Tensile Properties of GFRP Rebars

#3 GFRP rebars | Tensile properties evaluation under ASTM D7205.

GUARANTEED ULTIMATE TENSILE FORCE

62.50 kN

MEAN TENSILE MODULUS OF ELASTICITY

46.27 GPa

MEAN ULTIMATE TENSILE STRAIN

2.08%

1. TEST SUMMARY

ASTM D7957 specification property: Guaranteed Ultimate Tensile Force, Mean Tensile Modulus of Elasticity, and Mean Ultimate Tensile Strain.
Reference standard: ASTM D7205 / D7205M-22, Standard Test Method for Tensile Properties of Fiber Reinforced Polymer Matrix Composite Bars.

Test objective: Determine the Guaranteed Ultimate Tensile Force, Mean Tensile Modulus of Elasticity, and Mean Ultimate Tensile Strain.
Product under evaluation: GFRP rebars.
Test machine: KQL-200B for tensile; 300KN capacity tension/compression; Test System: MTEST.

2. TEST SPECIMENS

A total of 24 tests are reported, eight tests from three different production groups.

Group	Tests
Group A	8
Group B	8
Group C	8

Specimen size and layout: The rebar specimens were installed with two steel pipe anchors to the two ends of the rebar, as indicated in ASTM D7205, using expansive grout. All specimens were cured for at least 7 days to ensure the grout reached enough internal pressure, ensuring proper gripping of the rebar.

Rebar specimen length: 1000mm

Anchor length: 250mm

3. TEST SET-UP

Uniaxial tensile load was applied to all specimens. Testing was performed using a screw-driven universal test machine. Tensile load was measured using a load cell of capacity of 300KN, while the extension (elongation) of the specimen was measured using a Class B-2 clip on extensometer with a 100 mm gauge length, placed at mid-length of the free length between the anchors. The extensometer was removed half way during the test to avoid damage of the instrument. Specimen anchors were gripped with hydraulic wedge type grips. All data was gathered by the data acquisition system at a rate of 100 Hz.

Rate and method of loading: Load was applied in displacement control to effect a near constant strain rate in the gauge section until failure at a constant frame head displacement of 2 mm/min (0.08 in./min), producing failure within 1 to 10 minutes and mostly around 4 to 5 minutes.

Tensile test set-up

4. TEST RESULTS

Results summary, mode of failure, calculation basis, and tabulated tensile properties.

4.1 RESULTS SUMMARY

All specimens behaved linear elastically until failure. Based on the experimental tests, the guaranteed ultimate tensile force, mean tensile modulus, and mean computed ultimate tensile strain met the requirements of ASTM D7957. The guaranteed ultimate tensile force is higher than 59 KN (13.2 kip); Mean Tensile Modulus of Elasticity is higher than 44.8 GPa (6.5 Msi); and Mean Ultimate Tensile Strain is higher than 1.1%.

Result	Metric Value	Specification Limit
Guaranteed Ultimate Tensile Force	62.50 kN / 13.98 kip	PASS
Mean Tensile Modulus of Elasticity	46.27 GPa / 6.71 Msi	PASS
Mean Ultimate Tensile Strain	2.08%	PASS

4.2 MODES OF FAILURE

The mode of failure for all bars was by tensile force of the rebar, as shown in the representative failure photo.

Representative failure mode of tensile test

4.3 CALCULATIONS

The results reported herein have been calculated per ASTM D7205 based on the nominal area of the rebar. For #3 rebar, the cross section area of 71.295mm^2 was used.

Detailed Results for Tensile Properties

DETAILED RESULTS

Sample	Ultimate Tensile Force (kN)	Ultimate Tensile Strength (MPa)	Tensile Modulus of Elasticity (GPa)	Ultimate Tensile Strain (%)
1	66.97	939.34	46.25	2.03%
2	70.36	986.89	45.39	2.17%
3	65.49	918.58	47.53	1.93%
4	67.43	945.79	47.12	2.01%
5	70.82	993.34	46.52	2.14%
6	71.63	1004.70	46.79	2.15%
7	70.94	995.02	45.92	2.17%
8	71.82	1007.36	46.38	2.17%
9	69.88	980.15	46.86	2.09%
10	67.82	951.26	46.59	2.04%
11	70.69	991.51	44.62	2.22%
12	69.33	972.44	45.37	2.14%
13	67.23	942.98	46.32	2.04%
14	70.88	994.18	46.21	2.15%
15	69.78	978.75	45.87	2.13%
16	65.78	922.65	45.81	2.01%
17	70.22	984.92	45.62	2.16%
18	65.93	924.75	46.17	2.00%
19	66.31	930.08	45.66	2.04%
20	66.74	936.11	45.83	2.04%
21	66.64	934.71	46.39	2.01%
22	71.23	999.09	47.12	2.12%
23	67.82	951.26	47.24	2.01%
24	68.28	957.71	46.84	2.04%
Average	**68.75**	**964.31**	**46.27**	**2.08%**
Standard deviation (Sn-1)	**2.082**	**29.20**	**0.689**	**0.015%**
Coefficient of variance	**3.03%**	**3.03%**	**1.49%**	**0.73%**
Guaranteed Ultimate Tensile Property	**62.50**	**876.71**		