Supplementary Materials

Table S1. Geometrical and physical characteristics of all thirteen initial recycled PP fiber types investigated during the screening stage, together with their aspect ratio, selection status, and reasons for exclusion or selection. Selected fibers (F1, F2, F5, F8) are highlighted in green.

Ref.	Length (mm)	Diameter (µm)	Aspect ratio (L/d)	Linear density (dtex)	Cross-sectional morphology	Density (g/cm³)	Melting point (°C)	Selection status	Reason for exclusion / selection
R23-02	12	43.2	278	13.19	Circular	0.89	160	Excluded	Geometrical characteristics (length, diameter, cross-section) similar to retained fibers; inclusion would not extend the range of geometrical variability covered by the selected set
R23-04	6	33.8	178	8.08	Mixed: circular hollow + triangular	0.90	160	Selected → F5	Unique mixed cross-sectional morphology (circular hollow + triangular) not represented by any other fiber type; suitable aspect ratio and processability confirmed during preliminary mixing trials
R23-05	12	31.0	387	6.79	Mixed: circular hollow + triangular	0.90	160	Excluded	Cross-sectional morphology (mixed circular hollow + triangular) already represented by retained fiber F5 (R23-04); inclusion would not extend morphological variability
R23-08	12	45.5	264	14.63	Circular	0.89	160	Excluded	Geometrical characteristics similar to retained fibers; inclusion would not extend the range of geometrical variability covered by the selected set
R23-09	6	19.6	306	2.72	Circular	0.89	160	Selected → F1	Smallest filament diameter among all investigated fiber types (19.6 µm); represents the fine-diameter end of the geometrical variability range; adequate processability confirmed during preliminary mixing trials
R23-10	12	33.2	361	7.79	Circular	0.90	160	Selected → F2	Intermediate diameter and longest length among selected circular-section fibers; extends geometrical variability in both length and diameter dimensions; adequate processability confirmed during preliminary mixing trials
R23-11	6	37.0	162	9.68	Circular	0.90	160	Selected → F8	Largest diameter among short-length circular-section fibers; lowest aspect ratio among selected fibers; complements F1 by covering the coarse-diameter, short-length end of the variability range
R23-12	3	43.0	70	13.07	Circular	0.90	160	Excluded	Fiber length of 3 mm falls at the minimum embedment length threshold; excluded to avoid ambiguity regarding stress transfer capacity and workability effects of sub-threshold fiber fractions [1]
R23-03	12	28.0	429	5.54	Circular	0.90	160	Excluded	Geometrical characteristics similar to retained fibers; inclusion would not extend the range of geometrical variability covered by the selected set
R23-02	20	36.0	556	9.16	Circular	0.90	160	Excluded	Fiber length of 20 mm results in an aspect ratio of 556, exceeding the recommended upper limit of 300 for adequate fiber dispersion in cementitious matrices; risk of fiber entanglement and balling during mixing documented in the literature [2,3]
R23-01	6	44.0	136	13.68	Circular	0.90	160	Excluded	Geometrical characteristics similar to retained fibers; inclusion would not extend the range of geometrical variability covered by the selected set
R23-01	20	32.0	625	7.24	Circular hollow	0.90	160	Excluded	Aspect ratio of 625 exceeds the recommended upper limit of 300; risk of fiber entanglement and balling during mixing [2,3]; hollow cross-sectional morphology considered geometrically covered by retained fiber F5 (R23-04) which exhibits a more distinctive mixed hollow-triangular section
R22-/01	24	36.0	667	9.16	Circular	0.90	160	Excluded	Highest aspect ratio among all investigated fibers (667); fiber length of 24 mm associated with severe balling tendency and workability loss in cementitious matrices at the investigated dosage range [2,3]

Note 1: All thirteen fiber types consisted of 100% polypropylene (PP) multi-filament structures, confirmed by solvent solubility testing in hot xylene and chemical composition analysis according to NF EN ISO 1833. These parameters were identical across all fiber types and are therefore not repeated in the table.

Note 2: Aspect ratio (AR) = L (µm) / d (µm), where L = fiber length and d = filament diameter. The recommended AR range for adequate fiber dispersion and workability in cementitious matrices is 20–300. AR values exceeding 500 are associated with increased fiber entanglement, balling tendency, and workability loss during mixing [2,3]. For selected fibers with AR slightly exceeding 300 (F1: 306; F2: 361), adequate dispersion was confirmed during preliminary mixing trials at the investigated dosage range (0.05–0.15% by mass of cement).

References: [1] Lauff et al., Materials 2021, 14, 7005 — minimum embedment length for effective stress transfer. [2] US Patent 9145337 — recommended AR range 20–300; AR > 500 associated with fiber balling and loss of fluidity in cementitious matrices. [3] Scientific Reports 2025 — excessive PP fiber length results in increased balling and non-uniform fiber distribution in concrete.