

EXPERIMENTAL INVESTIGATION ON FRESH AND HARDENED PROPERTIES OF CONCRETE INCORPORATING CARBON FIBRES COMPOSITES.

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Abstract:

This review examines how adding carbon fiber to different concrete mix designs can improve performance and overcome the poor tensile strength of concrete. Although traditional reinforcements like steel fibers increase strength and toughness, they have disadvantages such as corrosion and expensive cost. An alternative that is both lightweight and strong, carbon fiber has a greater modulus, is more durable, and can withstand extreme conditions. It reduces cracking due to shrinkage and enhances performance under dynamic loads. Studies show promising results: Basit et al. found 0.60% carbon fibre optimal in self-compacting concrete, improving fresh and hardened properties. Andrew et al. compared aerospace, industrial, and recycled carbon fibres in ultra-high-performance concrete. Aksar et al. concluded 0.25% CCFRP is ideal in both normal and low-strength concrete. Md. Safiuddin et al. found 3% carbon fibre optimal in reinforced mortar for strength and reduced absorption. Overall, compressive strength improves up to a certain fibre content, after which it declines. Flexural and split tensile strength generally increase with fibre dosage. Slump flow decreases with more carbon fibre, and water absorption is minimized only up to an optimal level. With the right dosage, carbon fibre significantly enhances concrete's mechanical and durability properties.

Keywords: Concrete, Carbon-fiber, Experimental, FRC

1. Introduction:

Concrete is the most widely used building material in the world and plays a crucial role in the infrastructure of the world. It is a highly heterogeneous material used in the housing or construction industry. It is made up of cement, sand, aggregate, and water in a specific proportion. The reaction of these materials with the aid of water creates the hard mass known as concrete. Historically, concrete has been reinforced with continuous bars for both crack control and tensile load carrying. The price of continuous reinforced bars and the labor required to install them account for a large portion of the building cost of concrete. Fiber-Reinforced Concrete (FRC) is one possible remedy for this, in which short, chopped fibers are mixed into the concrete to provide reinforcement. Applications for FRC are numerous and include architectural design, blast protection, 3D printing, and many more. Steel, glass, basalt, and synthetic fibers are among the sorts of fibers that have been utilized as reinforcements in concrete. It has been shown that steel fiber, one of the most widely used fibers in concrete applications, improves FRC's tensile, compressive, and flexural strength as well as endurance and energy absorption. Furthermore, steel fiber has appropriate workability and homogeneous dispersion up to a 3% volume proportion. Additionally, a lot of research has been done on the use of carbon fiber as concrete reinforcement. Because of its superior mechanical qualities, excellent corrosion resistance, and chemical inertness, carbon fiber may be a better option than steel fiber for use in concrete applications. At relatively low tensile strains, carbon fiber can develop higher stresses before concrete fails because it has a higher modulus than steel. Because concrete is extremely alkaline and may be used in harsh environments, the carbon fiber's chemical inertness is especially crucial in these applications. The physical characteristics of carbon fiber may make it a perfect substitute for steel fiber in concrete. Many research and study has done on carbon fibre to understand their properties and behaviour while incorporating to concrete. Andrew et. al investigate on carbon fibre incorporating Ultra- High- Performance Concrete. The three carbon fibre-based concrete mixes were evaluated using the neat concrete and steel fibre-based concrete mix design as a baseline. Carbon fiber comes in three varieties: Hexcel, Zoltek, and recycled carbon fiber (RCF). Concrete mix designs for compressive, tensile, and flexural strength properties are connected with the porosity and microstructure of fiber-reinforced concrete mixes. The fiber was then cut to a nominal length of 12.7 mm using a fiber-chopping module. Each mix's flow was measured, and the steel had the second-best flow at 74%, followed by the neat at 133%, the Hexcel carbon fiber at 44%, the CF at 36%, and the Zoltek carbon fiber at 27%. The RCF mix design's compressive strength (135.3 MPa) was roughly 42.5% greater than that of the neat mix design (87.9 MPa), 17.9% higher than that of the steel mix design (113.1 MPa), 0.6% higher than that of the Hexcel carbon fiber mix design (134.5 MPa), and roughly 23.2% higher than that of the Zoltek carbon fiber mix design (107.2 MPa). In comparison to the neat mix design (5.21 MPa), the RCF mix design (6.89 MPa) had a tensile strength that was roughly 27.8% higher, 4.6% higher than the steel mix design (6.58 MPa), 26.3% higher than the Hexcel carbon fiber mix design (5.29 MPa), and roughly 26.4% lower than the Zoltek carbon fiber mix design (8.99 MPa). About 8.9% less

flexural strength was achieved by the RCF mix design (10.7 MPa) than by the neat mix design (11.7 MPa), 18.6% less than by the steel fiber mix design (12.9 MPa), 0.9% less than by the Hexcel carbon fiber mix design (10.8 MPa), and 8.5% more than by the Zoltek carbon fiber mix design (9.83 MPa). A study by Aksar et al. sought to determine how chopped carbon fiber reinforced polymer (CFRP) affected the mechanical characteristics of concrete. In order to achieve the desired strengths of 13 MPa (LSC) and 28 MPa (NSC), concrete mixes containing four CFRP volume fractions (0%, 0.25%, 0.5%, and 0.75%) were added. In order to attain the required strength, five trials were carried out for each grade using the mix ratios of 1:2.6:4.1 for LSC and 1:1.5:2.5 for NSC. The study assessed CFRP's effects on flexural, tensile, and compressive strengths, offering information about how it can improve concrete's mechanical performance. According to tests conducted at 7 and 28 days, the addition of 0.25% CFRP increased NSC by 5% and LSC compressive strength by 10% (from 9.5 MPa to 11.2 MPa). NSC saw a 44% improvement in split tensile strength (from 2.5 MPa to 3.6 MPa), whereas LSC had a 16.6% increase. NSC's flexural strength increased from 4.5 MPa to 5.4 MPa, whilst LSC's changed very little. The study suggests that the ideal dosage of CFRP is 0.25%. The strength and absorption characteristics of short carbon fiber reinforced mortar composites were investigated by Md. Safiuddin et. al. The water absorption and strength characteristics of 12 mm-long short carbon fiber reinforced mortar (CFRM) composites are the main subject of this work. Four CFRM composites containing 1%, 2%, 3%, and 4% short pitched based carbon fiber were used. The compressive, flexural, and split tensile strengths of the hardened mortar composites were measured, as well as the workability, wet density, and trapped air content of freshly mixed mortar. Surprisingly, it was found that the compressive strength increased to 3% before declining. Splitting tensile and flexural stresses result in an improvement in strength for all fiber contents. Furthermore, the water absorption of CFRM composites decreases up to 3% carbon fiber content before sharply increasing at 4% fiber content. The best CFRM composites, according to their test results overall, include 3% carbon fiber. Basit et al. conducted research on the new and mechanical properties of carbon fiber reinforced concrete composites using self-compaction concrete. Their study involved combining self-compacting concrete with carbon fiber. The samples were categorized as either conventional or fiber-added, and their weight-based fiber contents varied (CF0%, CF0.20%, CF0.40%, CF0.60%, CF0.80%, and CF1.0). Compressive strength and split tensile strength were tested for hardened concrete, whereas slump and L-box tests were done for fresh concrete. Acid attack and water absorption tests were part of the durability test. Type I OPC, micro silica, fine and coarse aggregate, superplasticizer, and industrial grade 36 carbon fiber were the materials employed in the experiment. Compressive strength and split tensile strength were tested for hardened concrete, whereas slump and L-box tests were done for fresh concrete. Acid attack and water absorption tests were part of the durability test. Type I OPC, micro silica, fine and coarse aggregate, superplasticizer, and industrial grade 36 carbon fiber were the materials employed in the experiment.

2. Literature Review

To find the alternate of steel fibre various studies have been conducted on carbon fibre to understand their properties and make it more reliable source for reinforcement, some of these studies are given below:

(Basit et al.2023) In this project, self-compacting concrete was mixed with carbon fiber. The samples had different fiber contents (CF0%, CF0.20%, CF0.40%, CF0.60%, CF0.80%, and CF1.0) by weight and were divided into two categories: conventional and fiber-added. Compressive strength and split tensile strength were tested for hardened concrete, whereas slump and L-box tests were done for fresh concrete. Acid attack and water absorption tests were part of the durability test. Type I OPC, micro silica, fine and coarse aggregate, superplasticizer, and industrial grade 36 carbon fiber were the materials employed in the experiment.

(Andrew and Stephen et.al 2023) Steel fiber-based concrete mix design and neat concrete were used as a baseline for comparing the three carbon fiber-based concrete mixes. The three varieties of carbon fiber are recycled carbon fiber (RCF), Hexcel, and Zoltek. There exists a correlation between the concrete mix designs for compressive, tensile, and flexural strength qualities and the porosity and microstructure of fiber-reinforced concrete mixes. Following that, the fiber was cut to a nominal length of 12.7 mm using a fiber-chopping module. Each mix's flow was measured, and the steel had the second-best flow at 74%, followed by the neat at 133%, the Hexcel carbon fiber at 44%, the CF at 36%, and the Zoltek carbon fiber at 27%. About 42.5% more compressive strength was achieved by the RCF mix design (135.3 Mpa) than by the neat mix design (87.9 MPa), 17.9% more than by the steel mix design (113.1 Mpa), 0.6% more than by the Hexcel carbon fiber mix design (134.5 MPa), and roughly 23.2% more than by the Zoltek carbon fiber mix design (107.2 MPa). The RCF mix design's tensile strength (6.89 MPa) was roughly 27.8% greater than that of the neat mix design (5.21 Mpa), 4.6% higher than that of the steel mix design (6.58 MPa), 26.3% higher than that of the Hexcel carbon fiber mix design (5.29 MPa), and roughly 26.4% lower than that of the Zoltek carbon fiber mix design (8.99 MPa). The RCF mix design's flexural strength (10.7 MPa) was roughly 8.9% lower than that of the neat mix design (11.7 MPa), 18.6% lower than that of the steel fiber mix design (12.9 MPa), 0.9% lower than that of the Hexcel carbon fiber mix design (10.8 MPa), and 8.5% higher than that of the Zoltek carbon fiber mix (7.83 Mpa). (Aksar et.al 2023) This study investigates how the mechanical characteristics of Normal Strength Concrete (NSC) and Low Strength Concrete (LSC) are affected by chopped carbon fiber reinforced polymer (CCFRP). Four volume fractions of CCFRP (0%, 0.25%, 0.5%, and 0.75%) were added to concrete mixtures that were intended to have goal strengths of 28 Mpa (NSC) and 13 MPa (LSC). In order to attain the required strength, five trials were carried out for each grade using the mix ratios of 1:2.6:4.1 for LSC and 1:1.5:2.5 for NSC. The study assessed CCFRP's mechanical performance. According to tests conducted at 7 and 28 days, the addition of 0.25% CCFRP increased NSC by 5% and LSC compressive strength by 10% (from 9.5 MPa to 11.2 MPa). NSC saw a 44% improvement in split tensile strength (from 2.5 MPa to 3.6 MPa), whereas LSC had a 16.6% increase. NSC's flexural strength increased from 4.5 MPa to 5.4 MPa, whilst LSC's changed very little. The study suggests that the ideal dosage of CCFRP is 0.25%.

(Md. Safiuddin et.al) The water absorption and strength characteristics of 12 mm-long short carbon fiber reinforced mortar (CFRM) composites are the main subject of this work. Four CFRM composites containing 1%, 2%, 3%, and 4% short pitched based carbon fiber were used. The workability, wet density, and trapped air content of freshly mixed mortar were evaluated, and the compressive, flexural, and split tensile strengths of the hardened mortar composites were assessed. Remarkably, it was discovered that the compressive strength rose to 3% and then fell. Strength increases for all fiber contents in the event of splitting tensile and flexural stresses. Additionally, CFRM composites & water absorptions decrease up to 3% carbon fiber content before significantly increasing at 4% fiber content. According to their test results, the ideal CFRM composites contain 3% carbon fiber.

3. Mechanical Properties:

Researchers have performed an experiment to know the mechanical properties of concrete incorporating carbon fibre. Hardened concrete were carried out for their compressive strength, split tensile strength, flexural strength and also the water absorption with various fraction of volume of carbon fibre.

Compressive strength

(Basit et al.2023) Study the compressive strength at 28 days. It was found that the addition of carbon fibre enhances the concretes compressive strength up to a specific quantity, beyond which it decreases the strength considerably. By adding carbon fibre (CF) 0.20% compressive strength improve by 13.98%; by adding 0.40% fibre, it increased by 16.29%; and by adding 0.60% carbon fibre, compressive strength increased by a maximum of 20.93%. By adding 0.80% fibre compressive strength start to decline, by adding CF1% compressive strength enhance by 10% only. It is now clear that carbon fibre more than 0.60% lowered the compressive strength of the concrete.

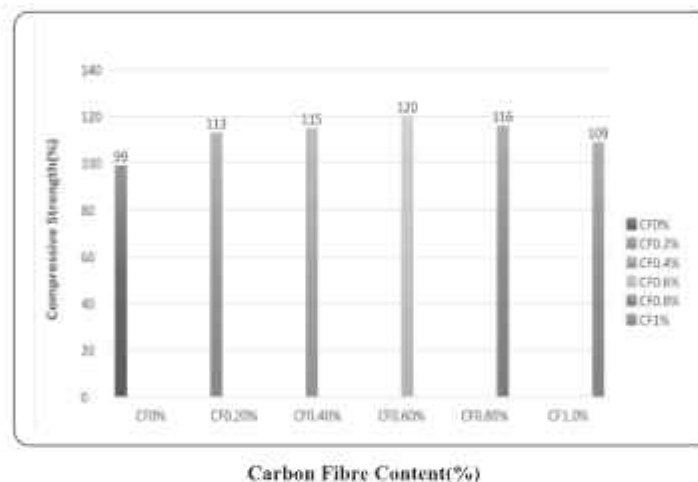


Fig1. Effect of carbon fibre on compressive strength (Basit et.al 2023)

(Andrew et.al 2023) In this study they have used recycle carbon fibre with Ultra- High- Performance Concrete. Thereafter, compared result compressive strength with neat concrete, aerospace grade carbon fibre (Hexcel), industrial grade fibre (Zoltek) and the steel fibre. The RCF mix design's compressive strength (135.3 MPa) was roughly 42.5% greater than that of the neat mix design (87.9 MPa), 17.9% higher than that of the steel mix design (113.1 Mpa), 0.6% higher than that of the Hexcel carbon fiber mix design (134.5 MPa), and roughly 23.2% higher than that of the Zoltek carbon fiber (107.2 MPa).

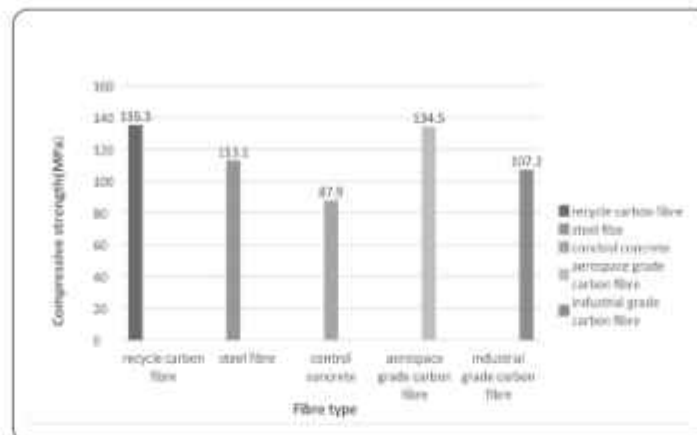


Fig2. Effects of carbon fibre on compressive strength (Andrew et.al 2023)

(Aksar et.al 2023) Compressive strength increased by about 6% and 10%, respectively, in 28- day NSC and LSC samples when a 0.25% CCFRP ratio was added to the mixture. Compressive strength decreased by roughly 20% and 40% for 0.5% and 0.75 percent CCFRP, respectively, as the CCFRP ratio increased. According to the results of the 7-day age samples test, the addition of 0.25% CCFRP significantly increased early-age strength; however, the addition of 0.5 and 0.75% CCFRP negatively affected the concrete's compressive strength. CCFRP has less of an effect on concrete's compressive strength than ordinary added fiber.

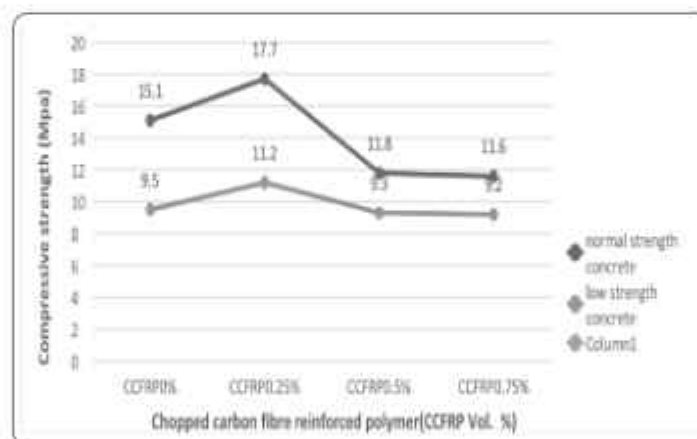


Fig3. Compressive strength 7 days (Aksar et.al 2023)

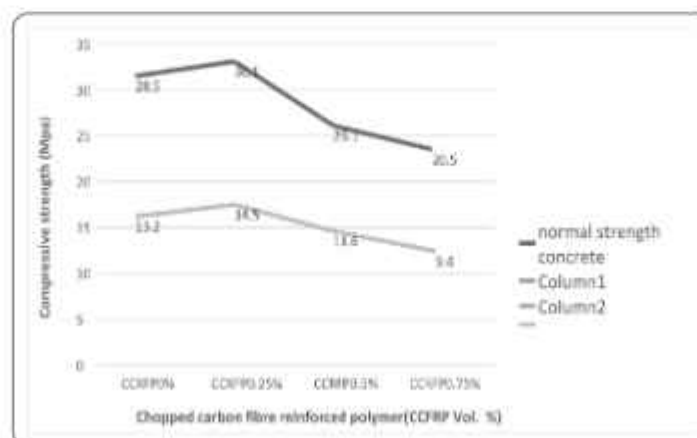


Fig4. Compressive strength 28 days (Aksar et.al 2023)

(Md. Safiuddin et.al) In this study they have determine the compressive strength of hardened mortar composites at the ages of 7 and 28 days in accordance with ASTM C39/C39M-01. Their research revealed that, up to a 3% fiber content, the compressive strength rose linearly with the addition of carbon fiber before abruptly declining. Thus, it may be said that the compressive strength decreased as the fiber content surpassed 3%.

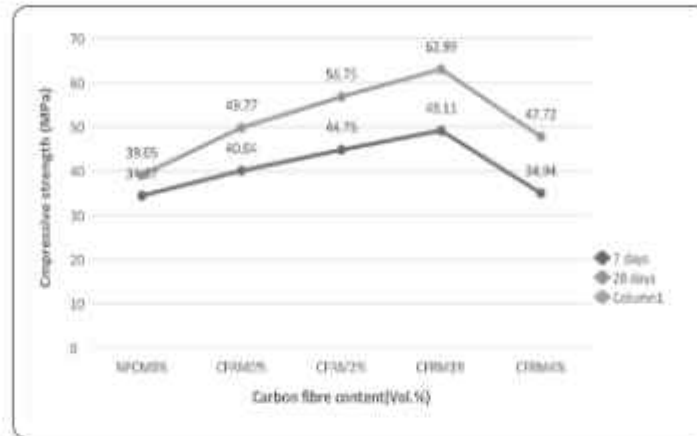


Fig5. compressive strength 7 and 28 days (Md. Safiuddin et. al 2021)

Split Tensile Strength

Split tensile strength is mostly determine to understand the behaviour of concrete under tension. (Basit et al.2023) With addition of carbon fibre content CF0.20%, CF0.40%, CF0.60%, CF0.80 and CF1.0% the tensile strength improved by about 56%, 57%, 59%,56% and 53%. This study concluded that when amount of carbon fibre goes above 0.60%, the split tensile strength of concrete begins to decline.

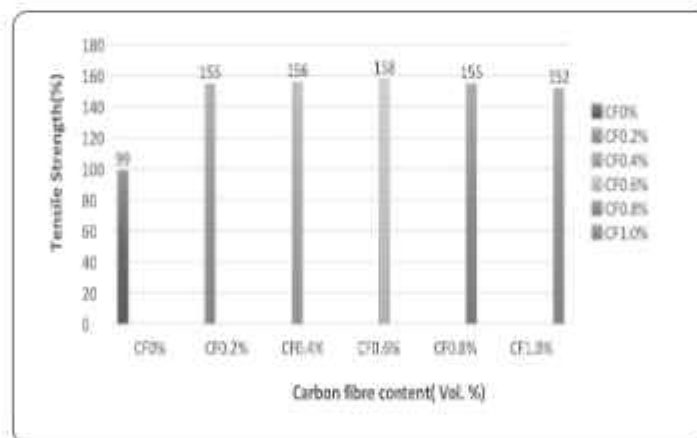


Fig6. Split tensile strength (Basit et. al 2023)

(Andrew et.al 2023) According to the study, the recycled carbon fiber mix design's tensile strength (6.89MPa) was roughly 27.8% higher than that of the neat mix design (5.21MPa), 4.6% higher than that of the steel fiber mix design (6.58MPa), 26.3% higher than that of the Hexcel carbon fiber mix design (5.29MPa), and roughly 26.4% lower than that of the Zoltek carbon fiber mix design (8.99MPa).

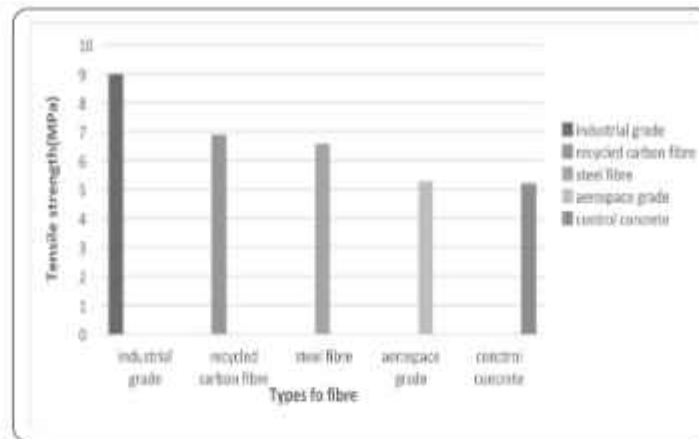


Fig7. Split tensile strength (Andrew et.al 2023)

(Aksar et.al 2023) When 0.25% CCFRP is added to the concrete mix, the split tensile strength rises by around 17% for LSC and 44% for normal strength samples tested at 28 days. Similar behavior was seen in samples that were 7 days old. Increasing the dosage of CCFRP causes this beneficial impact to turn negative. These findings show that CCFRP significantly increased the concrete's split tensile strength and that it can function as a substitute for

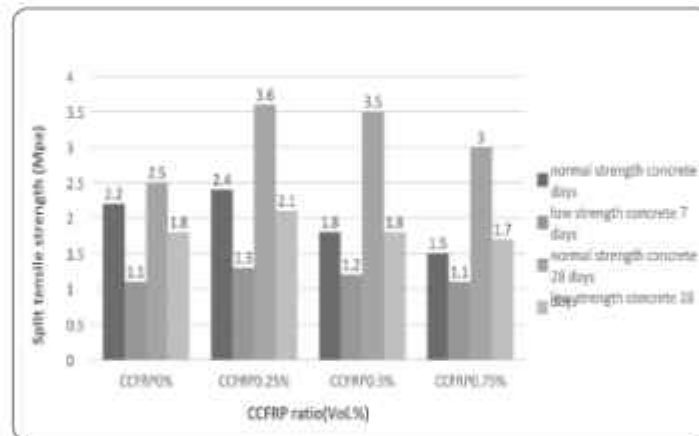


Fig8. Split tensile strength at 7 and 28 days (Aksar et.al 2023)

(Md. Safiuddin et.al) Tensile strength increased roughly linearly, according to their findings. It was shown that CFRM composites with 4% carbon fiber had a splitting tensile strength that was 1.5–2 times higher than that of NPCM. This strength enhancement was caused by the carbon fiber's bridging effect during crack formation. Therefore, it is concluded that the increase in the carbon fibre content increase splitting tensile strength of the concrete.

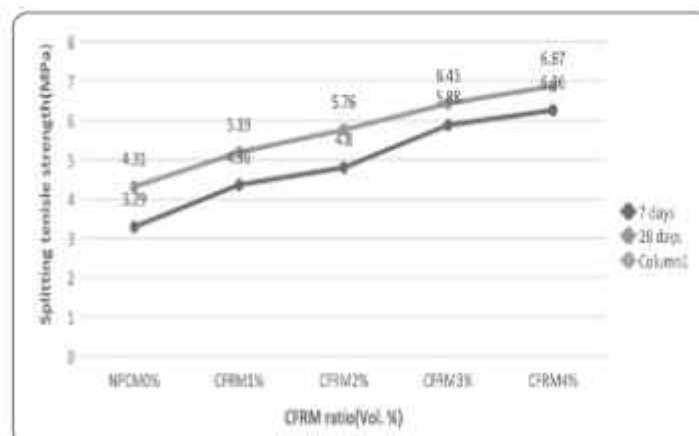


Fig9. Splitting tensile strength at 7 days and 28 days (Md. Safiuddin et.al 2021)

Flexural Strength

(Andrew et.al 2023) The RCF mix design's flexural strength of 10.7 MPa was roughly 8.9% lower than that of the neat mix design (11.7 MPa), 18.6% lower than that of the steel fiber mix design (12.9 MPa), 0.9% lower than that of the Hexcel carbon fiber mix design (10.8 MPa), and 8.5% higher than that of the Zoltek carbon fiber mix design (9.83 MPa).

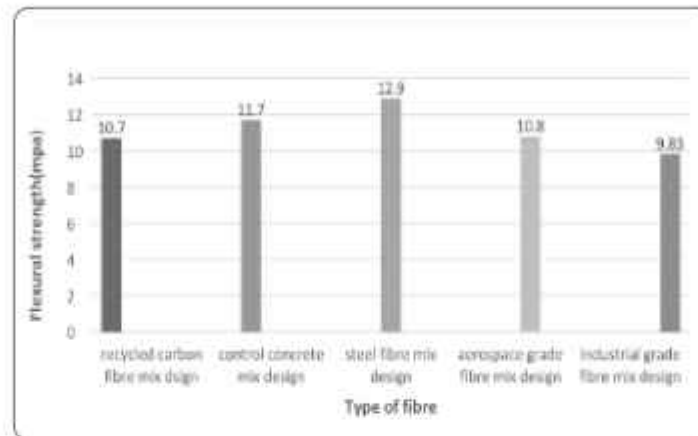


Fig10. Flexural strength (Andrew et.al 2023)

(Aksar et.al 2023) CCFRP increases flexural strength by 20% in samples with normal strength and 3% in samples with poor strength at a dosage of 0.25%. Higher dosages of CCFRP have a detrimental impact on low-strength samples and somewhat improve normal-

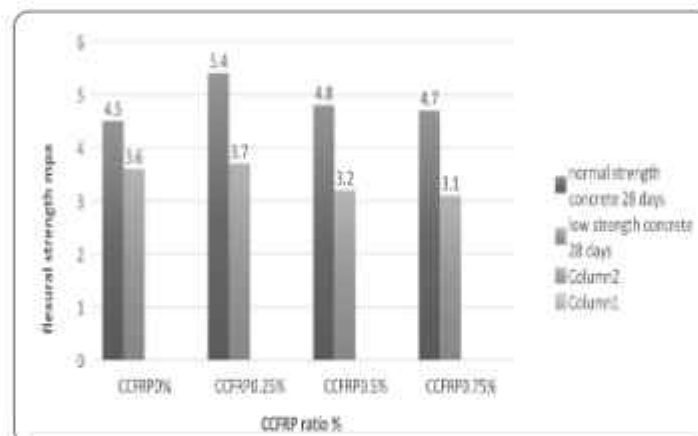


Fig11. flexural strength 28 days (Aksar et.al 2023)

(Md. Safiuddin et.al) The third-point loading configuration was used for the study's flexure test since it often yields more accurate results. This study demonstrates that when the amount of carbon fiber in CFRM composite grew, its flexural strength increased nonlinearly. For maximal flexural strength, the mortar composite with 4% carbon fiber was used. Additionally, they proposed that the improved reinforcing and bonding effects of carbon fiber, which are brought about by the densified microstructure of mortar created by silica fume and superplasticizer, are the primary cause of the increase in flexural strength that occurs when carbon fiber is used.

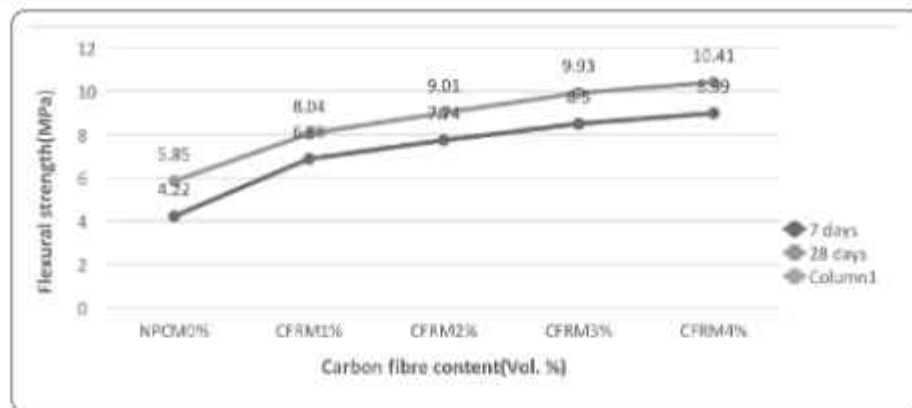


Fig12. Flexural strength of mortar composites (Md. Safiuddin et.al 2021)

4. DURABILITY:

Water Absorption

(Basit et. al 2023) Water absorption in the control sample and samples with fiber added were examined in this study. The largest water absorption, at around 10.12%, is seen in 0% fiber. Water absorption is reduced by 12.19%, 17.81%, 31.60%, 71.23%, and 81.2%, respectively, when carbon fiber (CF) is added at 0.20, 0.40%, 0.60%, 0.80%, and 1.0%. According to this study, while concrete's durability is increased, an increase in carbon fiber is frequently linked to a decrease in water absorption.

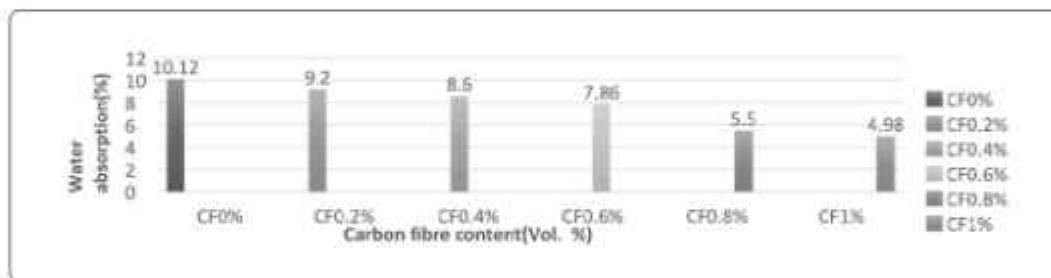


Fig13. Water Absorption (Basit et.al 2023)

(Md. Safiuddin et.al) It has been shown that adding carbon fiber reduced water absorption up to a 3% fiber content, after which it rose at a 4% fiber concentration. They have proposed that the larger capillary pores and air voids in the mortar composites may be the cause of this rise. We also know that mortar's water absorptions were primarily controlled by its porosity; the higher the porosity, the higher the water absorptions.

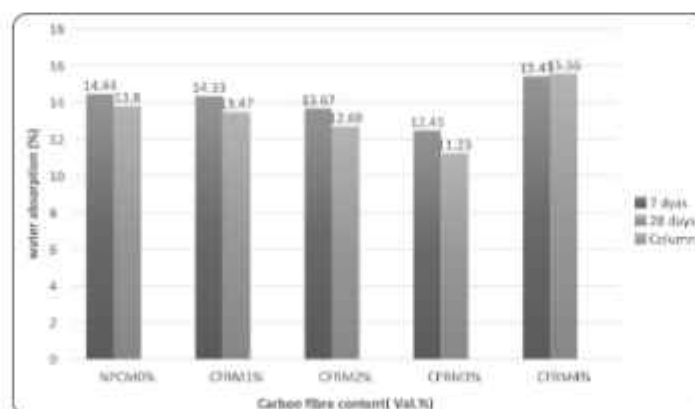


Fig14. Effects of carbon fibre content on the water absorption of mortar composites (Md. Safiuddin et.al 2021)

Acid Attack

(Basit et al.2023) It was shown that the mass loss from acid attack significantly decreased at the maximum carbon fiber ratio. This research indicates that by lowering mass loss from acid attack, carbon fiber may successfully improve the serviceability and durability of self-compacting concrete.

5. WORKABILITY:

Slump flow test

(Basit et. al 2023) The EFNARC standards, which provide a 711mm slump for control concrete, served as the basis for the test. Different proportions of carbon fiber (CF0.20%, CF0.40%, CF0.60%, CF0.80%, and CF1.0%) were added to concrete, and the resulting sag reduction increased by 2.30%, 4.55%, 6.91%, 9.38%, and 11.92%, respectively. However, as the percentage of carbon fiber increases, the concrete becomes less workable, leading to different design limitations.

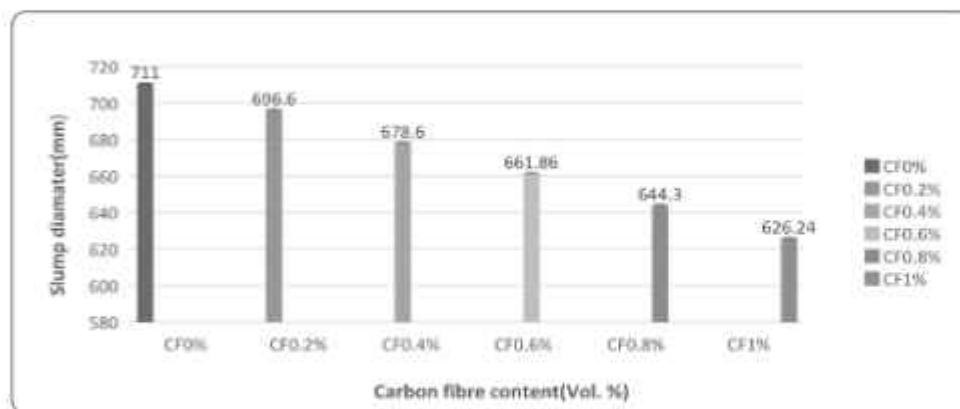


Fig15. Slump flow test (Basit et.al 2023)

(Andrew et.al 2023) When the flow of each blend was measured, the steel had the second- best flow at 74% and the neat had the highest at 133%. 44% of the carbon fiber was Hexcel, 36% was RCF, and 27% was Zoltek.

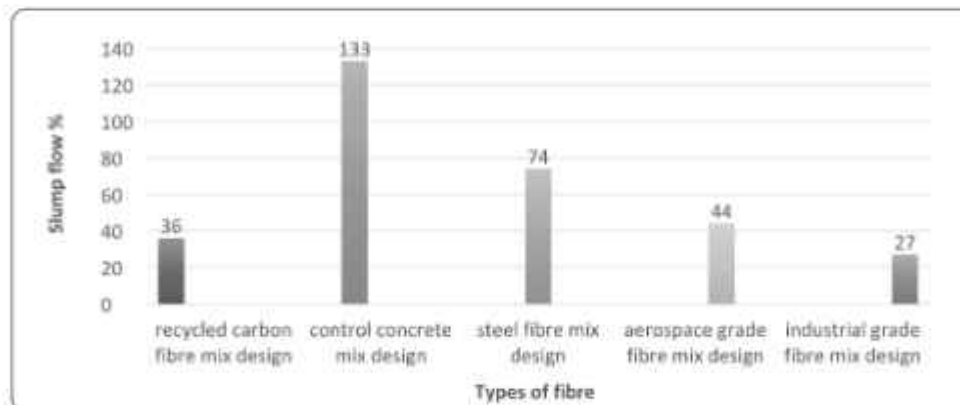


Fig16. Slump flow (Adrew et.al 2023)

(Aksar et.al 2023) Even with the application of the water reducer Visco Crete 5930, the presence of CCFRP had a substantial impact on the slump test findings. With the addition of 0.5% CCFRP to LSC, the slump test result decreased from 140 mm to 20 mm. However, when CCFRP is added, the slump of regular-strength concrete decreases from 190 mm to 30 mm.

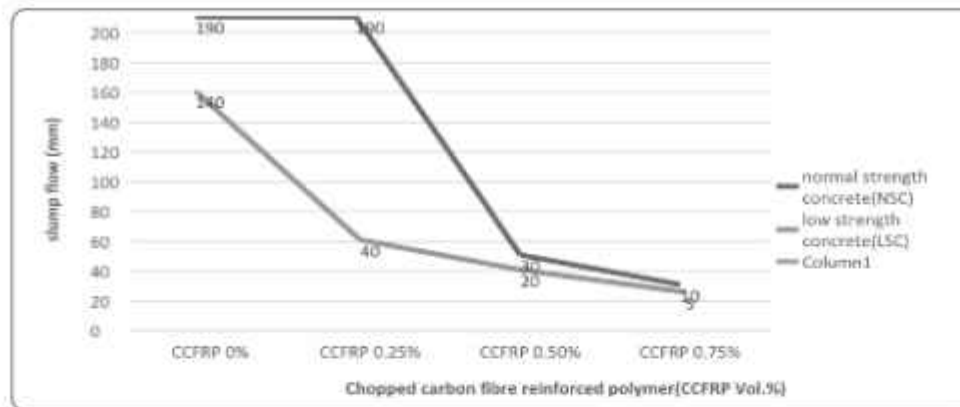


Fig17. slump flow (Aksar et.al 2023)

(Md. Safiuddin et.al) We are aware that, generally speaking, the slump of mortar composites decreased as the fiber content increased. According to this study, 3% is the ideal amount of carbon fiber for slump. They also came to the conclusion that CFRM composites need a greater dosage of the superplasticizer in order to be sufficiently workable for vibration- induced compaction. Due to varying carbon fiber concentrations, it was not feasible to use the same superplasticizer dosages for all mortar composites. We are aware that, generally speaking, the slump of mortar composites decreased as the fiber content increased. According to this study, 3% is the ideal amount of carbon fiber for slump. They also came to the conclusion that CFRM composites need a greater dosage of the superplasticizer in order to be sufficiently workable for vibration-induced compaction. Due to varying carbon fiber concentrations, it was not feasible to use the same superplasticizer dosages for all mortar composites.

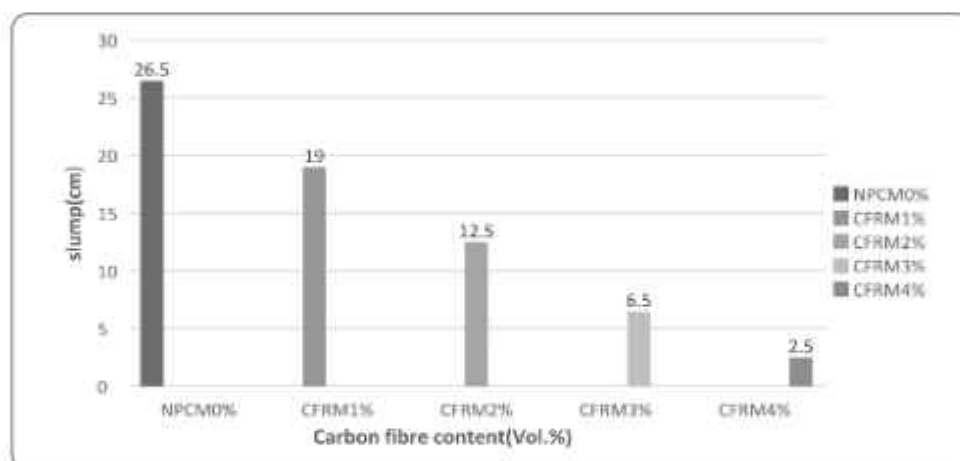


Fig18. slump flow (Md. Safiuddin et.al 2021)

L-Box Test

(Basit et al.2023) This test implies CF0.8% is the best level for adding carbon fibre to concrete in order to improve its workability and remain within the permissible range. Otherwise, it might hinder the ability of self-compacting carbon base concrete.

6. RESEARCH GAPS:

The review of the available paper has the following research gaps:

- * The previous study concluded that fibre orientation affects the mechanical properties of concrete, but there is a lack of method by which the fibre can be oriented in the direction perpendicular to the load.
- * There should be direct comparison between various length of fibre (Eg.6mm and 12mm carbon fibre) to know the best strand length of fibre
- * Compressive strength increased up to certain limit beyond it start decrease. Study should be performed to linearly increase the compressive strength incorporating carbon fibre of any fraction of volume.
- * There is also need to study using a recycled coarse aggregate and check their fresh and harden properties because the previous studies were limited to fresh coarse aggregate only.

7. CONCLUSION:

This paper reviewed the influence of fibre addition on hardened and fresh properties, and the following conclusions are made based on from our studies.

- * Excessive fibre addition to concrete led to the development of voids, which in turn reduced the compressive strength of concrete. Despite this, splitting and flexure tensile strength rises linearly with fibre content.
- * The post-cracking strength of concrete has increased as the fibre content has increased; however, the pre-cracking strength of concrete has had minimal effect. Specimens with fibres aligned perpendicular to the axis of load have greater strength than specimens with fibres aligned parallel to the axis of load.
- * Water absorption of carbon fibre decreased up to certain fibre proportion, and then increase almost linearly. This can be due to the increased number of capillary pores and air voids existing in the mortar composites.
- * The slump of mortar composites decreased with the increased volume content of carbon fibre. It implies that the increase in carbon fibre content lessened the workability of mortar due to large surface area and interlocking of the fibre. Hence, higher dosages of superplasticizer were required for the mortar composites.
- * At the highest ratio of carbon fibre, the mass loss due to attacks is greatly decrease because it offers adequate strength to limit the mass loss as it combined the constituents of concrete into one family, thereby preventing any major or minor crack progression in the concrete due to external attacks.
- * Increase in proportion of carbon fibre could effectively increase the durability of concrete by reducing the mass loss from acid attacks.

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Evaluate Growth of Entrepreneurial Eco system with AGI

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Abstract:

Organizations, and institutions collaborate and form entrepreneurial ecosystem (EES) to promote entrepreneurship. It embraces the policies, culture, networks with institutional support and resources that include talent, leadership, finance, knowledge and infrastructure that aid in the establishment and expansion of new businesses. These elements of entrepreneurial ecosystem enable them to interact successfully by quickly locating the resources they require at every step of Progress. The existence of successful companies is due to the quality of its entrepreneurial ecosystem. When the EES elements are managed in such a way that they make it possible for productive entrepreneurship. The purpose of this paper is to develop an EES in with AGI to enhance the quality of regional EES. AGI back up entrepreneurial ecosystem through sophisticated proficiencies in market analysis, creating unique idea, client perceptions, best utilisation of resource, talent evaluation, and network linking with public and private entrepreneurs for the group accomplishment. Artificial general intelligence (AGI), permits entrepreneurs to be aware of latest market information, and assist them to competently restructure their business processes. AGI is able to identify high-potential talent employee for startups and assist them in recruiting people, who are Taylor made for the roles based on their competencies and involvement and evaluate the applicant profiles and aptitude to suit the business. Through communication and entering partnership with others, various domains in EES typically have the ability to transfer or share crucial technologies and knowledge. Taking Silicon Valley as an illustration, a prominent entrepreneurial ecosystem was formed by the universities and research institutes have significantly provided to the expansion of the local economy by providing businesses with fresh information and talent.

Keywords:

Entrepreneurial ecosystem, institutional support, culture, Artificial general intelligence, talent employee, expansion of the local economy

1. Introduction

The three primary pillars of sustainable development theory are environmental eco system, social progress, and economic viability. This theory is most appropriate for the current study since it fully explains the necessity, procedure, and results of a business organization's progress. It meant to protect and highlight the current situation without sacrificing aspirations for future generations of nations. Due to the rapid changes in the world, product development is unclear, as trends, consumer interest, and local requirements keeps changing. Understanding how the demands are changing in time, when manufacturing a product should not become obsolete before it's introduced in the market is difficult for businesses. This issue is significantly lessened by a healthy EES. Using AGI, it becomes easier to connect with salespeople, customer service representatives, and consumers who generates a wealth of feedback about what the market requirements and ideas for creating unique products. If a company wants to continue producing market-relevant products, it needs this kind of feedback immediately through AGI, to change as per the customer wants.

Both domestic and multinational enterprises have gradually improved their capacity to innovate for the global market. The Indian software services sector experienced a sharp increase during that time due to the availability of highly skilled, reasonably priced workers and dependable connectivity, which allowed for the remote provisioning of software and software-enabled services. AGI is a tool to make the world a better, more satisfying place for everyone, not just a way to increase automation, boost profits, and cut expenses. Leadership will be essential in directing the development of AGI to uplift humanity and guarantee its responsible integration into all facets of life, whether we are in charge of businesses, organizations, or even entire nations.

2. Review of literature

Shabnam Khan et al (2023) highlighted that over the past two decades, a new phenomenon known as entrepreneurial agility has emerged. It's the ability of an individual or organization to anticipate, visualize, and take advantage of unanticipated opportunities and issues for entrepreneurs in the market. The study also looked at the moderation of environmental eco system between entrepreneurial agility and workable business routine and business modernization and entrepreneurial liveliness.

Kellie Auman (2019) explained Environmental ecosystems are undoubtedly transforming business in the modern era, shifting it away from rigid vertical hierarchies of the 20th century and towards more resilient Artificial general intelligence (AGI) applied business models. They obtained the advantages of operating a service without incurring the exorbitant expenses by employing independent contractors as a part of an open network. These problems are significantly reduced by the ecosystem-based approach.

Srivardhini K. Jha (2018) mentioned that the new paradigm of entrepreneurial ecosystems, fundamental idea is that businesses operating in an ecosystem have a better chance of success. When eco system is supportive, chance of success is there. The EES can be divided into six domains, each of which has a number of components that interact in unique and complicated ways. They are available markets, finance obtainability, a supportive culture, high-calibre human capital, an advanced policy framework, and a variety of institutional support are these areas. India is the third major developing ecosystem in the world.

Alex Goryachev (2025) stated that Artificial general intelligence (AGI) has the potential to completely transform a variety of fields, including science, healthcare, and even our comprehension of the cosmos. AGI will revolutionize sectors and spur innovation at a rate never before seen. AGI promote cross-functional cooperation between teams with different backgrounds both inside and outside of one's company. A comprehensive approach to AGI development will guarantee that the solutions users develop are all-encompassing, sustainable, and human-centered, regardless of the field, engineering, human resources, or business strategy. There will be less red tape and more creative, significant AI applications as a result of different disciplines working together.

David B. Audretsch et al (2021) described that we use the institutional pillars to forecast how people's behaviour will shift towards either productive or unproductive entrepreneurship within the ecosystem. The changing aspects of entrepreneurial activity and how entrepreneurs perceive chances are transformed by institutional contexts. The regulatory pillar of institutions and entrepreneurship have a serious trust issue. In the case of corporate taxes, for instance, entrepreneurs would be less likely to pay taxes if they did not think that they would not benefit from doing so. They are entering the shadow economy and engaging in unsuccessful entrepreneurship.

The objectives of the study are to find the domains of entrepreneurial eco system and the support of institutional theory to promote EES. Finally check whether the application of AGI support the growth of entrepreneurial eco system.

3. Domains of Entrepreneurship Ecosystem

Finance is the main source for the growth of EES. Capital can be obtained from various sources like angel investors, venture capitalist and by issue of shares and debentures in stock market. To compete in globalised world talent plays an important role. AGI supports in recruiting skilled labourers through social media. In contrast to traditional methods, an artificial general intelligence could play a significant role in the selection of leaders by analysing large datasets of eligible contenders and appraising their performance, leadership abilities. A good leader holds qualities like coordination, good communicator, compassion, vision, decisiveness, adaptability, and the ability to inspire others. Culture is an important component of an ecosystem for entrepreneurship because it moulds the attitudes, customs, and costs that affect the amount of entrepreneurial activity in a community. It decides whether risk-taking, modernization, teamwork, and a readiness to accept new ideas, which has a momentous effect on the accomplishment of startups and the energy of the ecosystem as a whole. Culture serves as a basic element that rely on characteristics, which support or impede entrepreneurial endeavours.

Knowledge is essential to an entrepreneurship ecosystem because it serves as the basis for innovation, allowing entrepreneurs to spot opportunities, create workable business plans, get the resources they need, and eventually boost economic growth by facilitating the exchange of knowledge and skills amongst the ecosystem's many actors, such as universities, accelerators, mentors, and other entrepreneurs. In other words, a strong knowledge base is essential for entrepreneurs to overcome obstacles, make wise decisions, and promote teamwork, all of which contribute to a more vibrant and prosperous entrepreneurial environment. In essence, a vigorous market is where entrepreneurs can contact customers and examine their business model to regulate its feasibility and potential for accomplishment. The market helps new businesses, an opportunity for entrepreneurs to authenticate their ideas, trade their goods or services, earn income, and ultimately attain workable development. The above areas support healthy environment eco system where entrepreneurs can succeed in their venture with confidence. AGI supports existing entrepreneurs and startups to get fund, recruit talented apt employees, train able leadership, obtain knowledge regarding business in global level and finally enhance their marketing abilities to sell their products in international level.

Figure 1 Domains of Entrepreneurship eco system



4. Institutional Theory

According to institutional theory, institutions are social framework with normative, regulative, and cultural-cognitive elements that helps to bounce back from any issues. Institutions are a complicated concept. It covers a variety of subjects in a broad range of social science domains, from a sociological perspective of institutions to an economic perspective. The inheritance of institutions study how the intricacy of cultural, political, and legal frameworks impact economic development (David B. Audretsch et al (2021)). Two opposing perspectives on the development of entrepreneurial ecosystems are top-down approach and the bottom-up approach that intensify the role of institutions. The mechanisms that enable this progress are deep-rooted in cognitive framework, rules, culture, and attitudes regarding entrepreneurship, even though the bottom-up approach adopts that ecosystems progress similar to natural ecosystems. The three institutional pillars that support entrepreneurial behaviour are normative, cognitive, and regulatory institutions. The institutional framework explains how changes in the institutional context at the national and regional levels contribute to variations in entrepreneurial activity across different ecosystems for innovation and entrepreneurship. The institutional framework elucidates how variations in the institutional framework at the national and regional levels offer variations in entrepreneurial activity in different ecosystems for novelty and entrepreneurship (Content J. et al-2019).

The three institutional pillars that support entrepreneurial behaviour are regulatory, normative, and cognitive institutions. The regulatory pillar, consists of laws, rules, and other entrepreneur backup materials that establish the legal limits and rules of the business. The normative pillar, supports the social values, customs, and beliefs that influence how people behave as an individual and as a group. The cognitive pillar shared logics of deed that people and organizations use to understand the material that is existing, set their hopes regarding the results of their behaviour, and choose market strategies for entrepreneurial ecosystem. The three pillars alter the behaviour of interdependent entrepreneurs, legislators, investors, banks, to promote or hinder successful entrepreneurship.

According to various viewpoints, institutions set hopes that dictate what organizations should do and serve as the justifications by applying laws, regulations, and accepted behavioural norms that seem normal and enduring (Bylon Abeeku Bamfo et al -2023). Since regulatory pillar have relations with economic agents are predisposed by the rules recognized by the government, the regulatory pillar both helps and deters entrepreneurship by inducing the degree of risk intricated in the formation and launch of a business. The regulatory pillar may result in unproductive entrepreneurship activity and alter the scope and complexity of resources that the government made accessible to entrepreneurs. Opportunities brought about by increased government support for entrepreneurship and formal institutional networks that are open and crystal clear to all economic actors in the entrepreneurship ecosystem directed to productive entrepreneurial activity (Belitski M. et al -2019).

Low regulatory pillars of institutions are more common in developing and transitioning nations, which lowers the entrepreneurship ecosystem's overall efficacy and leads to a rise in ineffective entrepreneurship. There reasons include: the dissolution or collapse of previously established institutions as a result of independence, war, regime change, or other factors (Estrin S. et al -2013). When entrepreneurial chances and positive outcomes are perceived, cross-city cultural differences, perceptions of entrepreneurial action, and the place given to an entrepreneur are likely to impact entrepreneurial activity.

Figure 2 Entrepreneurship ecosystem model

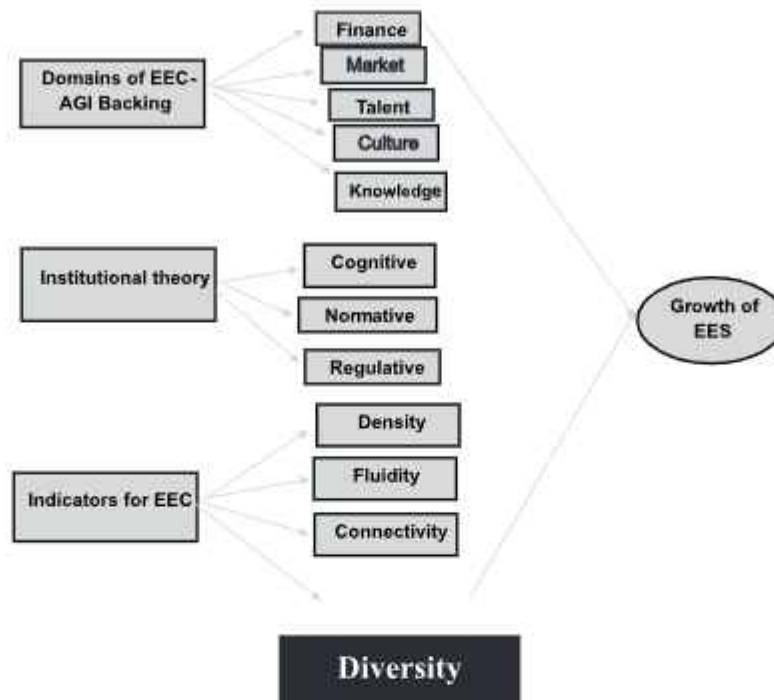


Source: Saurav Sonkar (2021)

5. Entrepreneurship Ecosystem

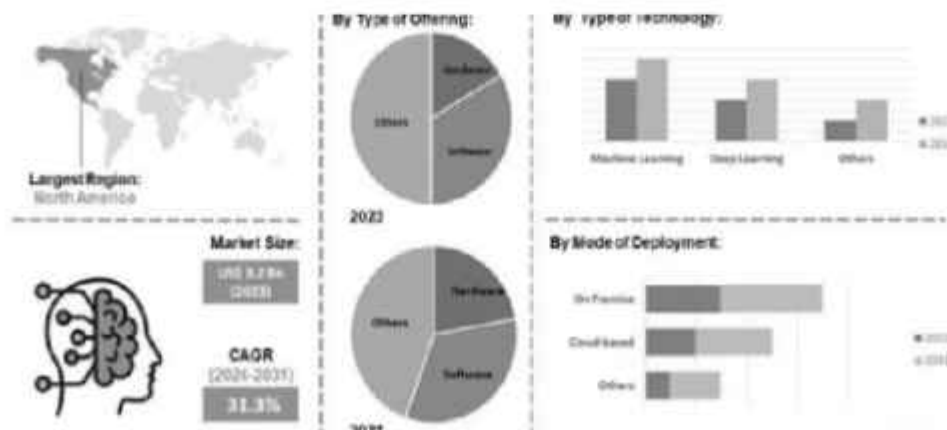
An entrepreneurial ecosystem conceptual model illustrates the market, human capital, finance, culture, support, and policy was proposed. A seed accelerator model was put forth whereby a large number of start-ups participate in cohort-based boots camps where they receive training and mentorship, revealing to a diverse range of mentors and experts (Saurav Sonkar (2021)).

Figure 3 Conceptual model of study



6. Indicators of EES

Entrepreneurs are the backbone of any entrepreneurial ecosystem, entrepreneurs vary based on old or new start-ups and determine the relative density of entrepreneurship. Population flux, or people moving between cities, and geographic mobility are ways to measure fluidity. People must find suitable employment within a region. Concentration of fast-growing businesses will show whether or not business owners can quickly profit from that bricolage process and direct resources toward fruitful endeavours. Besides this, connections ought to enable them to ascertain how various resources are used and how the organizations interact with one another. Programs, spin-off rates, and deal maker networks must all be connected (Dane Stangler et al -2015). Economic complexity has been linked to innovation and growth, according to research. Economic diversity, is a crucial idea as no city should be unduly dependent on any one sector. A key indicator of development should be how well cities are able to draw in immigrants and integrate them into the entrepreneurial ecosystem. Therefore, data on the likelihood of moving up or down the economic ladder between income level should be used to measure economic mobility, which should be a key indicator for the entrepreneurial ecosystem.



Source: AGI market report

The global artificial general intelligence (AGI) market is projected to grow at a compound annual growth rate (CAGR) of 31.3% from 2024 to 2031, from its estimated US\$ 3.2 billion in 2023 to US\$ 26.9 billion by 2031, it uses machine learning, deep learning and other technologies, according to the most recent research by InsightAce Analytic. AGI mainly relies on cutting-edge advancements in computer power and machine learning methods to build robots that are capable of carrying out any creative task that a human can. Recent advancements in machine learning and natural language processing (NLP) have led to significant advancements in the development of expanding algorithms. Through the use of these technologies, artificial general intelligence (AGI) systems can process and understand a greater variety of information, learn from experiences more effectively, and make more difficult decisions, thereby becoming more cognitively similar to humans and help for the growth of entrepreneurial ecosystem. The applications of AGI, increasing market demand and investment and promote EES.

For effective entrepreneur eco system and individualized service, an AGI-powered customer support system would access a large amount of customer data and integrate it with real-time analytics. AGI may be able to foresee issues, customize responses, offer solutions, and even anticipate follow-up questions by building a thorough customer profile. Because of its emotional intelligence, it can modify communication to be sympathetic and encouraging, which improves the customer experience. By offering a hardcoded understanding of architecture, dependencies, and change history, AGI can increase productivity. When a function that computes shipping costs according to location, weight, and method is required, after analysing pertinent code, AGI creates a draft function with solutions outlining its reasoning, which the programmer can then review, improve, and incorporate. When an entrepreneur plans to invest AGI spot intricate market trends and possible disruptions, analyse hedge funds, it examines enormous data sets from social media, and satellite imagery to make better investment decisions, it verifies a potential market correction by examining news stories and historical data, that assist the fund manager to make well-informed choices to modify their portfolio and reduce risk.

7. Research Methodology

Qualitative research method was used to collect data from 115 entrepreneurs in Chennai using a structured close-ended questionnaire, finally 100 respondents Selected for the study. Snowball sampling method selected to collect samples from respondents. The study analysed the data to test the growth of Environmental eco system using AGI. The effect of AGI on EES based on GDP, talented labour force, capital, and total productivity studied. Growth of EEC using AGI is a dependent variable. Domains of EES, Institutional theory and indicators of EES are independent variables. AGI play an important role for entrepreneurial growth by obtaining the domains required and lead them in right direction for their development.

Linear Multivariate Regression**Model Summary - Effect of EES with AGI**

Model	R	R ²	Adjusted R ²	RMSE
M1	0.99	0.998	0.993	1.233
M2	0.99	0.988	0.976	1.299

The multiple linear regression model elucidates the change in risk growth of EES, an independent factor, that is influenced by the domains of EES, Institutional theory and Indicators of EEC as dependent variable. Since the value of RMSE is 1.233, better to select Model 1 as the best model for forecasting growth acceptance because it has the lowest RMSE value, which indicates that the average difference between the forecasted and actual prices is the smallest.

R^2 value is close to 1, it means that the predictor variables can fully explain the response variable.

ANOVA

Model		Sum of Squares	df	Mean Square	F	P
M1	Regression	870.480	3	290.160	190.920	0.053
	Residual	1.520	1	1.520		
	Total	872.000	4			
M2	Regression	861.426	2	430.713	81.468	0.012
	Residual	10.574	2	5.287		
	Total	872.000	4			

Since the p-value is smaller than $\alpha = .05$, we reject the ANOVA's null hypothesis and come to the assumption that the three groups & means differ statistically significantly. There is a variance between the group means when the F-statistic is advanced.

Coefficients

Model		Unstandardized	Standard error	Standardized	t	P
M ¹	(Intercept)	16.366	2.026		8.079	0.078
	Domains of EES	-0.843	0.095	-0.717	-8.833	0.072
	Institutional theory	0.328	0.135	0.188	2.441	0.248
	Indicators of EES	0.781	0.078	0.570	9.964	0.064
M ²	(Intercept)	16.249	3.777		4.302	0.050
	Domains of EES	-0.649	0.098	-0.551	-6.638	0.022
	Indicators of EES	0.901	0.114	0.657	7.914	0.016

Under coefficient test Predictors with high t-values and low p-values are considered significant. With the usage of AGI, there is growth in Entrepreneurial ecosystem.

8. Research Gap

The researcher evaluated many prevailing literatures, and identified limitations, and found that regarding Entrepreneurial ecosystem one or 2 independent variables were considered. In this study three independent variables influencing the growth of business in AGI era was analysed. Access to AGI technology, helps in data availability, a talent pool with AI skills, the regulatory environment, cultural acceptance of AGI, the degree of ecosystem connectivity, knowledge sharing, and the ability of AI to facilitate crucial interactions between ecosystem players like investors, mentors, and entrepreneurs are all important factors to take into account when examining the impact of AGI on an entrepreneurial ecosystem. These factors all have an impact on how AGI can be used to boost innovation, spot prospects, modernize procedures, and progress in decision-making within the ecosystem.

9. Findings

The regulatory structures incompetence carried on by corruption and unadorned political economic collapse, particularly through the period of transitioning from one form of governance to another. The issues in normative pillar of institutions, is lack of strong government ethnicities, the progress of civil society, and constraint of political and economic liberty. Entrepreneurs who operate in an environment of weak civil society and low regard for entrepreneurs as transformers, will select an unproductive business venture that neither benefits nor hurts society. It is perceived entrepreneurial opportunities and the level of entrepreneurial effort directed towards progress and striving entrepreneurs prejudiced by the local entrepreneurial ecosystem. There is a robust positive correlation between entrepreneurial culture and informal networks for the successful entrepreneurship. Business education fosters entrepreneurial cognition support high-growth and productive businesses. No state in India has all internal and external components of the entrepreneurial ecosystem, according to the analysis of the startup and industrial policies of the states. Suppliers, culture, technology, and entrepreneurial education are absent from Tamil Nadu's startup and industrial policies. With the help of AGI, entrepreneurs can easily obtain capital, talent, competent people and expand AGI-powered companies; feel a supportive environment where AGI innovation can thrive through cooperation and easily accessible resources.

10. Suggestions

As high levels of corruption result in unproductive entrepreneurship performance, Government must regulate the government departments from getting corruption, through severe punishments. Indian government can be suggested that all states are instructed to include all the factors mentioned in the proposed model so that growth will occur. Organisation will hold fruitful entrepreneurial goals, when there is enhancement in growth-focused entrepreneurship, the positive hopes and beliefs of entrepreneurship resolve societal problems and encounters through innovation and economic growth. Entrepreneur when he discovers right time to start his venture, with individual involvement can contact a businessperson who has launched a business in the past, is vital to entrepreneurial cognition. Business education is important for entrepreneurs as it will boost entrepreneurs & confidence to take gain from market prospects within the urban ecosystem.

11. Conclusion

Multifaceted measure of the institutional environment at Chennai level is studied, and its relationship to the ecosystem's productive and unproductive entrepreneurial activity in developing and transitional economies is examined. In institutional context, it comprises of 3 institutional pillars that are connected to the entrepreneurial activity in Chennai's entrepreneurial ecosystem. In order to learn more about local institutions, this study investigates normative, cognitive, and regulatory institutional preparations. The findings provide fresh insight into the differences among different institutions. EES of advanced value have normative, cognitive, and regulatory pillars of institutions working together as a conduit to productive entrepreneurship, spur innovation and reduce opportunistic behaviour of corporates, entrepreneurs and policy makers. EECs of advanced value have normative, cognitive, and regulatory pillars of institutions work together as a channel to productive entrepreneurship, outgrowth innovation and lessen resourceful behaviour of corporates, entrepreneurs and policy makers. During AGI period, entrepreneurial ecosystem designates a network of interrelated people, organizations, and resources in a particular area that actively encourage the establishment and expansion of startups using AGI technology. Instead of being exceptionally good at one thing, AGI would be able to do a variety of tasks. To dispel the myths surrounding AGI's potential and dangers, public education is essential. Public education can decrease misunderstandings, encourage community participation in forming the moral and practical framework surrounding AGI, and create a more informed conversation. AGI has the potential to revolutionize many fields and bring about positive change (Katie Le (2024)).

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