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# A Comprehensive Review on Physical and Mechanical Properties of Polymer as Concrete Material

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**Abstract**: Polymers, the most malleable of all materials, have gained widespread acceptance and recognition due to their chemical, physical, and biological inertness as well as their lifespan, but if they are not recycled, they negatively harm the environment. The focus of this research is to conduct a comprehensive evaluation of the existing research on the use of polymers in concrete and to compare the physical and mechanical properties of polymer concrete to those of conventional cement concrete. The variable parameters such as resin / binder type used, the additives / micro-fillers used, and the properties evaluated from 20 previous study were listed, and the observations on its physical or mechanical properties were classified and reviewed. The elastic modulus and density of polymer concrete increase with polymer binder concentration (10-20%), water absorption is low, and porosity increases with resin-to-aggregate ratio as setting time reduces. Polymer concrete's compressive, flexural, and tensile strengths increase with finer particles, adequate micro-filler content, and stronger binder. Future study suggests using other forms of polymer such as acrylic resin with different additives such as coal bottom ash (CBA) at varying ratios.

**Keywords**: Polymer Concrete, Physical Properties, Mechanical Properties

## 1. Introduction

Polymers are made up of chemically linked atomic groups and have a chain-like structure. Organic polymers, man-made polymers, and semi-synthetic polymers are all synthetic materials [1]. Many organic and synthetic polymers rely on polymers for their existence [2]. Polymers are the most pliable materials, ranging from soft gels and rubbers to super-strong fibres. Non-recyclable plastics accumulate in the environment, losing their chemical, physical, and biological inertness, as well as durability. Plastic pollution is a big issue in all countries. Polymer concrete is made by polymerizing a monomer and aggregate mixture.

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The polymerized monomer acts as a particle binder in composite concrete. In 1958, the US employed polymer concrete to build lamination [3]. It is also used to cover bridge surfaces with polymer concrete in football stadiums, laboratories, and hospitals [4]. Stones are mixed with a polymer binder that does not contain water or Portland cement. Polystyrene, epoxy, and acrylic are common resins and monomers used in this type of concrete. Polystyrene, epoxy, and acrylic resins are commonly used in this type of concrete. Most polymer concretes used in engineering are PC, PIC, and PMC, which are all based on polymer resins.

In the environment, PBMs can be released from various sources. If released into the environment, PBM are susceptible to mechanical and chemical weathering. Non-biodegradable plastics such as PET are a major issue in solid waste management [5]. Aerial movement of lightweight things such as PE bags, polystyrene foam products, and polymer drinking bottles can easily accumulate along coastlines [6]. However, using polymer with concrete can assist prevent pollution from polymer waste in landfills.

The main purpose of this case study is to perform a comprehensive review of previous research on the application of polymers in concrete, with a particular emphasis on their physical and mechanical properties. At the conclusion of the presentation, the properties and capabilities of conventional concrete will be compared to those of polymer concrete, as polymer-based materials can help address environmental challenges. By adding polymer-based components into concrete, plastic bottles, rubber, and other polymer wastes can be eliminated. To remain effective in the future construction industry, polymer-based components in concrete must also undergo extensive testing for their physical and mechanical properties.

## 2. Research Methodology

The research criteria and type materials used in each study are described in this part. This section contains all of the information necessary to acquire the study's analysis and discussion.

### 2.1 Research Criteria

This study gathered major references on polymer concrete research from scholarly websites or e-books on polymer concrete research. It focused on the use of polymeric materials in concrete and their impact on its physical and mechanical properties. This research reviewed and analyzed the results of 20 previous studies on the physical and mechanical properties of polymer concrete. Earlier articles that have been parsed by other author [7] are used as references due to the difficulty and limits associated with obtaining specific reference materials.

This study includes a list of every type of resin/binder employed, as well as the types of aggregates and additives used, as well as the sorts of properties evaluated by each author. Because the foregoing criteria affect the ultimate output of each author, whether in terms of content, distribution sizes, or concrete mix composition. The results of polymer concrete research will be compared to cement concrete results. For polymer concrete, the comparison will be limited to the 20 prior research, whereas for traditional concrete, it will be based on assumptions made from credible sources.

### 2.2 List of Materials

Polyester and epoxy resins are the most often used types of polymer resins in the aforementioned experiments since they have been extensively used as binders in the construction of polymer concrete for a long period of time. This is proved by [8, 9] with using SBR and glycoluril-formaldehyde modified polymers with Portland cement concrete created PMC. Based on the aforementioned research, it can be inferred that the vast majority of researchers are involved in PC research, which is less difficult, simpler, and does not use cement. The Table 1 summarizes the usage of materials including resin type, aggregates type and additives used by chosen past researches.

When it comes to aggregate, the majority of researches have used either the same type of aggregate for coarse and fine aggregate (but with a size difference) or a different type of aggregate for coarse and fine aggregate. The study indicated usage of aggregate such as andesite, river sand, broken stone, quartz, granite, gravels, hematite, colemanite etc. [10] evaluated polymer concretes with a variety of aggregate compositions, including sand as both fine and coarse aggregate, sand in conjunction with hematite as the coarse aggregate, and sand in combination with colemanite as the coarse aggregate.

Admixtures, catalysts (hardener or accelerator), and micro-fillers were employed to reduce deficiencies and increase the performance of polymer concrete. Assessment on the usage of micro-fillers with fly ash in combination with fine aggregates [11, 12]. Calcium carbonate is typically used as a micro-filler in PC to improve the adhesion of the resin binder to the inorganic particles. A silane coupling agent can improve inter-facial adhesion and consequently mechanical properties. Several authors employed a variety of coupling agents and silane in various ways. Polypropylene fibre used as a hardener to increase tension resistance, impact resistance, and shrinkage [13]. MEKP is a polymer concrete accelerator that can be solidified at room temperature [14, 15].

## 3. Polymer

Polymer comes from two Greek words: ‘poly’ means many and ‘mer’ means unit or part. According to American Heritage, a polymer is "any of a wide variety of naturally occurring and man-made molecules with a typically high molecular weight that are formed of up to millions of repeating linked units, each of which is a relatively light and simple molecule." Polymerization is the process by which polymers are created from monomers. A polymer molecule is normally formed of hundreds of thousands of monomer units, and the process of polymerization usually requires the mixing of 100 monomer units in order to produce a product with unique features such as high elasticity, tensile strength, or the ability to form fibres.

There are three types of polymers: biopolymer (natural polymer), Man-made synthetic polymer and semi-synthetic polymer. Biopolymers (natural polymers) are naturally occurring polymers produced by living animals' cells. Examples include natural rubbers (isoprene polymers), suberin and lignin (complex polyphenolic polymers), cutin and cutan (complex polymers of long-chain fatty acids), and melanin. Synthetic polymers created by humans are frequently derived from petroleum. Thermoplastics, elastomers, and synthetic fibres are three major classes found in numerous items worldwide. Meanwhile, chemical modifications have been made to the fundamental polymer properties of semi-synthetic polymers. Nitrocellulose and cellulose acetate are both examples of this type of material.

## 4. Polymer Concrete

Polymer concrete (PC) is a concrete mix that replaces lime-based cements with polymers. Improved properties can be achieved by incorporating polymers into concrete. PC is well-suited for use in corrosive projects such as swimming pools, drainage systems, and other similar structures. PC is made up of aggregates and resins bonded together in a polymer matrix to form a strong structure. PC performance is heavily influenced by the aggregates and resins used, as well as their proportions [16]. Micro-fillers are sometimes applied as a last alternative to fill voids in aggregate mixtures. The most common polymeric resins used in polymer concrete include methacrylate, vinyl-ester, polyester, epoxy, and furan.

A mineral admixture, such as aggregates, plus a thermoplastic or thermosetting polymer binder are the components of PC. **Figure 1** depicts the polymer concrete's composition. When sand is used as a filler, the composites are simply referred to as polymer mortars. Additional fillers include crushed sandstone, gravel, limestone, silica fume, granite, quartz, clay, glass, and metal. In general, any dry, non-absorbent solid can be utilized as a filler [17]. PC is made by mixing a monomer or polymerize with a hardener (merge agent) and a catalyst. Flame retardants, plasticizers, and other additives are also included.

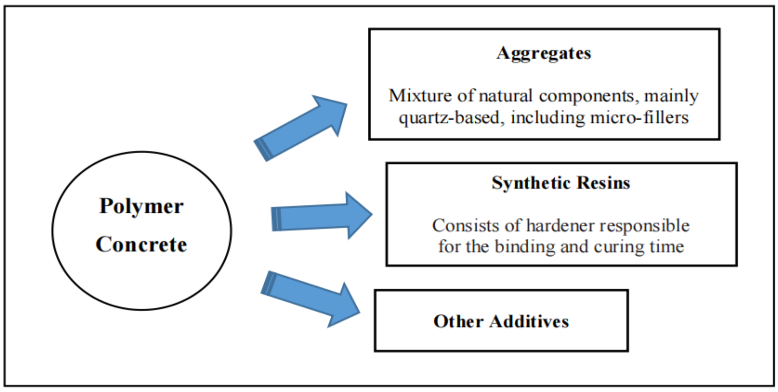


**Figure 1: Composition of a polymer concrete. In "Intended Use of Polymer Concrete,"**

PC is made up of several monomers and prepolymers. Polymers are divided into five categories. In order to harden epoxy polymers, a variety of additives can be used, the most common of which being poly-amines. Carbamide resin is made by poly-condensing urea and formaldehyde in water or water-alcohol solution. Polyester resins are low viscosity, mechanically and electrically insulating, and resistant to gasoline, oils, and acids. Acrylic polymer is created by polymerizing methyl methacrylate and has exceptional freeze–thaw resilience. Furan polymers are commonly cross-linked with furfuryl alcohol, formaldehyde, or formaldehyde to make thermosetting polymers which high resistant to acidic, basic, and strong organic solvents such aromatics, ketones, and chlorinated chemicals.

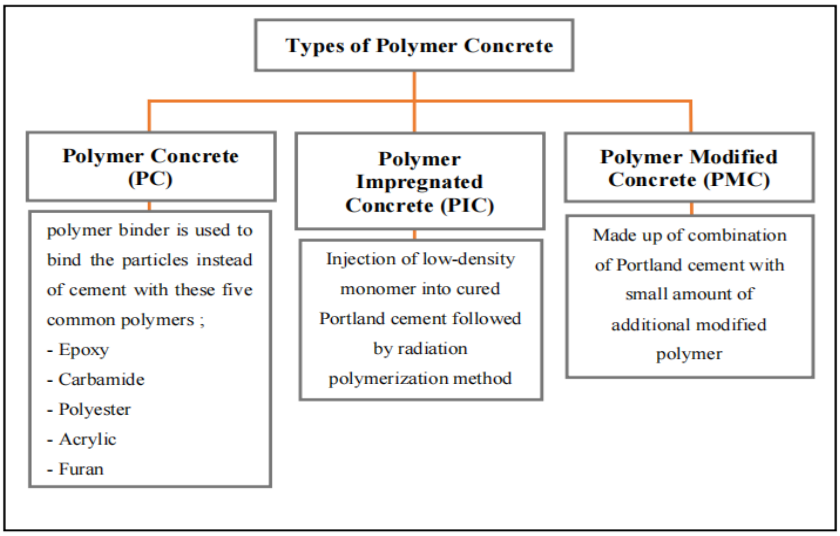


**Figure 2: The three types of polymer concrete**

The three distinct types of polymer concrete are summarized in **Figure 2**. Polymer Impregnated Concrete (PIC) and Polymer Modified Concrete (PMC) are two other concrete mixes that include polymers as additives. After injecting a low-density monomer into hydrated Portland cement, radiation polymerization removes the voids and diffuses a low-viscosity monomer into the pores to create PIC. PMC is constructed of Portland cement with polymer modifications such polyvinyl acetate, SBR, acrylic, or ethylene vinyl acetate. PMC is applied in bridge and other structures. Among the benefits are better concrete adhesion, flexural strength, and lowered permeability [18, 19].

## 5. Physical & Mechanical Properties of Polymer Concrete

According to the research result, this part will elaborate on the physical and mechanical properties of polymer-based concrete. For clarity, the variable condition will be included in the outcome.

### 5.1 Results of Past Research

Researchers agreed that polymer concrete's resin content should be between 10% and 20%. The amount of resin in polymer concrete affects its compressive strength [20]. Flexural and compressive strength are highest between 14 and 16 percent resin concentration by weight. To obtain maximal compressive and flexural strengths, [21] used a 12 percent resin content in which three times that of typical cement concrete.

Epoxy resins outperform polyester, vinyl-ester, furan, and methacrylate resins mechanically, but are more expensive. They maintain their dimensions well, are very resistant to heat, have a high mechanical strength, and are chemically resistant. The mechanical qualities of epoxy-polymer concrete are significantly greater than those of polyester-polymer concrete [22]. However, by including micro-fillers and silane coupling agents into the slurry, polyester concrete can achieve the properties of epoxy concrete.

Micro-fillers such as fly ash, silica fume, and calcium carbonate have been reported to improve both the mechanical properties and workability of polymer concrete. When 15% fly ash is added to polymer concrete, compressive strength gains of up to 30% have been recorded. When additives such as silane coupling agent are applied to polyester and epoxy concrete, the compressive strengths rise by 30% and 36%, respectively [22]. Because there is no standard mix proportion or aggregate grading criterion for polymer concrete, several ideal mix proportions have been described in the literature. According to [11], the properties of polymer concrete varied depending on the proportions of hematite, colemanite, and fine river sand.

In the curing phase, polymer concrete's overall properties are greatly influenced by the temperature. Curing at room temperature is preferable for field use and operation. In a single day, the polymer concrete systems attained greater than 70% strength at room temperature. Compressive strength increases linearly with curing temperature, peaking after one day at ambient and one day at 80°C [23]. The **Table 1** shows the summarize of results based on each past researches.

**Table 1: Summary of Past Research on Properties of Polymer Concrete**

| Author | Resin / aggregates / additives | Variables | Properties evaluated | Results |
|---|---|---|---|---|
| [24] | Polyester, andesite, river sand, calcium carbonate | Mixture composition, curing conditions, moisture content of aggregate | Compressive strength | - The optimal mix percentage has been suggested using 11.25% resin and calcium carbonate, 29.1% andesite (5-20mm), 9.6% sand (1.2-5 mm) and 38.8% sand (<1.2mm)<br>- After seven days of curing at 20° C, the compressive strength becomes constant.<br>- Since strength decreases as the water content of the aggregate increases, the allowable moisture content shall be restricted to 0.1 percent. |
| [25] | Polyester, crushed | Silane treatment, | Compressive strength | - The use of a 1% silane agent elevates the load required to withstand 2 million |

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|---|---|---|---|---|
| | stone, fine sand, silane agent | resin content (9 to 13%) | | cycles from 59% to 64% of ultimate strength.<br>- Compressive strength is not significantly affected by resin percentage. |
| [22] | Epoxy, polyester, crushed quartzite, siliceous sand, calcium carbonate, silane agent | Type of resin, silane treatment, micro-filler addition | Compressive strength, flexural strength, tensile strength | - Epoxy concrete outperforms polyester concrete.<br>- Adding a silane coupling agent to polyester and epoxy concrete increases compressive strength by 30% and 36% respectively. |
| [23] | Epoxy, polyester, Ottawa sand, blasting sand | Temperature, strain rate, type of aggregate, curing conditions | Compressive strength, tensile strength | - Compressive strength increases in direct proportion to the curing temperature.<br>- The maximum strength was attained after a one-day curing period at room temperature followed by a one-day curing period at 80 degree Celsius.<br>- Compressive strength was increased by using gap graded aggregate. |
| [12] | Polyester, granite, river sand, fly ash | Sand content, fly ash content | flexural strength | - Fine aggregates containing fly ash and river sand demonstrate synergy in strength and resistance to water absorption up to 75% fly ash by weight.<br>- Since pure fly ash has a large surface area, it's doesn't mix well with resin binder at higher levels of fly ash. |
| [26] | Polyester, 58% crushed granite, 21.8% sand, 10.4% calcium carbonate | - | Compressive strength, flexural strength | - Compressive strength has been observed to be between 90 to 108 MPa. |
| [21] | Epoxy, polyester, 56% coarse, 36% fine | Resin content | Compressive strength, flexural strength | - All resin types had maximum compressive strength at 12% resin concentration.<br>- The maximum flexural strength was also achieved at 12% resin content, about 3 times amount of cement concrete. |
| [13] | Polyester, pea gravel, sand, fly ash | Fly ash content | Compressive strength | - By replacing 15% of sand with fly ash, compressive strength increases 30%.<br>- Caution should be taken when employing a significant amount of fly ash because the material's high surface area will render the mix too sticky and impractical. |
| [27] | Epoxy, river gravel (0-4 | Resin content, | Compressive strength, | - The compressive strength ranges between 43.4 and 65.3 MPa. |

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| | mm and 4-8 mm), silica fume | micro-filler content | flexural strength | - The flexural strength ranges between 12.29 and 17.5 MPa.<br>- Resin concentration of 15.6% was found to be acceptable for practically all polymer concrete qualities. |
| [28] | Polyester, crushed gravel (4-20 mm), sand (0-4 mm) | Mixture composition, polymer addition, curing period | Compressive strength, flexural strength, elastic modulus, water absorption | - PC mixture demonstrated high compressive strength after 1 day and roughly 100 MPa after 7 days of curing.<br>- PC recorded the highest modulus of elasticity throughout 90 days.<br>- At various ages, water absorption into polymer concrete was negligible. |
| [9] | SBR, coarse and fine aggregates with SG - 2.62, superplasticizer | Concrete grade, polymer content (5 to 10%) | Compressive strength, tensile strength, elastic modulus | - The strength of concrete increased as the polymer percentage rose in all concrete grades.<br>- At 10% polymer content, compressive strength increased from 16.25% to 33.4%, while split tensile strength increased from 5.1% to 19.8%. The increase in flexural strength ranged from 13.2% to 18.4%.<br>- For M20 concrete with 10% polymer content, the maximum drop in permeability and increase in elastic modulus were 32.40% and 11% respectively. |
| [29] | Epoxy, 2-4 mm gravel, gravel-sand ratio of 0.25 | Resin content, curing conditions | Compressive strength, flexural strength | - 13% resin content was recorded for maximum compressive and flexural strength.<br>- 3 days of curing exhibited highest compressive and flexural strength. |
| [11] | Epoxy, hematite, colemanite, medium-size river sand, hardener (aliphatic polyamine) | Mixture composition, resin content, aggregates content | Compressive strength, flexural strength, tensile strength, density, elastic modulus | - The density increases with increasing hematite content while it decreases with increasing colemanite content.<br>- The axial compressive strength, flexural strength and split tensile strength increases with hematite content but decreases as colemanite concentration increase.<br>- The hematite sample with the highest hematite content had a peak elastic modulus of 42.3 GPa while concretes with high colemanite have lower elastic.<br>- The epoxy-polymer concrete with highest hematite content shows the overall high strength compared to normal epoxy-polymer concrete. |

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| [30] | Epoxy, crushed gravels (4–10 mm), natural river sand (0–4 mm), hardener (modified polyamines) | Resin content (6 to 16%), curing conditions | Compressive strength, tensile strength, elastic modulus, porosity | - By increasing the epoxy polymer ratio to 13%, the density is increased.<br>- With increasing curing age, the highest values of elastic modulus are observed at 13% polymer content by weight.<br>- Compressive and flexural strength both increase as polymer percentage increases, but only up to a 16% resin concentration.<br>- For low cost and strong mechanical strength, a 13% polymer content is ideal. |
| [31] | Epoxy, vinyl-ester, fine dry sand, fly ash, catalysts | Type of resin, type/content of catalysts, fly ash content | Compressive strength, flexural strength, tensile strength, elastic modulus | - The compressive strengths of epoxy resin and vinyl-ester polymer concrete are 75MPa and 113MPa, respectively.<br>- Tensile strengths of both types of polymer concrete reached 15MPa.<br>- As fly ash content increases, the elastic modulus increases while the flexural strength declines. |
| [14] | Polyester, natural basalt, recycled basalt and limestone (from concrete sleepers), MEKP, calcium carbonate | Resin content, size distribution of micro-filler, type of aggregates | Compressive strength, flexural strength, density, elastic modulus, water absorption | - PC with NBA-13MF (13% resin) shows the highest value of compressive strength, flexural strength and density.<br>- The modulus of elasticity and the water absorption of PC were the highest with RBA-11 sample.<br>- Increasing the amount of unsaturated polyester resin in the RBA PC improved the mechanical strength and rigidity. |
| [15] | Polyester, white sand, red sand, MEKP | Sand content | Compressive strength, flexural strength, water absorption | - The density of PC increase as the sand content for both type increases.<br>- The flexural strength of PC with white sand higher than with red sand while the compressive strength of PC with red sand higher than with white sand.<br>- The water absorption for both PC types considered negligible. |
| [32] | Epoxy, fine aggregate, foam | Mixture composition, resin content | Compressive strength, density, setting time | - PC mixture with 23.57 MPa and a density of 1773.76 kg/m3 had the maximum compressive strength of concrete.<br>- Epoxy-polymer concrete density decreases as epoxy-fine aggregate ratios decrease, but foaming agent-water ratios increase.<br>- The initial time obtained ranged between 60-195 minutes while the final was between 120-300 minutes. |

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|---|---|---|---|---|
| [13] | Epoxy, Akhaither sand (0-4 mm size), polypropylene fibers (hardener), polyethylene | Size distribution of sand | Compressive strength, flexural strength, water absorption | - Polymer concrete has three times the compressive strength of cement mortar where the varied sand sizes in polymer concrete increased compressive strength.<br>- The ratio of polypropylene fibers in polymer concrete increases flexural strength while compressive strength falls.<br>- Polymer concrete is non-water absorbent, making it tough and impervious. |
| [9] | Glycoluril-formaldehyde, quarry crushed SG-2.72, natural siliceous sand SG-2.56 | Polymer content | Compressive strength, flexural strength, tensile strength, water absorption | - The addition of polymer increases strength gradually, with a maximum strength of 3% glycoluril content. Both 7 and 28 day tests reveal a 28% increase in strength.<br>- Tension and flexural test revealed that the polymer is critical to strength development. Such as the compressive strength research, the greatest tension and flexural strength development were 3%.<br>- The use of glycoluril-formaldehyde polymerization improves water resistance and eliminates chemical capillary in concrete. |

### 5.2 Discussions

Numerous physical parameters, including density, elastic modulus, water absorption, porosity, and setting time, have been stated. **Table 2** shows the summary on physical properties of polymer concrete. Elastic modulus, density, and water absorption are commonly stated properties in the literature. Polymer concrete, according to the majority of research, has a higher elastic modulus than conventional concrete. When polymer is used in place of cement, PC has a higher elastic modulus than normal concrete (NC) and durable concrete (DC) [28].

Concrete with a higher density has fewer voids and is less permeable to water and soluble substances. A study on lightweight polymer concrete and discovered that the ratio of epoxy to fine aggregate affects density, with a smaller ratio resulting in a lower density [32]. Nevertheless, water absorption is clearly distinguishable in polymer concrete than in conventional concrete, where its value is considered minimal.  Research by [15] discovered that water absorption is negligible for both white and red sand polymer concrete samples.

For physical properties such as porosity and setting time, only one author indicated the finding [30, 32] respectively. Overall porosity drops to 3.66 percent with 13 percent polymer content [30]. The setting time of polymer concrete is determined by the resin concentration and micro-filler content. The fastest start and final setting times were reported to be 60 and 120 minutes [32]. But this depends on the amount of micro-filler utilized (in this case foaming agent has been used with combination of water).

**Table 2: Physical Properties of Polymer Concrete**

| Properties | Results | Variable dependant |
|---|---|---|
| Elastic modulus | High at optimum resin content (10% to 20%) | Aggregate size distribution, Type of resin, resin content, additives / micro-filler content |
| Density | High at optimum resin content (10% to 20%) | Type of resin, Resin-fine aggregate ratio, aggregate content, additives / micro-filler content |
| Water Absorption | Negligible (almost zero) | Resin content |
| Porosity | Low as resin content increases | Type of resin, resin content, aggregate size distribution |
| Setting time | Low as resin content increases | Type of resin, resin content, aggregate content |

Several mechanical properties have been studied, including compressive, flexural, and tensile strength. The two mechanical properties most discussed in the literature are compressive and flexural strength. **Table 3** shows the summary on mechanical properties of polymer concrete. Study by [24] discovered that after seven days of curing at 20°C, polyester-polymer concrete's compressive strength settles down. But as the aggregate's moisture content rises, so does its strength. According to [23] compressive strength improves linearly with curing temperature and that gap graded aggregate can improve compressive strength. Silane coupling agents improved the compressive strength of polyester and epoxy concrete [22].

However, flexural strength is also dependent on the aggregate used in the concrete mix. According to [10], flexural strength increases as the hematite content increases, but falls as the colemanite percentage increases. The flexural strength of polymer concrete is 17.5 MPa, although it improves when hematite replaces regular sand, and reduces when colemanite is added. Based on study by [15] discovered that polymer concrete with white sand had higher flexural strength than polymer concrete with red sand at 60% concentration. However, a sample with a high proportion of white sand has poor flexural properties, whereas a sample with a low proportion of white sand has great flexural properties.

Tensile strength is not as essential as compressive or flexural strength in concrete. Because concrete's overall tensile strength is lower and requires steel reinforcement. Aside from that, it can be used to compare the value of normal concrete and polymer concrete. Previous research shows that polymer concrete tensile strength is equivalent to flexural and compressive strength, but smaller. According to [31], epoxy and vinylester both have tensile strengths of 15MPa, while conventional concrete has a tensile strength of just 5MPa.

**Table 3: Mechanical Properties of Polymer Concrete**

| Properties | Results | Variable dependant |
|---|---|---|
| Compressive strength<br>Flexural strength<br>Tensile strength | High at optimum resin content (10% to 20%), low resin-aggregate ratio, with additives / micro-filler | - Type of resin / polymer<br>- Resin / polymer content<br>- Type of aggregate<br>- Aggregate content<br>- Additives / micro-filler content<br>- Concrete mixture ratio<br>- Curing conditions |

According to the majority of researches cited, polymer concrete possesses superior mechanical properties and is capable of substituting cement in concrete mixtures. However, due to the diverse applications of materials, procedures, and techniques in polymer concrete research, the values presented in **Table 4** are approximate and not specific. Indeed, the value and yield properties of polymer concrete vary according to the resin/polymer used, the aggregate used, and the mixing ratio used in the study.

**Table 4: Polymer Concrete vs Conventional Cement Concrete**

| Properties | Polymer Concrete (PC) | Conventional Cement Concrete (OPC) |
|---|---|---|
| | Physical Properties | |
| Elastic Modulus | 12 - 50 GPa | 14 - 40 GPa |
| Density | 1600 - 2800 kg/m$^3$ | 2240 - 2400 kg/m$^3$ |
| Water absorption | 0 - 0.5 % | 5.5 - 6.5 % |
| Porosity | 3 - 18 % | 9 - 10 % |
| Setting time | 60 - 300 min | 30 - 600 min |
| | Mechanical Properties | |
| Compressive strength | 15 - 115 MPa | 20 - 40 MPa |
| Flexural strength | 2.0 - 38 MPa | 3 - 5 MPa |
| Tensile strength | 3.5 - 18 MPa | 2 - 5 MPa |

## 6. Conclusion

Many researchers have studied the influences of resin type and content, curing conditions, aggregate type and content, additives, and micro-fillers on polymer concrete properties. Below is a summary of the research findings from a comprehensive review on polymer concrete:

i. Polymer concrete research mostly used polyester and epoxy resins. Polyester resin concrete has superior mechanical qualities and durability compared to epoxy polymer concrete. These qualities are improved by using new polymers like SBR co-polymer and glycoluril (10% and 3% polymer concentrations).

ii. Polymer content increased concrete strength. As stated by several sources, the resin dosage ranges between 10% and 20% by weight. The resin dose should be increased as the surface area of the fine aggregate increases.

iii. Research shows that curing procedures include room temperature, high temperature, and water curing. Many research employed the 7, 28, or 90-day room temperature norm. Its compressive strength was around 100 MPa after just one day.

iv. The researchers employed only indigenous materials. The researchers cited andesite and river sand as examples of their findings. In polymer concrete, each aggregate is different. A combination of elastic modulus and density gives aggregate strength.

v. In order to achieve maximum bulk density, the fine/coarse aggregate ratio should be adjusted. So less binder is needed to properly bond all aggregate particles. The ideal resin/binder concentration for fine aggregate combinations is 6–16% of total weight. The total strength of polymer concrete was reduced by adding tiny particles (like sand).

vi. Because polymer concrete has low binder, the aggregate is attached by a thin coating of resin. To increase contact area, smaller additives or micro-filler particles are needed. Superplasticizers and polyamines were recommended as epoxy hardeners, while calcium carbonate and fly ash were suggested as micro-fillers.

A thorough literature review on the physical and mechanical properties of polymer concrete yielded the following research outcomes:

vii. As the polymer binder content increases (10 percent to 20 percent), the polymer concrete's elastic modulus and density increase. Concrete with fine particles has a greater elastic modulus and density than concrete with coarse aggregates.

viii. Water absorption of polymer concrete is nil or insignificant compared to conventional concrete which is between 5 and 6%.

ix. The porosity and setting time of polymer concrete are determined by the resin/binder ratio or the resin-aggregates ratio. When the resin-to-aggregate ratio increases, the porosity of polymer concrete increases, while the setting time decreases.

x. Concrete has the best compressive strength when the polymer/resin binder content is optimal (10 percent to 20 percent). A polymer concrete's ultimate compressive strength was influenced by aggregate size distribution, additive/micro-filler content, and binder type. Compressive strength increases with finer aggregates, optimum micro-filler content, and a stronger binder such epoxy.

xi. Flexural and tensile strength are almost identical to compressive strength but have a lower value. Flexural strength, on the other hand, is dependent on the amount of fibre reinforcement present in the mixture; the greater the ratio, the lower the flexural strength.

Further research & development are necessary to prepare for the development of more inventive polymer concrete and to define a more feasible polymer concrete mix design. Future research on polymer concrete with varied ratios of resin/binder and other polymers such as acrylic resin with different additives, such as coal bottom ash (CBA) suggested. Evaluate various concrete ratios to find the best one for using acrylic resin in polymer concrete, and increase the sample size to get more precise findings.

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