COMPARATIVE ANALYSIS OF CHEMICAL AND NATURAL ADMIXTURE IN CONCRETE

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ABSTRACT

Admixture is a substance added to concrete to enhance its properties or performance. It can influence the workability, strength, durability, and other characteristics of the concrete. There are two types of admixtures, one is chemical admixture and the other one is natural admixture. Natural admixture is eco-friendly and helps to achieve environmental sustainability. This investigation explores the use of chemical and natural admixtures to improve concrete's compressive and splitting tensile strength. For this study, fifty-four (54) cylinder samples were prepared in three (03) sets where each set contained eighteen (18) cylinder samples following ASTM standard. Chemical and natural admixture were used in two (02) sets and the other set contained no admixture. Self-compacting admixture was used as chemical admixture and gram flour was used as natural admixture. Concrete was mixed at a 1:1.5:3 ratio, without admixture and with Self-compacting admixture of 130 ml (1% of cement weight) and Gram flour of 130 gm (1% of cement weight) for eighteen (18) samples respectively. The compressive and splitting tensile strengths were calculated for 7, 14, and 28 days of curing time using the Universal Testing Machine (UTM). For normal concrete, observed compressive strength was 1305 psi, 1902 psi, and 2372 psi, and splitting tensile strength was noted 192 psi, 241 psi, and 309 psi following 7, 14, and 28 days curing period. After 7, 14, and 28 days of curing, respectively, the splitting tensile strength improved to 213 psi, 272 psi, and 365 psi, while the compressive strength increased to 1485 psi, 2176 psi, and 2969 psi with the application of 1% (by weight of cement) chemical admixture. Besides applying 1% (by weight of cement) natural admixture, compressive strength was found 1473 psi, 2206 psi, and 2707 psi, and the splitting tensile strength was found 200 psi, 310 psi, and 348 psi after 7, 14, and 28 days of curing respectively. Comparing the applied admixtures to regular concrete, the compressive strength increased by 335 and 597 psi, and the tensile strength increased by 39 and 56 psi respectively. The additional cost for chemical and natural admixture was 19.5 taka and 9 taka only for eighteen (18) samples respectively. So natural admixture was cheaper than chemical admixture. The compressive and splitting tensile strength were increased by adding a certain amount of natural or chemical admixture and the strength was close among the samples of chemical and natural admixture. The results of three (03) set samples were compared with one another and in terms of cost and the compressive and splitting tensile strength, it was evident that the natural admixture (gram flour) was a good substitute for the chemical admixture.

Keywords: *Chemical admixture, Natural admixture, Gram flour, Compressive strength, Splitting tensile strength*

1. INTRODUCTION

Concrete is a ubiquitous and indispensable construction material that has shaped the modern world. Comprising a mixture of cement, water, and aggregates, it offers unparalleled strength, durability, and versatility. Its ability to withstand heavy loads and environmental conditions, coupled with its fire resistance and adaptability to various shapes and sizes, makes it the backbone of our infrastructure and architectural achievements. Concrete's history dates back to ancient civilizations, and its continued evolution, along with ongoing efforts to improve its environmental sustainability, ensures it remains at the forefront of construction, playing a pivotal role in the construction of everything from buildings and bridges to roads and dams.

Admixtures in concrete are essential components that enhance the properties and performance of this versatile construction material. These additives, whether chemical or natural, play a pivotal role in tailoring concrete mixes to meet specific project requirements. Chemical admixtures, such as plasticizers, retarders, accelerators, and superplasticizers, allow for precise control over workability, setting time, and strength. They are instrumental in optimizing concrete mixes to ensure they perform well in a variety of environmental and structural conditions. Natural admixtures, like gram flour, pozzolans, and rice husk ash, provide eco-friendly options to enhance durability and sustainability. These materials, when properly incorporated into concrete, improve its strength, reduce permeability, and contribute to its long-term resilience. Admixtures are a testament to the constant innovation in construction, enabling engineers and builders to craft concrete solutions that are tailored to the unique challenges of each project.

The use of chemical admixtures in concrete is a common practice in modern construction. Although chemical admixtures improve the properties of concrete but also create leaching problems and are responsible for environmental pollution (Deo, October 2016). Natural admixtures in concrete harness the power of nature to enhance the performance and sustainability of this widely used construction material. These organic and mineral substances, derived from natural sources, offer eco-friendly solutions to improve various concrete properties. Gram flour, also known as besan, is a natural product derived from ground chickpeas and is commonly used in cooking. However, it reduces permeability and increases strength, providing a sustainable alternative. Incorporating natural admixtures not only optimizes concrete performance but also aligns with eco-conscious construction practices by reducing the environmental footprint associated with synthetic chemical additives. Natural admixtures exemplify the synergy between sustainable building practices and the innate strength and versatility of concrete.

1.1 Objectives of the study

The primary goals of the study are-

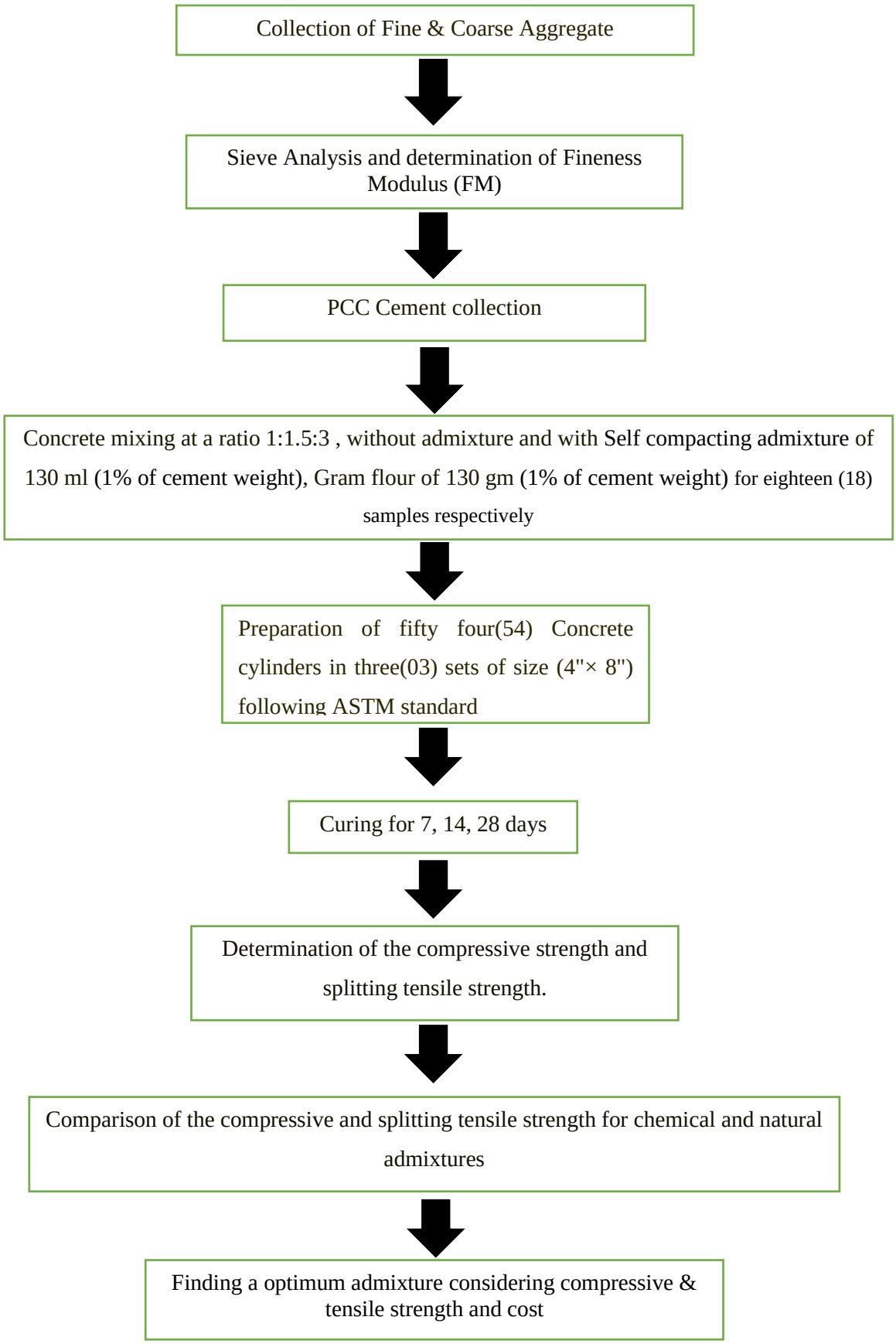
- To compare the effect of natural and chemical admixture in concrete based on compressive strength and splitting tensile strength of concrete.
- To find a suitable admixture considering strength and cost.

2. METHODOLOGY

2.1 Materials

- Cement- Portland Composite Cement (PCC)
- Fine aggregate- Sylhet sand (FM=2.62)
- Coarse aggregate- Stone chips (FM=7.2)
- Admixture- Self-compacting admixture as chemical admixture which mainly contains polyether-polycarboxylate and gram flour as natural admixture which mainly contains 11.2% moisture, 22.5% protein, 5.2% fat, and 58.9% carbohydrate (A.S. Bawa, 2003).
- Water

2.2 Workflow


Collection of Fine & Coarse Aggregate
Sieve Analysis and determination of Fineness Modulus (FM)
PCC Cement collection
Concrete mixing at a ratio 1:1.5:3 , without admixture and with Self compacting admixture of 130 ml (1% of cement weight), Gram flour of 130 gm (1% of cement weight) for eighteen (18) samples respectively
Preparation of fifty four(54) Concrete cylinders in three(03) sets of size (4"× 8") following ASTM standard
Curing for 7, 14, 28 days
Determination of the compressive strength and splitting tensile strength.
Comparison of the compressive and splitting tensile strength for chemical and natural admixtures
Finding a optimum admixture considering compressive & tensile strength and cost

2.3 Sample preparation

Necessary materials were collected for sample preparation. Sieve analysis was performed for the coarse and fine aggregate and the Fineness Modulus (FM) of both materials was determined. Concrete was mixed at a 1:1.5:3 ratio, without admixture and with Self-compacting admixture of 130 ml (1% of cement weight) and Gram flour of 130 gm (1% of cement weight) for eighteen (18) samples respectively. A slump test was performed. A total of fifty-four (54) concrete cylinders were prepared in three (03) sets of size (4"× 8") following ASTM standards. Twenty-seven (27) samples were for the compressive strength test and the remaining twenty-seven (27) samples were for the splitting tensile strength test. The samples were kept under water for curing for 7 days, 14 days, and 28 days.

Table 1: Slump value of concrete

Slump	At 0 min
Normal concrete (Without admixture)	82 mm
Concrete with self-compacting admixture	113.5 mm
Concrete with gram flour	87 mm

2.4 Tensile & splitting tensile strength test

Compressive strength (CS) and splitting tensile strength (STS) tests were performed for the samples using a Universal Testing Machine (UTM) for 7 days, 14 days, and 28 days curing periods following ASTM standards.

Figure 1: Compressive strength test

Figure 2: Splitting tensile strength test

3. RESULT & DISCUSSION

3.1 Compressive Strength

Compressive strength was tested for twenty-seven (27) concrete cylinders in three(03) sets of size (4"× 8") following ASTM standards.

3.1.1 Normal Concrete

The average compressive strength (CS) of normal concrete was found 1305 psi, 1902 psi, and 2372 psi for 7 days, 14 days, and 28 days curing periods respectively.

Table 2: Compressive strength of normal concrete

Curing Time (Days)	Sample No	Compressive Strength (psi)	Average Compressive Strength (psi)
7	1	1252	1305
	2	1377	
	3	1288	
14	1	1985	1902
	2	1770	
	3	1950	
28	1	2289	2372
	2	2432	
	3	2396	

3.1.2 Concrete with chemical admixture

Self-compacting admixture was used as a chemical admixture. The average compressive strength (CS) of concrete with chemical admixture was found 1485 psi, 2176 psi, and 2969 psi for 7 days, 14 days, and 28 days curing periods respectively.

Table 3: Compressive strength (CS) of concrete with chemical admixture

Curing Time (Days)	Sample No	Compressive Strength (psi)	Average Compressive Strength (psi)
7	1	1467	1485
	2	1430	
	3	1556	
14	1	2164	2176
	2	2271	
	3	2093	
28	1	2986	2969
	2	3005	
	3	2915	

3.1.3 Concrete with natural admixture

Gram flour was used as a natural admixture. The average compressive strength of concrete with natural admixture was found 1473 psi, 2206 psi, and 2707 psi for 7 days, 14 days, and 28 days curing periods respectively.

Table 4: Compressive strength of concrete with natural admixture

Curing Time (Days)	Sample No	Compressive Strength (psi)	Average Compressive Strength (psi)
7	1	1413	1473
	2	1449	
	3	1556	
14	1	2146	2206
	2	2271	
	3	2200	
28	1	2647	2707
	2	2719	
	3	2754	

3.1.4 Comparison of compressive strength

The compressive strength (CS) of three (03) types of samples was compared. Table 5, Table 6, and Figure 3 show that the use of admixture has increased the compressive strength over normal concrete, and compressive strength is close for both chemical and natural admixture.

Table 5: Comparison of compressive strength (CS)

Specimen	W/C Ratio	Mix Ratio	Curing Time (days)	Compressive Strength (psi)		
				Normal Concrete	Concrete with chemical admixture	Concrete with natural admixture
Cylinder	0.5	1:1.5:3	7	1305	1485	1473
			14	1902	2176	2206
			28	2372	2969	2707

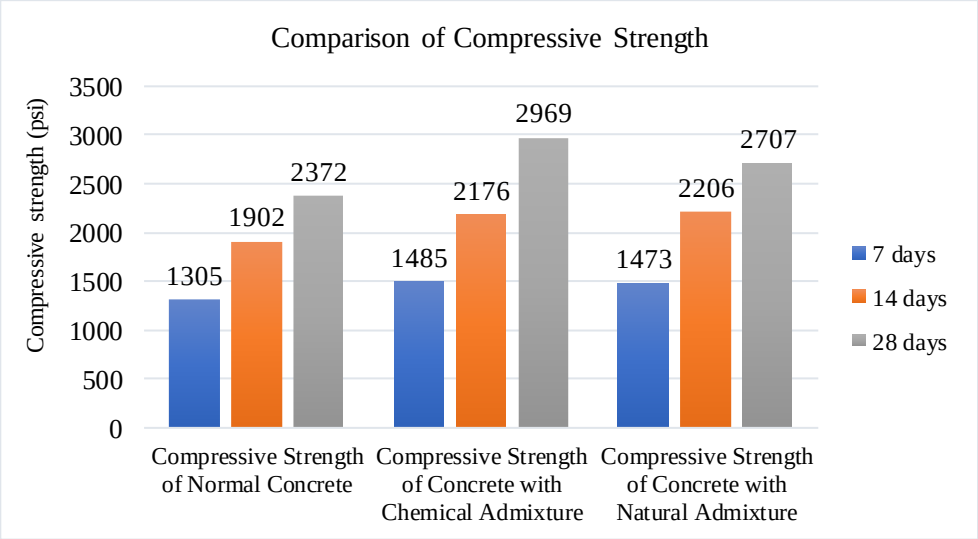


Figure 3: Comparison of compressive strength

Table 6: Variation of compressive strength after 28 days of curing

	Normal Concrete	Concrete with chemical admixture	Concrete with natural admixture
Compressive Strength after 28days curing (psi)	2372	2969	2707
Increment of strength (psi)	-	2969-2372 = 597	2707-2372 = 335
Percentage increment	-	= 25.16%	=14.12%

3.2 Splitting Tensile Strength

Splitting tensile strength (STS) was tested for twenty-seven (27) concrete cylinders in three (03) sets of size (4"× 8") following ASTM standards.

3.2.1 Normal Concrete

The average splitting tensile strength of normal concrete was found 192 psi, 241 psi, and 309 psi for 7 days, 14 days, and 28 days curing periods respectively.

Table 7: Splitting Tensile strength (STS) of normal concrete

Curing Time (Days)	Sample No	Tensile strength (psi)	Average tensile Strength (psi)
7	1	187	192
	2	206	
	3	182	

14	1	226	241
	2	255	
	3	241	
28	1	309	309
	2	290	
	3	329	

3.2.2 Concrete with chemical admixture

Self-compacting admixture was used as a chemical admixture. The average splitting tensile strength of concrete with chemical admixture was found 213 psi, 272 psi, and 365 psi for 7 days, 14 days, and 28 days curing period respectively.

Table 8: Tensile strength of concrete with chemical admixture

Curing Time (Days)	Sample No	Tensile strength (psi)	Average tensile Strength (psi)
7	1	201	213
	2	231	
	3	206	
14	1	260	272
	2	270	
	3	285	
28	1	388	365
	2	349	
	3	358	

3.2.3 Concrete with natural admixture

Gram flour was used as a natural admixture. The average splitting tensile strength of concrete with natural admixture was found 200 psi, 310 psi, and 348 psi for 7 days, 14 days, and 28 days curing periods respectively.

Table 9: Splitting Tensile strength (STS) of concrete with natural admixture

Curing Time (Days)	Sample No	Tensile strength (psi)	Average tensile Strength (psi)
7	1	211	200
	2	187	
	3	201	
14	1	314	310
	2	329	
	3	289	
28	1	358	348

	2	349
	3	339

3.2.4 Comparison of splitting tensile strength

Splitting tensile strength (STS) of three (03) types of samples was compared. Table 10, Table 11, and Figure 4 show that the use of admixture has increased the tensile strength over normal concrete, and tensile strength is close for both chemical and natural admixture.

Table 10: Comparison of tensile strength

Specimen	W/C Ratio	Mix Ratio	Curing Time (days)	Tensile Strength (psi)		
				Normal Concrete	Concrete with chemical admixture	Concrete with natural admixture
Cylinder	0.5	1:1.5:3	7	192	213	200
			14	241	272	310
			28	309	365	348

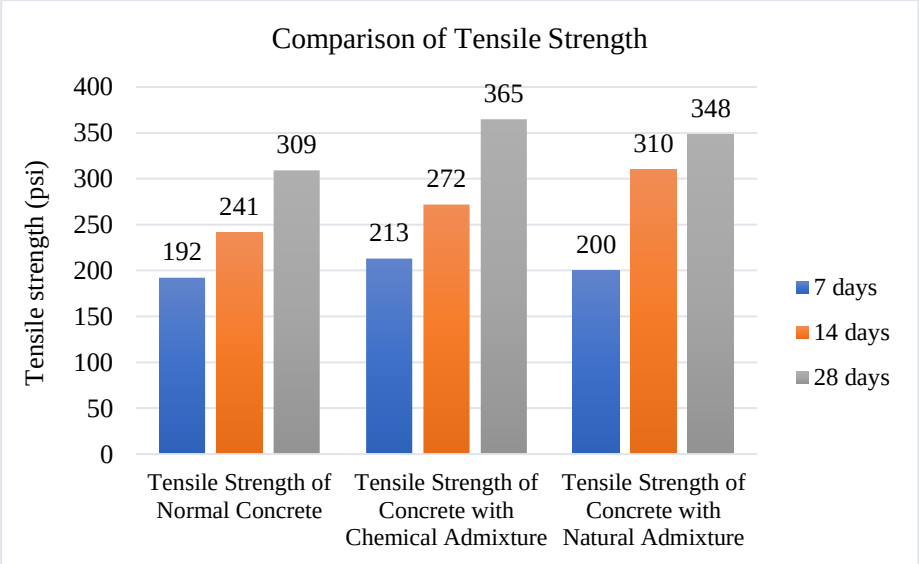


Figure 4: Comparison of splitting tensile strength

Table 11: Variation of tensile strength after 28 days of curing

	Normal Concrete	Concrete with chemical admixture	Concrete with natural admixture
Tensile Strength after 28days curing (psi)	309	365	348

Increment of strength (psi)	-	365-309 = 56	348-309 = 39
Percentage increment	-	= 18.12%	= 12.6%

3.3 Cost Analysis

The construction cost of each sample was the same except for the cost of admixtures. The additional cost for chemical and natural admixture was 19.5 taka and 9 taka only for eighteen (18) samples respectively which means 1.2 taka and 0.5 taka per sample respectively. So natural admixture is cost-effective.

Table 12: Variation of cost for admixtures

	Normal Concrete	Concrete with chemical admixture	Concrete with natural admixture
Additional cost for admixture (taka)	0.0	19.5	9.0

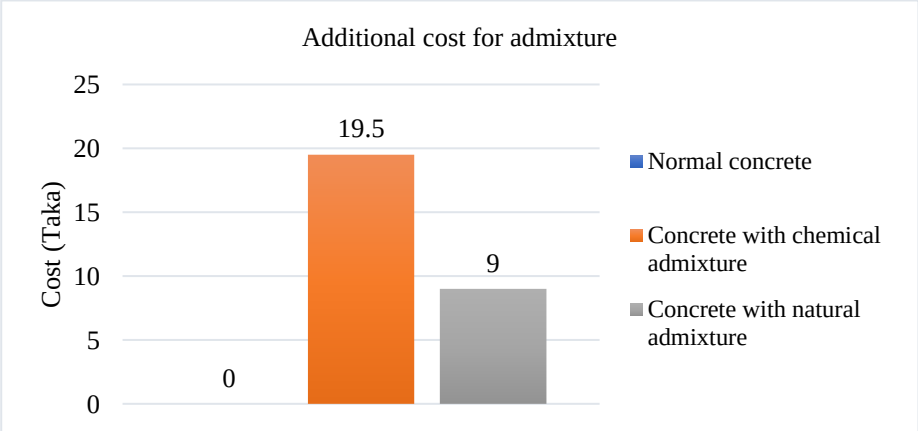


Figure 3: Variation of cost for admixtures

4. CONCLUSIONS

4.1 Findings of the study

- For normal concrete, observed compressive strength was 1305 psi, 1902 psi, and 2372 psi, and splitting tensile strength was noted 192 psi, 241 psi, and 309 psi following 7, 14, and 28 days curing period.
- After 7, 14, and 28 days of curing, respectively, the splitting tensile strength improved to 213 psi, 272 psi, and 365 psi, while the compressive strength increased to 1485 psi, 2176 psi, and 2969 psi with the application of 1% (by weight of cement) chemical admixture.
- Besides applying 1% (by weight of cement) natural admixture, compressive strength was found 1473 psi, 2206 psi, and 2707 psi, and the splitting tensile strength was found 200 psi, 310 psi, and 348 psi after 7, 14, and 28 days of curing respectively.

- Comparing the applied admixtures to regular concrete, the compressive strength increased by 335 and 597 psi, and the tensile strength increased by 39 and 56 psi for natural and chemical admixture respectively.
- The additional cost for chemical and natural admixture was 19 taka and 9 taka only for eighteen (18) samples respectively. So natural admixture is cheaper than chemical admixture.

This study shows that we can improve the compressive and splitting tensile strength by adding a certain amount of natural or chemical admixture. This can be useful in the construction of improved reinforced cement concrete structures.
In terms of cost and compressive and splitting tensile strength, we can conclude that the natural admixture (gram flour) is a good substitute for the chemical admixture.

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