone, early cementitious composite for mortar often contained crushed, burnt limestone, sand, and water. Around 6500 BC, Nabataean traders who controlled a number of oasis and established a big nation in the areas of southern Syria and northern Jordan created the first constructions that resembled concrete [3].

By 700 BC, they had built kilns to produce mortar for the creation of rubble-wall homes, concrete floors, and beneath watertight cisterns after learning about the advantages of hydraulic lime, or cement that hardens underwater. The Nabataea were able to survive in the desert in part because of the cisterns, which were kept a secret. There are two significant differences between modern construction concrete and older concrete. First, because the mix is fluid and uniform, it may be pumped into forms instead than needing to be hand-layered with the aggregate, which in Roman practice was frequently made of rubble. While older concrete could only rely on the power of the concrete bond to resist stress, newer concrete assemblies have significant strength in tension because to second integrated reinforcing steel [4]. Incidents of Travel in the Yucatán by John L. Stephens makes reference to Mayan concrete at the remains of Uxmal (850-925 A.D.). "The roof was coated with cement and is flat." The flooring were made of cement, which was in some places firm but has now broken down due to prolonged exposure. But the entire wall was sturdy and made of huge stones embedded in mortar, which was nearly as hard as rock. The Nabatean merchants, who from the fourth century BC held and controlled a number of oasis and established a tiny empire in the areas of southern Syria and northern Jordan, were the first to produce concrete-like materials on a modest scale. By 700 BC, they had learned about the benefits of hydraulic lime, which had some self-cementing abilities [5].

Construction workers learned that adding volcanic ash to the mixture made it possible for cement to set underwater during the Ancient Egyptian and later Roman eras. In the royal palace of Tiryns, Greece, which was built about 1400 and 1200 BC, concrete floors were discovered. In 800 BC, Cyprus, Crete, and Greece all utilised lime mortars. Concrete that was waterproof was used to build the Assyrian Jerwan Aqueduct (688 BC). Numerous ancient constructions were built with concrete to between 300 BC and 476 AD, the Romans made widespread use of concrete. Roman concrete, also known as opus caementicium, was created as during Roman Empire using quicklime, pozzolana, and a pumice aggregate. The Roman architectural revolution, a pivotal moment in the evolution of architecture, was made possible by its widespread application in several Roman constructions [6].

The Romans were the first to make use of concrete, which was a brand-new material. It immediately solidified into a stiff mass, free from a lot of the internal thrusts & stresses that disturbed the builders of similar buildings in stone or brick. It was laid out in the shape of arches, vaults, and domes. According to contemporary testing, opus cementicium had a compressive strength of around 200kg/cm2 [20 MPa; 2,800 psi]—the same as contemporary Portland-cement concrete. However, because there was no reinforcement, it had far lower tensile strength than contemporary concrete blocks, and it was used differently: Roman structural concrete varies from modern structural concrete in two key ways. First, because the mix is fluid and uniform, it may be poured form forms rather than needing to be hand-layered with the aggregate, which in Roman practice was frequently made of rubble. Second, while Roman concrete could only rely on the strength of the concrete joining to resist stress, modern concrete assemblies have significant strength in tension because to inherent reinforcing steel. The use of pyroclastic (volcanic) sandstone and ash, whereby the crystallisation of strätlingite (a specific and complex oxalate alumino - silicate hydrate), and the coalescence of this and similar calcium-aluminum-silicate-hydrate cementing binders, helped give the concrete a greater degree of microhardness even in seismically active environments, has been found to be responsible for the long-term reliability of Roman concrete structures. Roman concrete employed pyroclastic ingredients, which over time react with seawater to generate Al-tobermorite crystals, making it substantially more resilient to erosion by saltwater than modern concrete.

Many Roman constructions have survived to the modern day thanks to the widespread usage of concrete in such structures. One such is the Caracalla Baths in Rome. Numerous Roman aqueducts and bridges, including the renowned Pont du Gard in southern France and the dome of the Pantheon, have masonry veneer atop a concrete core. Concrete use declined with the fall of the Roman Empire until it was revived in the middle of the eighteenth century. In terms of material utilised globally, concrete has surpassed steel in tonnage. After the fall of the Roman Empire, pozzolana and burnt lime usage significantly decreased. Poor mixing, a shortage of pozzolana, and low kiln temperatures while burning lime all led to a deterioration in the calibre of the mortar and concrete. Mortar demand surged starting in the 11th century as a result of the greater use of stone in the construction of churches and castles. The 12th century saw the beginning of quality improvement due to greater grinding and sifting. Non-hydraulic lime binders and concretes were employed in the Middle Ages to bond masonry, "heart" (join masonry cores made of rubble), and lay foundations. The creation of mortar is described by Bartholomew Anglicus in work De proprietatibusrerum (1240) in a 1397 English translation.

Smeaton's Tower, which was constructed in Devon, England, between 1756 and 1759 by British engineer John Smeaton, is perhaps the biggest advancement in the contemporary usage of concrete. This third Eddystone Lighthouse, which used pebbles and powder brick as aggregate, was a pioneer in the use of hydraulic lime in concrete. Joseph Aspdin created and patented a process for making Portland cement in England in 1824. Due to its resemblance to Portland stone, which was produced here on Isle of Portland in Dorset, England, Aspdin adopted this name. William, who carried on the work until the 1840s, was credited with creating "modern" Portland cement. Joe Monier created reinforced concrete in 1849. And François Coignet constructed the first home made of reinforced concrete in 1853.

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CHAPTER 9

COMPOSITION OF CONCRETE

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A cementitious binder matrix (usually Portland cement paste or asphalt) and a dispersed phase or "filler" of sand make up the artificial composite material known as concrete (typically a rocky material, loose stones, and sand). To create a synthetic conglomerate, the binder "glues" the filler together [1]. The formulas of the binders and the types of material used to fit the purpose of the engineered material result in a wide variety of concrete types [2]. The final product's strength, density, chemical and heat resistance are all determined by these factors. Admixtures are used to change the therapeutic efficacy or the material's characteristics. As concrete additives, mineral admixtures utilise recycled resources [3]. Fly ash, a by-product of coal-fired power stations, is visible, as is crushed blast furnace granulated slag, a by-product of steelmaking, and silica fume, a by-product of industrial gas tungsten arc furnaces because Portland cement concrete may be manufactured with great compressive strength but always has lower tensile strength, structures that use it generally incorporate steel reinforcement. As a result, it is frequently reinforced using materials that are strong under tension, such as steel rebar [4]. The mix design is determined by the type of building being built, how the concrete is mixed and supplied, and how the structure is built. There are several varieties of concrete that may be identified by the ratios of the primary components below. The resulting product can be modified in this fashion or by changing the cementitious and aggregate phases to suit the application in terms of strength, density, chemical resistance, and heat resistance.

Cement

Portland cement is the most widely used form of cement. It is a fundamental component in concrete, mortar, and also many plasters. In 1824, British construction worker Joseph Aspdin invented Portland cement. It was called after the hue of Portland limestone, which is produced on the English Isle of Portland and often utilised in London architecture. It is made up of calcium silicate minerals (alite, belite), aluminates, and ferrites compounds that combine calcium, silicon, aluminium, and iron in water-reactive forms. Portland cement and comparable materials are created by burning limestone (a calcium source) with clay or shale (a silicon, aluminium, and iron source) and grinding the finished product (called clinker) with such a sulphate source (most commonly gypsum) [5].

Many innovative features are employed in current cement kilns to reduce fuel usage per tonne of clinker produced. Cement kilns are highly huge, complicated, and dusty industrial operations with emissions that must be managed. Cement is the most energy-intensive of the several components required to manufacture a particular quantity of concrete. Even the most sophisticated and efficient kilns take 3.3 to 3.6 gigatonnes of energy to make a tonne of clinker and then crush it into cement. Many kilns may be powered by complicated wastes, the most frequent of which being old tyres. Cement kilns can effectively and fully burn even difficult-to-use fuels due to their extremely high temperatures and lengthy time periods at those temperatures. There are several types of cement. Portland cement, a hydraulic cement that sets and hardens by chemical interaction with water and therefore is capable of doing so under water, is the most widely used in concrete. Cement is the "Glue" that holds the structure together. It holds the concrete materials together and contributes to the composite's strength.

Water

Hydration occurs when water and a cementitious substance are combined to generate a cement paste. The cement paste holds the aggregate down, fills cavities, and allows it to flow more freely. According to Abrams' law, a lower water-to-cement ratio results in a stronger, more durable concrete, while the more water results in a freer-flowing, higher-slump concrete. Impure water used in the production of concrete might create issues during setting or early breakdown of the construction. Portland cement is made up of five primary calcium silicates and aluminates that range in weight from 5 to 50% and all undergo hydration to add to the final material's strength. As a result, the cement hydration process includes several processes, many of which occur concurrently. The results of the hydration of the cement gradually link together and the particular sand and sand particles or other components of concrete to create a cohesive mass as the reactions progress [6].

Aggregates

The majority of a concrete mixture is made up of fine and coarse particles. Sand, natural gravel, and stone dust are the most often utilised materials for this purpose. Recycled aggregates (from building, demolition, and excavation debris) are increasingly being utilised as partial replacements for bottom ash, while air-cooled blast furnace slag and bottom ash are also authorised. The amount of binder required is determined on the size distribution of the aggregate. The largest gaps are seen in aggregate with a relatively equal size distribution, but adding aggregate with tiny ones tends to fill such gaps. The binder, which must fill the spaces between the gravel as well as paste the aggregate surfaces together, is usually the most costly component. As a result, variation in aggregate size decreases the cost producing concrete. Because aggregate is almost always stronger than binder, its usage has no detrimental impact on the strength of a concrete. Because of the impact of vibration, aggregate redistribution following compaction frequently results in non-homogeneity. This may result in strength gradients. Beautiful stones like quartzite, tiny river stones, or broken glass are occasionally put to the surface of concrete to create a decorative "exposed aggregate" appearance that is popular amid landscape designers. Sand, gravel, crushed stones, or iron-blast furnace slag are examples of aggregates. It is graded by passing through a series of sieves with decreasing mesh sizes. Because aggregates make up 75% or more of the concrete volume, their qualities greatly influence the the concrete's properties. For excellent quality concrete, the aggregates must be strong and durable, as well as devoid of silts, organic waste, and oils.

Reinforcements

Concrete is frequently reinforced with steel bars because to its poor tensile strength. These bars are manufactured in regular sizes. The majority of concrete used in building is a reinforced concrete mixture of concrete and reinforcement. Concrete reinforcement is accomplished by inserting deformed metal bars or wire mesh fabric inside newly cast concrete. The goal of reinforcing is to give strength to concrete when it is required. Steel provides all of the tensile strength when concrete is under tension, such as in beams and slabs. It complements the concrete's compressive force in walls and columns and it adds shear strength to concrete in beams. Reinforced concrete is concrete in which steel is inserted in such a way that the two elements resist pressures together. In a concrete construction, reinforcing steel rods, rods, or fabric tensile, shear, and occasionally compressive stresses. Plain concrete is inappropriate for most structural purposes because it cannot handle tensile and shear stresses induced by wind, earthquake, vibrations, and other forces.

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CHAPTER 10

ROLE OF ADMIXTURES IN CONCRETE

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Admixtures are ingredients in the form of powdered substances or fluids that are added to concrete to give it properties that simple concrete mixes do not have. Admixtures are described as additives added while the concrete mix is being manufactured. Retarders and accelerators are the most prevalent admixtures [1]. Admixture doses are typically less than 5% by cement mass and are applied to the concrete during the batching/mixing process. Below-ground production The following are examples of frequent admixtures [2]. Accelerators accelerate the hydration (hardening) process of concrete. Calcium chloride, calcium nitrate, and sodium nitrate are common materials. However, because the use of chlorides can cause corrosion in steel reinforcement and is outlawed in some countries, nitrates may be preferred, although being less efficient than the chloride salt [3]. Accelerating admixtures are particularly beneficial for changing concrete characteristics in cold weather. Air entraining agents introduce and entrain microscopic air bubbles into the concrete, reducing damage during thaw cycles and enhancing durability. However, entrained air comes at a cost in terms of strength, since each 1% of air can reduce compressive by 5%. To reduce permeability, crystalline admixtures are often applied during the batching of the concrete. When immersed in water and un-hydrated cement particles, the reaction produces insoluble needle-shaped crystals that fill capillary holes and micro-cracks in the concrete, blocking paths for water and waterborne contaminants [4].

Concrete with admixtures should self-seal since frequent contact to water will induce crystallization, ensuring permanent waterproof protection.] For aesthetic purposes, pigments may be employed to modify the color of concrete. Plasticizers make plastic, or "fresh," concrete more workable, allowing it to be laid more simply and with less consolidation effort. Pumping aids enhance pump ability by thickening the paste and reducing separation and bleeding. Retarders delay the hydration of concrete and are utilized in big or difficult pours where incomplete setting prior to completion is undesirable. Sugar, sucrose, sodium gluconate, fructose, citric acid, and oxalate are examples of polyol retarders [5].

Chemical Admixtures

Admixtures are materials other than cement, aggregates, and water that are added to concrete before or during mixing to change its qualities and performance in both the fresh (workability, setting time, and so on) and hardened states (strength, durability etc.) Concrete admixtures are roughly classified into two types: chemical admixtures and mineral admixtures. Chemical admixtures are used to modify the properties of concrete such as temperature of hydration, accelerating or delaying the setting time, improving workability, assisting in water reduction, dispersing/deflocculating the cement particles, assisting in air entrainment, and finally improving impermeability and durability. These are combined to produce a variety of qualities. These additives can speed up or slow down the pace at which the polymer hardens, as well as impart many other important features like as greater tensile strength, air and water resistance [1].

Mineral admixtures

Mineral admixtures (fly ash, silica fume (SF), and slags) are typically added in increasing proportions to concrete to increase workability, resistance to thermal cracking, alkali-aggregate expansion, and sulphate attack, and to allow for a reduction in cement content. Mineral admixtures are derived from other substances rather than being created chemically. Fly ash, blast furnace slag, and superplasticizer are examples of mineral admixtures. They play a variety of roles in the cementitious material and enhance the various properties of the concrete. Almost never build anything without utilizing concrete additives on the building site to improve the quality. Pozzolanic or mineral admixtures have been used in concrete from the beginning of time. Mineral admixtures influence the properties of both new and cured concrete. Mineral admixtures are also referred to as concrete additions or additional cementing ingredients. Cementitious elements include natural pozzolanic materials (such as the volcanic ash used during Roman concrete), fly ash, and silica fumes. They can be used alone or in combination with Portland or mixed cement. Mineral admixtures are mostly sourced from other substances rather than being chemically synthesized [6]. Mineral admixtures include silica fume, fly ash, blast furnace slag, and others. Mineral admixtures serve diverse roles in the concrete mix and improve various qualities of the concrete.

Mineral admixtures such as silica fume, metakolin, and fly ash, on the one hand, and superplasticizer on the other, are employed in conjunction with standard constituents. The addition of mineral admixtures to concrete improves its strength, durability, workability, and economy. They operate as pozzolanic materials and as micro fillers, making the hardened concrete's microstructure denser and stronger. Because superplasticizers are surfactants, they help to disperse cement particles in the mix and so improve the fluidity of the blends at low water binder ratios. The purpose of this study is to look at the influence of mineral admixtures including silica fume, metakolin, and fly ash on HPC performance. The mineral admixtures have been studied in terms of their pozzolanic reaction, contribution to strength qualities, mix proportioning, and self-compact ability. Strength properties such as compressive and tensile strength are tested at various ages with varied water binder ratios (w/b) to determine the best replacement of mineral admixtures. At 7 days, 28 days, 56 days, and 90 days of curing, the compressive strength of HPC using mineral admixtures was tested at replacement levels of 0%, 5%, 10%, and 15%. These very fine-grained inorganic minerals with pozzolanic or latent hydraulic capabilities are added to the concrete mix to improve the qualities of concrete (mineral admixtures) or as a substitution for Portland cement (blended cements). Products having pozzolanic qualities that include dolomite, fly ash, blast slag, and other beneficial materials are being tested and employed. These advancements are becoming increasingly important in reducing the effects of cement consumption, which is renowned for being one of the main contributors (at roughly 5 to 10%) of worldwide greenhouse gas emissions.

The use of alternative materials can also reduce costs, improve concrete properties, and recycle wastes, the latter of which is important for the circular economy aspects of the construction economy, whose demand is increasing with greater impacts on raw material extraction, waste generation, and landfill practises. The technology of high-performance concrete (HPC) is relatively new. When constructed to meet specified performance criteria, high strength concrete

(HPC) is typically referred to as having compressive strengths more than 60 MPa and enhanced characteristics. In addition to strong strength, concrete is frequently used in field applications that have unique performance criteria. Concrete should have a high fatigue strength for prestressed bridges, offshore constructions, highway and airport pavements, and in machine foundations. Concrete for nuclear containers exposed to extremely high temperatures has to have a strong thermal cracking resistance. With regard to finding an acceptable technology through study in light of all these criteria, HPC was the result.

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CHAPTER 11

GLASS POWDER

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Glass powder (sometimes known as ground glass) is a glass powder. However, the identification of the glass itself, not the grind size, is what gives it its characteristics [1]. Glass is an amorphous (lacks long range order in the solid phase) solid, non-crystalline, generally transparent substance. Glass powder (sometimes known as ground glass) is a glass powder. However, the identification of the glass itself, not the grind size, is what gives it its characteristics. Glass is an amorphous (lacks long range order in the solid phase) solid, non-crystalline, generally transparent substance [2].

Use of Glass Powder as Partial Replacement of Cement

In light of the century's environmental and economic commitments, a thorough review of building techniques and materials has become critical [3]. In this regard, one of the main problems targeted by industry and academic research institutes is the production of cement used in concrete, first to protect the environment from CO_2 released into the atmosphere by the strenuous production of cement to meet the increasing demand for this binder over time, and secondly to improve its properties to better meet the new quality and performance obligations. Glass is an amorphous material with a high silica content that can be pozzolanic if the particle size is less than 75m. The primary issue with utilising crushed glass as aggregate in cement-based construction is expansion and cracking induced by alkali silica reactivity in the glass aggregate.

Ground glass is considered a pozzolanic material due to its silica concentration and, as such, can display qualities comparable to other pozzolanic materials. This study compared finely powdered waste glasses to ordinary concrete as a partial replacement for cement in concrete. Concrete mixes with varying concentrations of glass powder ranging from 5 to 40% with the a 5% increase were evaluated for compressive strength after 7, 28, and 90 days of curing [4]. When compared to regular concrete, ultra-high-performance concrete (UHPC) can withstand high-strength impacts and has superior mechanical and durability features investigated the use of hematite powder to partially replace natural river sand at various replacement ratios, as well as the influence on the qualities of ultra-high-performance concrete. The inclusion of hematite somewhat lowered the work performance and strength properties of UHPC, but significantly boosted its flexural and impact strength and demonstrated good high-temperature performance [5].

The Coating Process

An opaque powder base coat is put to the glass substrate as the first and most critical layer of UV protection. After the powdered attracts, the product is heat to initiate the gelling process, which solidifies the adhesive bond. It is critical to keep the concentration of powder on the surface under control. When used insufficiently, the coating becomes translucent and the protection is reduced. Too much can cause leakage or uneven distribution, resulting in one of the glass container being thicker that the other. When powder painting nail polish and other cosmetics bottles, professional powder coaters often employ a highly chemical-resistant kind of powder that is immune to the strong chemicals inherent in the process.

The powder coater applies the top coat, which flows along with the base coat as additional heat is applied. After curing in the oven, the two coatings become one, sealing together and encasing the bottle or bottle as a single protective shell. This method should not only successfully filter UV radiation, but the molecular structure of the powder also should give further chip and scratch resistance to the bottle In general, the transfer of granular paint to a glass substrate may be divided into four distinct stages. Assuming the item has been thoroughly cleaned, this includes: Attraction - obtaining an electrostatic charge; Gelatinization - converting dry powder to wet powder; fusing or cross-linking coat treatments for a robust, hardened protective layer. Every year, millions of tonnes of waste glass are produced worldwide. Glass is disposed of in landfills after it becomes garbage, which is unsustainable because glass does not disintegrate in the environment. Silica is the main component of glass. Utilization of ground (milled) waste glass [6].

A significant step toward the development of sustainable (environmentally friendly, energy-efficient, and cost-effective) infrastructure systems might be the partial substitution of cement in concrete. In order to evaluate the flow and compressive strength of mortar and concrete, 0 to 25 percent ground glass was added, with the water to binder (cement and glass) ratio being constant throughout all replacement levels. Increased glass inclusion resulted in a small increase in mortar flow and a negligible impact on concrete workability. Additional experiments were carried out with the same mix specifications and 1% superplasticizing admixture dosage (by weight of cement) to assess the packing and pozzolanic effects, and they typically revealed an improvement in compressive strength of mortars with admixture. Concrete cube samples were taken and evaluated for strength similarly to mortar (until 1 year curing). The findings of the compressive strength test showed that concrete and mortar made from recycled glass were stronger than the control samples.

The atmosphere is polluted by greenhouse gases like CO_2, which contribute to global warming. CO_2 makes up roughly 65% of the greenhouse gases that cause global warming. About 7% of the world's total greenhouse gas emissions come from the cement sector. As a result, attempts have been undertaken in the concrete industry to partially substitute cement and coarse or fine aggregates with waste materials.

Waste glass is one material that exhibits pozzolanic qualities when crushed to an extremely fine powder and can be used in concrete as a partial replacement for cement. This study makes an effort to determine the strength of concrete that uses waste glass powder as a partial replacement for cement. Cement substitution with glass powder has been researched at 5% to 40% increments of 5%. It was evaluated for compressive and flexural strength at 7, 28, and 90 days of age and compared to normal concrete. The results revealed that replacing 20% cement with glass powder increased strength. In addition, an alkalinity test was performed to determine corrosion resistance.

The Influence of Waste Glass Powder

A building material called concrete is made up of cement, fine and coarse sand, water, and additives or not. The sustainability of the concrete industry is under jeopardy since it is one of the biggest users of natural resources. The biggest problem the concrete industry is now facing is the economic and environmental concern. A source of carbon dioxide emissions alongside deforestation and the use of fossil fuels is the cement making business. The atmosphere is filled with greenhouse gases like CO_2, which contribute to global warming. CO_2 is one of the greenhouse gases that accounts for around 65% of global warming. About 7% of the world's total greenhouse gas emissions come from the cement sector. It is necessary to create substitute binders for concrete in order to address the environmental consequences of cement manufacture. As waste glass powder exhibits pozzolanic qualities due to its high SiO_2 content, it can partially substitute cement in concrete and aid in the development of strength. In this research investigation, waste glass powder (GLP) has been used in place of ordinary portland cement (Grade 43) in the amounts of 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, and 50% by weight of M-40 grade concrete, respectively. Compressive strength and split tensile tests were performed on various concrete mixes, and the results were compared.

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CHAPTER 12

TYPES OF ADMIXTURES

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The following are some examples of mineral admixtures:

Fly Ash

A finely divided by product of burning coal is called fly ash. In an electrostatic precipitator, fly ash is gathered. Particulated fuel ash is another name for fly ash (PFA). Fly ash primarily contains calcium oxide, alumina, and silica (SiO_2, Al_2O_3) (CaO). It has recent time been used frequently as an additive in cement [1]. It facilitates attaining exceptional strength and performance. Although fly ash is an advanced manufacturing byproduct, it greatly improves the long-term strength of concrete when used in concrete. The fly ash used in cement additions comes in a variety of highly explosive forms, is extremely fine, and contains little carbon [2]. Fly ash has a significant impact on strength at later phases [3]. The fly ash added to cement is very fine, contains little carbon, and can take on a variety of extremely reactive forms. Fly ash has a significant impact on strength at later phases. In contrast to typical concrete, the response is slower or the initial vitality is lower. Fly ash has a low percentage of water and a long lifespan. Fly ash was divided into two classes by ASTM: Class F and Class C.

- Typically, anthracite and bituminous coal combustion produces Class F-Fly Ash.
- Lignite or sub-bituminous coal is the source of class C fly ash.

Fly ash particles are typically spherical, which makes concrete easier to work with. The time that it takes for concrete to set up is lengthened when fly ash is added. Improved concrete densification and, as a consequence, increased strength are made possible by longer setting times. Fly ash is added to the mixture to reduce concrete segregation and bleeding. Concrete segregation is the propensity for different-sized particles to separate out. Conversely, concrete bleeding occurs when water penetrates the concrete's surface. Both apartheid and bleeding are bad [4].

Ground Granulated Blast Furnace Slag (GGBFS)

A byproduct of the iron ore extraction is blast furnace slag. Of all mineral admixtures, blast furnace slag has the highest specific gravity (2.8 to 3.0). Typically, the slag fineness is marginally greater than the cement fineness. Slag can come in a variety of forms, including light slag, expanded or bubbled slag, granulated slag, and pelletized slag. The only one of these that is consistently used as a mineral additive is granulated slag. This type of highly reactive slag is frequently quenched to create a hardened substance that is ground into tiny particles resembling cement. It is referred to as ground granulated supplementary cementitious materials as a result [5].

GGBFS exhibits pozzolanic and cementitious properties. An activator is necessary in order to hydrate the slag. The first setting time of the concrete is sped up by GGBFS. Its fineness is remarkably similar to that of cement, so it has little impact on how easily concrete can be worked. The rate of compressive strengths gain is slowed by using GGBFS in place of cement in concrete. The ultimate strength gain and durability of the concrete are both improved by the replacement of slag. When used in bridge decks, concrete is very vulnerable to corrosion and chemical attack. GGBFS is a great admixture because it increases resistance to these attacks in this regard. . On the other hand, concrete containing GGBFS has reportedly been found to carbonate more quickly than concrete made with regular Portland cement [6].

Silica Fume

Silica fume is another mineral-based type of additive used in concrete construction. During the synthesis of silicon or ferrosilicon, silica fume is created in electric arc furnaces at a temperature of 2000 degrees Celsius. The typical diameter of the spherical particles in silica fume is 150 nm. The addition of silica fume increases the water needed to create concrete due to its fineness. The concrete also gets stickier and more cohesive. By-products of amorphous silica particles are what make up silica fumes. In electric arc furnaces, it is produced as a by-product of the production of elemental silica or other silicon-based compounds. Due to their fine nature, silica fumes increase the water requirement of concrete, practically requiring the use of a superplasticizer. The amount of bleeding in concrete has greatly decreased. Plastic shrinkage may happen in dry areas where the rate of evaporation exceeds the rate at which concrete sets. The permeability of concrete is decreased. The reaction between silica fume and cement paste strengthens the area where aggregates and cement paste meet, acting as both a cement and a filler. Chloride's permeability is significantly decreased.

Rice Husk Ash

While milling the paddy harvested from the fields, a lot of corncob is produced. The primary purpose of this rice husk is as a fuel source. When the rice husk is burned, rice husk ash is created. It accounts for about 25% of the mass of the husk. In the areas where it is disposed of, rice husk ash poses a serious threat to the environment. Rice husk ash can be produced by field burning (open), bed furnace burning (fluidized), and advanced manufacturing furnaces. It contains a lot of silica. Rice husk ash is used to strengthen the concrete. It also minimises permeability because it is significantly smaller in diameter than cement particles. It reduces the heat of hydration in concrete.

Metakaolin

Metakaolin is a thermally activated version of common clay and kaolin clay that has not been purified. The size of metakaolin particles is smaller than that of cement particles. In contrast to the other admixtures, metakaolin is not a by-product of production. Metakaolin helps to strengthen concrete by reducing permeability, enhancing chemical resistance, raising tensile strength, and assisting in the early development of concrete's strength. Metakaolin addition significantly reduces concrete bleeding. Additionally, ferro-cement and fiber-cement are made with metakaolin. It is also used to make sculptures for display. When used properly, admixtures can improve concrete's quality, speed up or slow down the setting process, increase frost and sulphate resistance, control the strength-development process, and improve workability and finishability. According to estimates, admixtures are now used in at least 80% of the concrete made in North America. The National Ready Mix Concrete Association conducted a survey, and it found that 39% of all ready mixed concrete producers use fly ash, and at least 70% of the concrete they produce includes a water reducer admixture. Binary blended mixes, also known as MA, such as SF, metakaolin, GGBS, or RHA, were used to partially replace the cement. The materials used to replace cement must meet the fundamental material requirements, including specific gravity, particle size, etc. Particle fineness may contribute to meeting the requirements for workability, strength, and durability. By partially substituting the cement with two different MA, the binary blended mixes could be transformed into ternary blended mixes.

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