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Mechanical Performance of Pro-Nylon Fabric Reinforced Non-Structural Concrete for Urban Sidewalks in Arequipa, Perú

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Abstract. *This study investigates the mechanical performance of non-structural concrete reinforced with Pro-nylon textile fibers (FNP) for pedestrian pavements in Arequipa, Peru. Four mix designs containing 0%, 0.25%, 0.50%, and 1.00% fiber by volume were tested after 28 days of water curing. The 0.50 % fiber mix achieved a compressive strength of 203.6 kg/cm², comparable to the control (207.7 kg/cm²), while the 1.00 % dosage reduced strength significantly to 168.7 kg/cm². One-way ANOVA confirmed that fiber content had a statistically significant effect on compressive strength (p = 0.0002). In contrast, indirect tensile strength peaked at 24.0 kg/cm² with 0.25 % fibers, but differences among groups were not statistically significant (p = 0.30). These findings identify an optimal dosage range (0.25–0.50 %) that enhances compressive performance without compromising material integrity, underscoring the need for further studies on tensile behavior and durability under real service conditions.*

Keywords— Pro-Nylon, Fiber-reinforced concrete, Compressive strength, Tensile strength, Urban infrastructure

I. Introduction

The rapid expansion of cities driven by population growth has intensified the construction and renewal of urban infrastructure. In Arequipa, 4,788 infrastructure projects were executed in 2023; however, heavy rains associated with the El Niño phenomenon deteriorated 2,489 km of roads and sidewalks, impairing pedestrian and vehicular mobility and requiring 186 critical repair interventions [1],[2],[3],[4]. With average precipitation of 28 mm between January and March and abrupt temperature fluctuations, recurrent pavement damage highlights the need for more durable materials in low-structural-impact urban applications [5].

Conventional concrete, though widely used, is inherently brittle, with low tensile strength, limited energy absorption, and a high susceptibility to cracking [1]. Synthetic fiber reinforcement has therefore gained attention for its positive effects on tensile and compressive strength, toughness, and durability. Studies report that nylon fibers—virgin or recycled—can increase tensile strength by 14–80% at fiber contents of 0.5–1% by volume, depending on the mix design and aggregate size distribution [6]. Regarding compression, results are more moderate but consistent: for example, a mix with 0.9 kg/m³ of fiber reached 345.3 kg/cm², while 1.8 kg/m³ yielded 314.3 kg/cm², compared to a baseline of 327.7 kg/cm² [7]. Likewise, concretes with recycled aggregates and nylon fibers at 0.6–1.2 kg/m³ have shown increases in tensile strength up to 80.6% [8].

Additional benefits include enhanced cohesion, better stress distribution, increased energy absorption, and reduced shrinkage and surface cracking, which are critical for structures exposed to impacts, wet–dry cycles, or repeated use, such as sidewalks[9],[10]. From an environmental perspective, recycled nylon fibers derived from textile or industrial waste represent a viable alternative within the circular economy framework to reduce environmental impact [7], [11], [12].

Despite these advances, most studies remain confined to controlled laboratory conditions and loose fibers. The use of nylon fiber fabric, such as Pro-Nylon, under real urban conditions has not been sufficiently explored. Its geometry and textile composition may alter concrete performance, including strength and workability. This study, therefore, experimentally evaluates the effect of incorporating Pro-Nylon fiber on the compressive and tensile strengths of non-structural concrete for urban sidewalks, with statistical analysis via ANOVA to determine the significance of the observed effects.

II. Methodology

A. Characterization of the Population and Sample Selection

The population group consists of possible combinations of non-structural concrete mixes that incorporate textile nylon fiber. The sample, of a non-probabilistic type, was selected based on the objectives established in the research. The independent variable corresponds to the percentage of textile nylon fiber used (0%, 0.25%, 0.5%, and 1%), The selection of fiber percentages (0.25%, 0.50%, and 1.00%) was based on previous experimental evidence and preliminary laboratory trials. Studies on nylon fibers—both loose and fabric-based—report improvements in crack control and tensile behavior within typical dosage ranges between 0.3% and 1.0% by volume [6], [7], which represent technically accepted limits that avoid excessive loss of workability or segregation. Additionally, preliminary tests conducted for this study showed that fiber contents above 1.00% produced agglomerations and a marked reduction in workability, while percentages below 0.25% did not generate noticeable changes in cohesion. Therefore, the selected range provides a representative and technically supported interval for evaluating the mechanical performance of concrete reinforced with Pro-Nylon fabric. while the dependent variable is the compressive capacity of the concrete, expressed in kg/cm², in accordance with TP 339.034 [13].

For each of the three mix proportions, eight standardized cylindrical specimens were prepared: four subjected to simple compression tests and four to indirect tensile tests, all at 28 days of curing. In total, 32 specimens were fabricated, as determined by the mathematical model, providing a solid basis for comparing results and validating the study hypothesis.

Mathematical Model

In this research, a complete one-factor design mathematical model was applied to estimate the total number of possible combinations to be evaluated. This statistical tool is used to analyze the impact of different factors, both individually and jointly on one or more responses. It allows assessment by considering all possible combinations among factor levels, optimizing the number of tests, and enriching the analysis[14], [15]

Table 1: Studied Variables

MECHANICAL PROPERTIES OF CONCRETE	
Compressive Strength	1
Tensile Strength	1

PRO-NYLON ADDITION PERCENTAGE	
At 0.00 % fiber	0
At 0.25% fiber	1
At 0.50% fiber	1
At 1.00% fiber	1

A one-factor design was applied with four levels corresponding to the percentages of Pro-Nylon fiber in concrete: 0%, 0.25%, 0.50%, and 1.00%. Each level was replicated in eight cylindrical specimens (four for compression tests and four for indirect tensile tests), yielding a total of 32 specimens. This design allows the evaluation of the effect of a single factor, the fiber proportion, on the mechanical properties of concrete, ensuring the statistical validity and representativeness of the data [14], [15].

B. *Experimental procedure and data collection*

Experimental records were obtained through laboratory compression and tensile tests, with results recorded in Excel for analysis. The instrument used was a UTEST automatic press with a capacity of 2000 kN and a traceable calibration certificate, which enabled measurement of compressive and tensile strength of the specimens, in accordance with NTP 339.034:2015 for curing with potable water and NTP 339.216:2016 for mechanical testing. A loading rate of 0.25 MPa/s was applied, using heads with neoprene pads as load distribution elements.

C. *Procedure*

1) *Characterization of Pro-Nylon Fiber*

Material collection:

Representative samples of Pro-nylon textile fibers were collected directly from the supplier to ensure quality, homogeneity, and provenance. Fibers were stored in a dry, clean environment to prevent moisture or contamination.

Preparation and cutting:

Fibers were manually cut to 3 cm in length and 0.5 cm in width to ensure adequate dispersion in the concrete mix. These dimensions are similar to those reported in [7], [16], and [6], which have demonstrated a significant impact in previous studies. A superficial cleaning was performed to remove impurities, and care was taken to prevent fraying, maintaining fibers in optimal condition for inclusion in concrete.

Characterization test:

Studies were conducted to determine the chemical composition of the fibers by identifying polymer functional groups. This confirmed their identity, detected possible mixtures with other materials, and evaluated factors that could influence their behavior within concrete.

2) *Mix design and preparation*

Mix design:

Four mixes were prepared: one control mix without fibers and three modified mixes with Pro-nylon fibers at 0.25%, 0.5%, and 1% relative to the total concrete volume. Mixes were designed according to normative criteria for urban elements, such as sidewalks, to maintain consistency across all mixes.

Control mix:

This mix contained no fibers and complied with conventional specifications for sidewalk concrete. It served as a reference for comparison with fiber-reinforced mixes.

Fiber reinforced mixes:

In modified mixes, fibers were incorporated during the mixing stage to ensure homogeneous distribution. Exact material quantities were documented, and the same mixing, molding, and curing process was used.

Curing of specimens:

Cylindrical specimens were demolded after 24 hours and placed in a tank with potable water for curing over 28 days. This process ensured optimal development of mechanical properties, particularly strength.

3) Testing

Two types of tests were performed in accordance with Peruvian standards:

Simple compression: Conducted under NTP 339.034 using a UTEST automatic press of 2000 kN capacity.

Indirect tensile strength: Conducted under NTP 339.084 using the same press.

Both tests were performed at a controlled loading rate, and heads with neoprene pads were used in accordance with NTP 339.216.

4) Data recording

The maximum load applied to each specimen was recorded, and strength values were calculated in kg/cm² for subsequent analysis.

5) Statistical analysis

To evaluate the mechanical performance of the concrete mixes, descriptive statistics were first calculated, including the mean $\bar{x}$, standard deviation σ, and coefficient of variation (CV). These parameters quantified central tendency, variability, and relative dispersion among groups [19].

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} xi \, , \sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(xi - \bar{x})^2} , \; CV = \frac{S}{\bar{X}} \times 100\%$$

Where x_i are the individual strength values (kg/cm²), n is the number of specimens per group, and $\bar{x}$ is the group mean.

A one-factor ANOVA was then applied to determine whether significant differences existed among the mean strength values of the concrete mixes with different nylon fiber contents (0%, 0.25%, 0.5%, 1%). The analysis considered both between-group variability and within-group variability, summarized through the mean squares:

$$MS_{\text{Between}} = \frac{SSB}{k-1}, \qquad MS_{\text{within}} = \frac{SSW}{kn-k}$$

Where SSB and SSW represent the sums of squares between and within groups, k is the number of treatments, and nn the number of replicates per group. The F statistic was calculated as:

$$F = \frac{MS_{\text{between}}}{MS_{\text{within}}}$$

The corresponding p-value was obtained using Excel's **DISTR.F. N** function, with significance evaluated at the 95% confidence level.

Null hypothesis (H_0): No significant differences exist among group means.
Alternative hypothesis (H_1): At least one group mean differs significantly.

III. Results

Charactization of Pro-Nylon fiber

The chemical characterization of the Pro-Nylon fiber by Fourier Transform Infrared Spectroscopy (FTIR) was carried out in order to identify the functional groups present and confirm its composition.

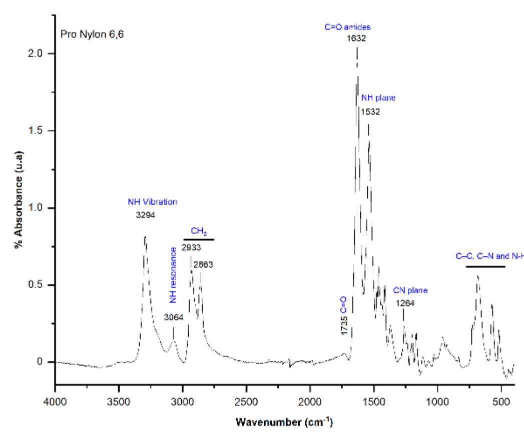


Figure 1: FTIR spectrum graph of Pro-Nylon fiber

The characteristic bands of polyamide Pro-Nylon (6,6 (nylon 6,6)) were identified in the FTIR spectrum, associated with the following functional groups typical of polyamides.

Table 2: Characteristic FTIR Bands of Polyamides

Wavenumber (cm^{-1})(Literature)	Functional group	Vibrational mode	Assignment	Peak position (cm^{-1})(own sample)
3300 – 3294	N–H (Amide A)	Stretching	Hydrogen bonding of amide group	~3294
2932 – 2859	CH_2 (aliphatic)	Asymmetric/ symmetric stretching	Aliphatic chains (–CH_2–)	~2933 and ~2863
1632 – 1635	C=O (Amide I)	Stretching (C=O)	Carbonyl group of the amide bond	~1632
1533 – 1535	N–H + C–N (Amide II)	Bending	N–H deformation and C–N bond	~1535
1275 – 1260	C–N + N–H (Amide III)	Stretching + Bending	C–N stretching coupled with N–H (Amide III)	~1264

In the region below 700 cm^{-1}, bands were observed that are attributed to deformations of the molecular backbone (C–C, C–N) and out-of-plane vibrations of the N–H group, corresponding to the so-called fingerprint region of the FTIR spectrum. Although these bands are not diagnostic on their own, they complement the characteristic spectral profile of nylon 6,6. The obtained spectrum confirms the presence of functional groups that form intermolecular bonds, such as amide and carbonyl groups, supporting the use of the material as a reinforcement in concrete mixes by providing mechanical properties associated with these chemical structures.

Cement characterization

The binder used in all mixes was Portland cement type HS (high sulfate resistance), brand Yuramax, which complies with NTP 334.071:2018 (equivalent to ASTM C150). This type is characterized by a low tricalcium aluminate (C_3A) content, conferring notable resistance to aggressive environments, such as soils or water with high sulfate concentrations. Its reported density was 2.750 kg/m³, and it was stored under dry conditions until use, ensuring its integrity.

Fine aggregate characterization

The fine aggregate consisted of natural silica sand, classified as medium sand. It was sourced from the "La Poderosa" quarry (Arequipa). The properties determined through standardized tests (ASTM C136, C128, and C29) were: fineness modulus of 2.31, absorption of 2.4%, and moisture content of 3.6%. In addition, unit weights of 1.52 g/cm³ (loose) and 1.68 g/cm³ (compacted) were recorded. These values ensure an appropriate gradation for non-structural concretes and adequate workability in mixes with fiber additions.

Table 3: Physical and mechanical properties

REQUIREMENTS	UNIT	Peruvian Technical Standar 334.082:2020	YURA MAX HS CEMENT
PHYSICAL REQUIREMENTS			
Density	g/cm³	-	2.70 to 2.8
Autoclave expansion	%	maximum 0.80	´-0.09 to 0.03
Initial setting time (Vicat)	minutes	45 a 420	170 to 280
Air content	%	maximum 12	3 to 8
Mortar bar expansion (14 days)	%	maximum 0.020	<0.020
COMPRESSIVE STRENGTH			
3 days	Kgf/cm³	minimum 112	150 to 200
7 days	Kgf/cm³	minimum 184	190 to 230
28 days	Kgf/cm³	minimum 255	270 to 310
SULFATE RESISTANCE			
Expansion at 6 months	%	maximum 0.05	0.03 to
Expansion at 12 months	%	maximum 0.10	0.04 to
Expancion at 18 months	%	-	0.04 to

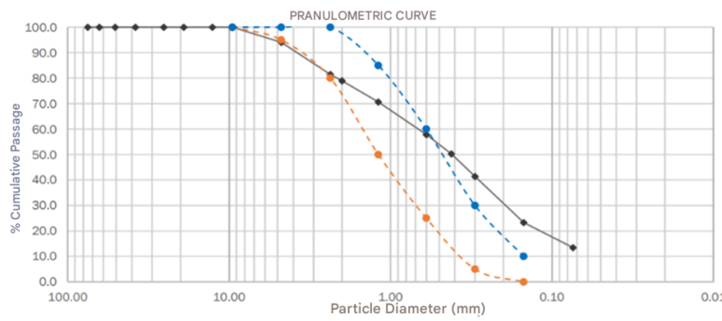


Figure 2: Fine aggregation gravation curve

Table 4: Results of fine aggregate gradation curve

RESULTS			
IMPORTANT	6.0 5%	GG	0.0 %
		GF	6.0 %
SAND	80.6%	AG	15.1 %
		AMI	28.7 %
		OF	36.8 %
FINE	0.9 %		
Maximum size (")			3/8"
Retained in 3" (%)			0.0
Sample weight (g)			520.1
Portion of fines (g)			376.1
Fineness modulus (MF)			2.31
Sand type according to MF			Medium

Coarse aggregate characterization

Angular–subangular gravel type 67, also of natural origin and sourced from the same quarry, was used as coarse aggregate. The material was evaluated in accordance with ASTM C136, C127, and C29 standards, yielding a fineness modulus of 6.74, absorption of 1.4%, and moisture content of 0.4%.

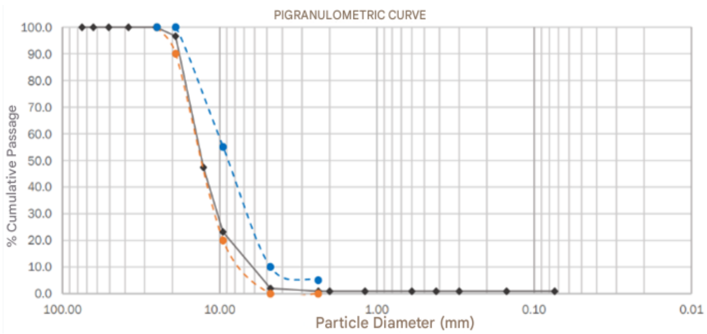


Figure 3: Coarse aggregate gradation curve

The maximum nominal size was 3/4", with unit weights of 1.45 g/cm³ (loose) and 1.53 g/cm³ (compacted). These parameters ensure a good relationship with the cementitious matrix, a necessary condition to guarantee the internal bonding of the concrete.

Table 5: Results of coarse curve gradation curve

RESULTS			
GRAVEL	98.0 %	GG	3.4 %
		GF	94.6 %
SAND	1.1 %	AG	1.1 %
		AMI	0.0 %
		OF	0.0 %
FINE	0.9 %		
Maximum size(*)			1”
Nominal maximum size			¾ ‘
Gravel spindle			67
Sample weight (g)			21.316
Fineness modulus (MF)			6.74

Water characterization

The water used came from the public potable supply of Arequipa. Its quality was verified in accordance with NTP 339.127:2009 (equivalent to ASTM C1602), ensuring the absence of organic contaminants, oils, chlorides, or dissolved salts that could interfere with cement hydration or alter concrete performance.

Mechanical evaluation of concrete

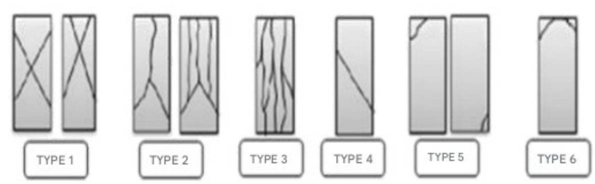
Four concrete mixes were designed: one control mix (0% fiber) and three with additions of Pro-Nylon fabric at 0.25%, 0.5%, and 1% by volume. All mixes were proportioned to a target strength of 175 kg/cm², with a water–cement ratio of 0.60 and a slump of 3"-4".

A total of 32 cylinders (10 cm × 20 cm) were prepared, with 16 cylinders used for compression and 16 for indirect tensile tests. The specimens were cured for 28 days in potable water according to NTP 339.034:2015. The tests were performed using a UTEST hydraulic press (2000 kN).

Table 6: Results of Compression and Tensile Tests

SUMMARY OF COMPRESSIVE STRESS AVERAGE				
ELEMENT	TESTING AGE	COMPRESSIVE STRESS (MPa)	COMPRESS STRESS (Kg/cm²)	FAILURE TYPE
ADDITION 0.00 %	28	20.36	207.65	3
ADDITION 0.25 %	28	19.83	202.23	3
ADDITION 0.50 %	28	19.97	203.60	3
ADDITION 1.00 %	28	16.54	168.65	3

SUMMARY OF TENSILE STRESS AVERAGE				
ELEMENT	TESTING AGE	TENSILE STRESS (MPa)	TENSILE STRESS (Kg/cm²)	FAILURE TYPE
ADDITION 0.00 %	28	2.05	20.94	Vertical plane
ADDITION 0.25 %	28	2.30	23.41	Vertical plane
ADDITION 0.50 %	28	2.09	21.34	Vertical plane
ADDITION 1.00 %	28	1.95	19.93	Vertical plane



Failure type 3 corresponds to a typical shear-cone failure as defined in NTP 339.216.

Statistical treatment of results

To examine how the analyzed characteristics of concrete vary with different percentages of nylon fibers (0%, 0.25%, 0.50%, and 1%), key descriptive statistics were calculated, including the mean, standard deviation, and coefficient of variation (CV).

These were applied to the compressive and tensile strength values obtained after 28 days of water curing.

Table 7: Standard Deviation of Compression Percentages

Percentage	Mean (Mpa)	Standard deviation	CV (%)
0.00%	20.375	0.797	3.91
0.25%	19.85	0.918	4.63
0.50%	19.95	0.968	4.85
1.00%	16.525	1.17	7.08

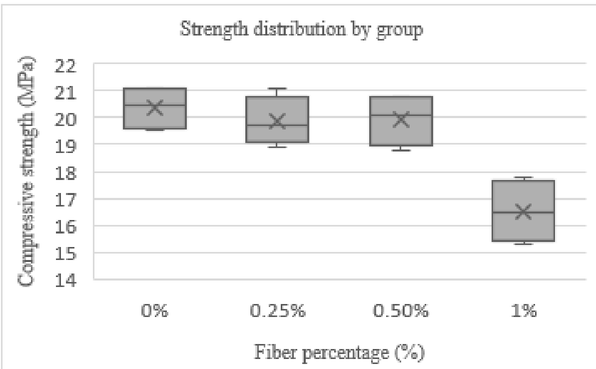


Figure 4: Compression Boxes

Table 8: Standard Deviation of Tensile Strength Percentages

Percentage	Mean (Mpa)	Standard deviation	CV (%)
0.00%	2.053	0.403	19.63
0.25%	2.298	0.053	2.31
0.50%	2.09	0.219	10.49
1.00%	1.955	0.173	8.85

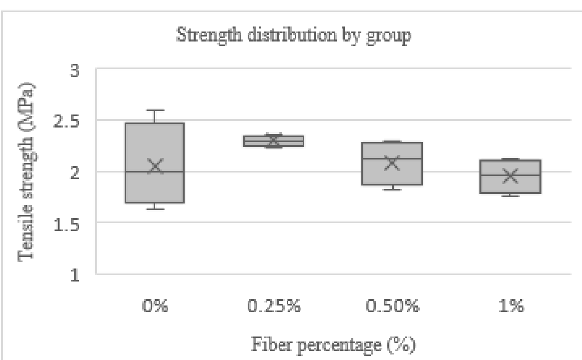


Figure 5: Boxplot of tensile strength

To determine whether the variations recorded among the different fiber percentages are statistically significant, a one-factor ANOVA was applied to the compression and tensile strength results.

Table 9: ANOVA of Compressive Strength

Percentage	Strength (Mpa)	Means	SSW	SSB
0%	21.1	20.375	1.9075	5.76
0%	19.5			
0%	19.9			
0%	21			
0.25%	18.9	19.85	2.53	1.8225
0.25%	19.6			
0.25%	21.1			
0.25%	19.8			
0.50%	18.8	19.95	2.81	2.4025
0.50%	19.5			
0.50%	20.7			
0.50%	20.8			
1.00%	17.2	16.525	4.1075	28.09
1.00%	15.3			
1.00%	17.8			
1.00%	15.8			

Table 10: Summary of Compressión

Overall mean	19.18
Sum of squares between groups (SSB)	38.08
Sum of squares within groups (SSW)	11.36
Degrees of freedom between ($DF_1 = k - 1$)	3
Degrees of freedom within ($DF_2 = N - k$)	12
Mean square between (MSB)	12.69
Mean square within (MSW)	0.95
F-statistic = MSB / MSW	13.41

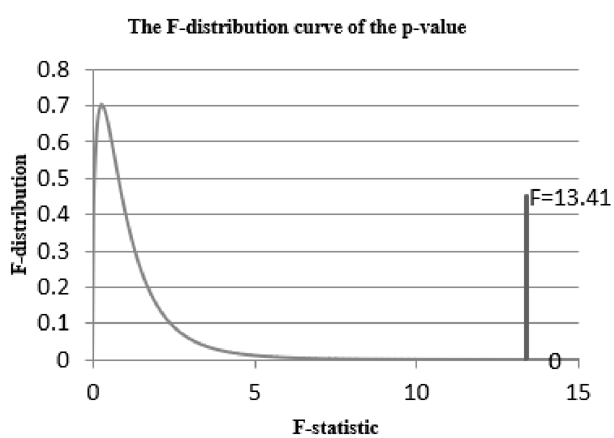


Figure 6: F-Curve of the p-Value for Compressive Strength

Table 11: Summary of F-Curve for Compressive Strength

Calculated F	13.41
p-value	0.00039
df1	3.00
df2	12.00

Since the p-value is below 0.05, the null hypothesis is rejected. The findings suggest that there are relevant differences among nylon fiber percentages[17].

Table 12: ANOVA of Tensile Strength

Percentage	Strength (Mpa)	Means	SSW	SSB
0%	2.59	2.0525	0.4869	0.0086
0%	1.89			
0%	1.64			
0%	2.09			
0.25%	2.27	2.2975	0.0085	0.158
0.25%	2.24			
0.25%	2.32			
0.25%	2.36			
0.50%	1.83	2.09	0.1442	0.0003
0.50%	2.3			
0.50%	2.24			
0.50%	1.99			
1.00%	1.86	1.955	0.0899	0.0827
1.00%	2.12			
1.00%	2.08			
1.00%	1.76			

Table 13: Summary of traction

Overall mean	2.1
Sum of squares between groups (SSB)	0.25
Sum of squares within groups (SSW)	0.73
Degrees of freedom between ($DF_1 = k - 1$)	3
Degrees of freedom within ($DF_2 = N - k$)	12
Mean square between (MSB)	0.08
Mean square within (MSW)	0.06
F-statistic = MSB / MSW	1.37

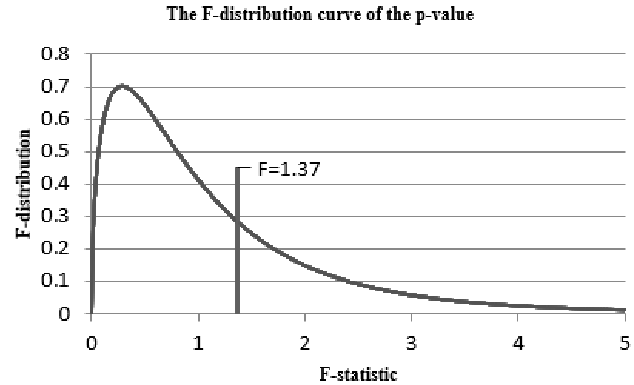


Figure 7: Curve of the p-Value for Tensile Strength

Table 14: Summary of F-Curve for Tensile

Calculated F	1.37
p-value	0.30000
df1	3.00
df2	12.00

Since the p-value is above 0.05, the null hypothesis is not rejected. The results indicate no significant differences among groups with different nylon fiber percentages[17]. Therefore, the fiber percentage did not have a statistically significant effect on the tensile strength of the concrete in this study.

IV. Discussion

FTIR analysis confirmed the composition of polyamide 6.6 in the Pro-Nylon fibers, evidencing the presence of polar functional groups (N–H, C=O, amide I–III) that promote interaction with the cementitious matrix. This characteristic supports their potential as reinforcement, as it may contribute to microcrack control and the distribution of internal stresses [18], [19]. Regarding compressive strength, the control mix reached 207.65 kg/cm² (≈20.3 MPa), while the mixes with 0.25% and 0.50% fiber achieved 202.23 kg/cm² and 203.60 kg/cm², respectively. However, when the fiber addition increased to 1.00%, the strength decreased markedly to 168.65 kg/cm² (≈16.5 MPa). The control mix exceeded the target strength due to conservative proportioning and favorable aggregate quality, which is standard practice in non-structural urban concrete. This behavior can be explained by the fact that moderate fiber doses act as bridges, limiting crack propagation and improving interfacial cohesion [7],[20]. In contrast, excessive amounts reduce workability, generate segregation and fiber agglomerations, increase internal porosity, and lower the final strength [13]. Normality and homogeneity of variance were verified through an exploratory analysis of residuals prior to ANOVA. ANOVA confirmed the statistical significance of these variations ($F = 13.41$; $p = 0.0002 < 0.05$), validating that fiber percentage significantly influences compressive strength [7]. Although moderate increases in indirect tensile strength were observed, the lack of statistical significance ($p = 0.30$) suggests that the flat geometry and manual cutting of the textile fibers limit the efficiency of the crack-bridging mechanism. Previous studies indicate that tensile performance strongly depends on fiber surface roughness and the quality of the fiber–matrix interface; chemical surface treatments or interface modifications have been shown to enhance adhesion and improve tensile response [12], [18], [19]. These aspects represent an important direction for future research to optimize the mechanical contribution of Pro-Nylon fibers.

Regarding indirect tensile strength, the concrete without fibers yielded 20.94 kg/cm² (≈2.05 MPa), increasing to 23.41 kg/cm² and 21.34 kg/cm² with 0.25% and 0.50% fiber, respectively. Nevertheless, at an addition of 1.00%, the strength decreased to 19.93 kg/cm². Although moderate increases were observed, ANOVA did not show significant differences ($F = 1.37$; $p = 0.30 > 0.05$). This result suggests that the flat geometry and manual cutting of textile fibers may limit the efficiency of crack bridging. Previous studies have indicated that improvements in tensile strength depend not only on fiber quantity but also on their orientation and surface condition; chemical treatments or interface modifications have been shown to enhance adhesion and tensile performance [12],[20].

From a practical perspective, the findings identify an optimal functional range between 0.25% and 0.50% fiber content for applications in non-structural concrete intended for urban sidewalks. This range improves compressive strength without compromising workability or generating internal defects. As this is a preliminary study, aspects such as the effects of temperature and radiation, durability, experimental designs that include additional factors, and mechanical responses in which fiber orientation produces different multiaxial behaviors remain pending for further investigation. In addition, the use of recycled fibers derived from textile waste could strengthen circular economy strategies in urban construction, reducing environmental impact and maintenance costs [11],[14]. Since polymeric fibers may undergo degradation due to UV radiation, thermal cycles, and moisture—conditions characteristic of the climate in Arequipa—future studies should incorporate durability tests such as freeze–thaw cycles, prolonged UV exposure, and accelerated aging. These evaluations will help validate the long-term performance of the material under real service conditions and strengthen its applicability in urban infrastructure.

V. Conclusions

The experimental evaluation demonstrated that incorporating Pro-Nylon textile fibers into non-structural concrete for urban sidewalks can improve mechanical performance within a controlled dosage range. Mixes containing 0.25–0.50% fiber by volume achieved compressive strengths comparable to or slightly higher than those of the control, confirming their potential to enhance cohesion and crack resistance without compromising workability. In contrast, excessive fiber content at 1.00% led to segregation and porosity, significantly reducing compressive strength. Indirect tensile strength increased moderately at 0.25% fiber, but statistical analysis showed no significant differences among fiber percentages, suggesting that the geometry and orientation of the textile fibers limit their efficiency in tensile reinforcement. FTIR characterization confirmed the polyamide 6.6 composition of Pro-Nylon fibers, supporting their role in microcrack control and stress distribution. Overall, the findings identify an optimal fiber range for practical application in sidewalks, highlight the risks of overdosing, and point to future research needs in durability, fiber orientation, and the use of recycled fibers to strengthen circular-economy strategies in urban infrastructure.

References

[1] R. V. Silva, J. De Brito, and R. K. Dhir, “Establishing a relationship between modulus of elasticity and compressive strength of recycled aggregate concrete,” *J Clean Prod*, vol. 112, pp. 2171–2186, Jan. 2016, doi: 10.1016/J.JCLEPRO.2015.10.064.

[2] "Thousands of beneficiaries with reconstruction of roads, sidewalks and sanitation in 13 regions of the country - La Razón." Accessed: Oct. 24, 2024. [Online]. Available: https://larazon.pe/miles-de-beneficiados-con-reconstruccion-de-pistas-veredas-y-saneamiento-en-13-regiones-del-pais/

[3] “SENAMHI Arequipa - Pronostico Detalle.” Accessed: Sep. 28, 2024. [Online]. Available: https://www.senamhi.gob.pe/main.php?dp=arequipa&p=pronostico-detalle

[4] Z.-T. Jorge Luis, S. Brito Jeferson, and D. F.-C. Miriam, "Runoff in Soil-Cement Block Pavements: An Experimental Approach," *Engineering, Research, and Technology*, vol. 16, no. 1, pp. 35–47, Jan. 2015, doi: 10.1016/S1405-7743(15)72105-0.

[5] P. A. Altamirano, L. Montoya Sánchez, and M. B. Rosado, “Avance coyuntural Actividad Económica Informe Técnico Abril 2024 Año base 2007 = 100,” 2024, Accessed: Oct. 03, 2024. [Online]. Available: www.inei.gob.pe

[6] M. Li *et al.*, “Quantifying the recycled nylon fibers influence on geometry of crack and seepage behavior of cracked concrete,” *Constr Build Mater*, vol. 373, p. 130853, Apr. 2023, doi: 10.1016/J.CONBUILDMAT.2023.130853.

[7] Y. Qin *et al.*, “Effects of nylon fiber and nylon fiber fabric on the permeability of cracked concrete,” *Constr Build Mater*, vol. 274, Mar. 2021, doi: 10.1016/J.CONBUILDMAT.2020.121786.

[8] “Revista edición N° 160 - Revista Constructivo.” Accessed: Oct. 03, 2024. [Online]. Available: https://constructivo.com/index.php/revista/160

[9] R. Haigh, M. Sandanayake, S. Sasi, E. Yaghoubi, P. Joseph, and Z. Vrcelj, "Microstructural attributes and physicochemical behavior of concrete incorporating various synthetic textile and cardboard fibers: a comparative review," *Journal of Construction Engineering*, vol. 86, doi: 10.1016/j.jobe.2024.108690.

[10] B. Ali, M. Azab, R. Kurda, N. Ben Kahla, and M. Atig, "A Multicriteria Evaluation and Optimization of Sustainable Fiber-Reinforced Concrete Developed with Nylon and Microsilica Waste Fibers," *Pollution and Environmental Science Research*, vol. 30, no. 22, pp. 62262–62280, doi: 10.1007/s11356-023-26492-6.

[11] N. Bheel, T. Tafsirojjaman, Y. Liu, P. Awoyera, A. Kumar, and M. A. Keerio, "Experimental Study on the Engineering Properties of Nylon Jute Fiber-Reinforced Cement Concrete," *Buildings*, vol. 11, no. 10, p. 454, 2021, doi: 10.3390/buildings11100454.

[12] R. Abirami and S. P. Sangeetha, “Effect of Surface Modification on the Characteristics of Sisal Fiber Reinforced Concrete Treated with Na2CO3,” *Nature Environment and Pollution Technology*, vol. 21, no. 1, pp. 289–295, 2022, doi: 10.46488/NEPT.2022.v21i01.034.

[13] R. Hernández Sampieri, C. Feránadez Collado, and M. D. P. Baptista Lucio, "Research Methodology," *Research Methodology*, p. 91, 2014, Accessed: Jan. 07, 2025. [Online]. Available: https://dialnet.unirioja.es/servlet/libro?codigo=775008&info=resumen&idioma=SPA

[14] K. Hinkelmann and O. Kempthorne, “Design and Analysis of Experiments: Second Edition,” *Design and Analysis of Experiments: Second Edition*, vol. 1, pp. 1–641, Apr. 2007, doi: 10.1002/9780470191750.

[15] A. A. Gomez and K. A. Gomez, “Statistical procedures for agricultural research: second Edition,” *A Wiley-Interscience Publication*, vol. 6, pp. 1–690, 1984, Accessed: May 25, 2025. [Online]. Available: https://www.wiley.com/en-us/Statistical+Procedures+for+Agricultural+Research%2C+2nd+Edition-p-9780471870920

[16] Y. Qin, X. Zhang, and J. Chai, “Comportamiento frente a daños y comportamiento compresivo del hormigón verde de edad temprana con tejido de fibra de nailon reciclado bajo una carga axial,” *Construcción y materiales de construcción*, vol. 209, pp. 105–114, doi: 10.1016/j.conbuildmat.2019.03.094.

[17] D. C. . Montgomery, *Design and analysis of experiments*, 9th ed. Hoboken, NJ: John Wiley & Sons, Inc., 2017.

[18] B. T. Weclawski, A. R. Horrocks, J. R. Ebdon, R. Mosurkal, and B. K. Kandola, “Combined atmospheric pressure plasma and UV surface functionalisation and diagnostics of nylon 6.6 fabrics,” *Appl Surf Sci*, vol. 562, p. 150090, Oct. 2021, doi: 10.1016/J.APSUSC.2021.150090.

[19] C. Gleissner, B. Kohn, U. Scheler, T. Bechtold, and T. Pham, “Modification of PA66 fibres with in-situ polymerisation of 2-hydroxyethylmethacrylate,” *Surfaces and Interfaces*, vol. 43, p. 103573, Dec. 2023, doi: 10.1016/J.SURFIN.2023.103573.

[20] H. Jahangir Qureshi, J. Ahmad, A. Aljabr, and N. Garcia-Troncoso, “Revisión sobre las características del hormigón reforzado con fibra de nailon,” *J Eng Fiber Fabr*, vol. 18, 2023, doi: 10.1177/15589250231189812.