TECHNICAL DATA SHEET
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FRP Deformed Rebar

GFRP REINFORCING BAR FOR CONCRETE











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NABAK COMPOSITE FRP deformed rebar (FRP / GRP Deformed Rebar) is a structural GFRP bar for reinforcing concrete. A helical or moulded rib and an optional sand coating give it full mechanical bond with concrete. It does not rust, has about twice the tensile strength of steel rebar at one quarter of the weight, is non-magnetic and electrically insulating, and extends the service life of concrete structures in corrosive environments many times over.

Ø 6 – 32 mm	≥ 7.6 MPa	≥ 44.8 GPa	ACI 440
FRP deformed rebar diameters	Bond to concrete (ASTM D7957)	Tensile modulus of elasticity	Structural design basis

What is FRP deformed rebar (ribbed GFRP rebar)?

FRP deformed rebar, also known as **composite rebar**, **FRP rebar**, **GFRP rebar**, **fiberglass rebar**, **composite reinforcement** and **ribbed FRP bar**, is made by pultruding continuous glass-fibre rovings impregnated with vinyl ester or epoxy resin. Before full cure, a helical rib is wound around the core or moulded ribs are formed, and the surface can be coated with silica sand; the GFRP bar is then cured in a heated tunnel.

FRP is the general name for fibre-reinforced polymers, and GFRP (or GRP) is FRP made with glass fibre. The surface rib is the main difference between deformed FRP rebar and smooth bar: through mechanical interlock and friction, the ribs transfer tensile force from the concrete into the fibre core, making the bar suitable as main reinforcement in beams, slabs, walls and columns in accordance with ASTM D7957, CSA S807 and ACI 440.

Surface and rib types of composite rebar

Helical wrap	Moulded rib	Sand-coated	Rib + sand
A fibre strand wound around the core forms a continuous spiral rib; the most common deformed GFRP rebar.	Transverse ribs formed in a mould, similar in appearance to deformed steel rebar.	Silica grains bonded to the surface increase roughness, chemical bond and friction.	Helical rib combined with sand coating for the highest bond of FRP rebar to concrete.

Benefits of deformed FRP rebar in concrete

- **No reinforcement corrosion:** composite rebar does not rust in chlorides, sulphates, carbonation or seawater, so rust-induced cracking and spalling of concrete are eliminated.
- **Less cover and fewer admixtures:** thick concrete cover, silica fume and corrosion inhibitors are needed less.
- **Lightweight:** GFRP rebar is about 70% lighter than steel; faster, safer handling and fixing.
- **High tensile strength:** 700 – 1100 MPa, two to three times the yield stress of steel rebar.
- **Non-magnetic and insulating:** suited to substations, railways, MRI rooms, airports and field-sensitive structures.
- **Cuttable by TBM:** composite reinforcement in tunnel launch and reception walls (soft-eye) can be cut by the boring machine.

Production steps of deformed GFRP rebar

1 **Roving feed:** dozens of alkali-resistant ECR glass rovings are fed from the creel into the composite rebar line.	2 **Impregnation:** the fibres are fully wetted in a vinyl ester or epoxy resin bath and excess resin is removed.	3 **Core forming:** the fibres pass through a round die and the FRP rebar core is formed to an accurate diameter.
4 **Rib forming:** the rib strand is wound helically around the core, or the rib is formed in a mould.	5 **Sanding and curing:** where required, silica sand is applied and the GFRP bar is cured in a heated tunnel.	6 **Cutting and control:** the deformed bar is cut to order length and its diameter, weight, Tg and tensile strength are checked.

Diameter and specification table of deformed composite rebar

Table 1 — Deformed GFRP rebar specifications (ρ ≈ 2.1 g/cm³, E ≥ 50 GPa)

Nominal diameter (mm)	Imperial equivalent	Nominal area (mm²)	Approx. weight incl. ribs (g/m)	Guaranteed tensile strength f_{fu}* (MPa)	Guaranteed tensile force (kN)	Rib height (mm)
6	#2	28.3	65 – 70	1100	31	0.4 – 0.6
8	—	50.3	115 – 125	1050	53	0.5 – 0.8
10	#3	78.5	180 – 195	1000	79	0.6 – 0.9
12	#4	113.1	240 – 260	950	107	0.7 – 1.0
14	—	153.9	330 – 355	920	142	0.8 – 1.1
16	#5	201.1	430 – 450	900	181	0.9 – 1.2
18	—	254.5	545 – 580	880	224	1.0 – 1.3
20	#6	314.2	675 – 710	850	267	1.0 – 1.4
22	#7	380.1	815 – 860	830	315	1.1 – 1.5
25	#8	490.9	1050 – 1110	800	393	1.2 – 1.6
28	#9	615.8	1320 – 1390	750	462	1.3 – 1.7
32	#10	804.2	1720 – 1810	700	563	1.4 – 1.8

Per ASTM D7957, the actual cross-sectional area of deformed composite rebar is measured by immersion and must fall within the permitted range of the nominal area; the weight is higher than smooth bar because of the ribs and sand. Imperial equivalents are approximate. The guaranteed strength of each order is determined by ASTM D7205 testing.

Bent bars, stirrups and spirals in composite rebar

Table 2 — Prefabricated GFRP shapes (bent in the factory, before cure)

Shape	Application	Minimum inside bend radius	Strength at the bend
L-bar (90° hook)	End anchorage, slab-to-wall connection	3 d_b	≈ 0.45 f_{fu} (Formula 13)
U-bar	Slab edges, column heads, transverse anchorage	3 d_b	≈ 0.45 f_{fu}
Closed and open stirrups	Shear reinforcement of beams and columns	3 d_b	≈ 0.45 f_{fu}
Spiral	Round columns and piles	To order	By testing

Cured composite rebar cannot be bent on site; the bar bending schedule must be submitted before production. Standard straight bar lengths are 6 and 12 m.

Applications of deformed composite rebar

Coastal and marine structures
Jetties, breakwaters, sea walls and structures in contact with seawater

Bridges and bridge decks
Deck slabs, parapets and slabs exposed to de-icing salts, reinforced with GFRP rebar

Car parks and industrial floors
Multi-storey car park slabs and floors exposed to chlorides and chemicals

Treatment plants and tanks
Basins, sewage tanks and concrete channels with composite reinforcement

Tunnels and metro
Soft-eye walls, segment elements and structures cut by TBM

Non-magnetic structures
Substations, transformer foundations, MRI rooms and navigation platforms

Properties of deformed GFRP rebar and ASTM D7957 requirements

Table 3 — Reference properties of deformed composite rebar compared with ASTM D7957 minimums

Property	Test method	Typical value, deformed FRP rebar	ASTM D7957 requirement
Glass fibre content (by weight)	ASTM D2584 / D3171	75 – 82%	≥ 70%
Tensile modulus of elasticity	ASTM D7205	50 – 60 GPa	≥ 44.8 GPa
Ultimate strain	ASTM D7205	1.4 – 2.2%	—
Bond strength to concrete	ASTM D7913	10 – 16 MPa	≥ 7.6 MPa
Transverse shear strength	ASTM D7617	150 – 200 MPa	≥ 131 MPa
Moisture absorption	ASTM D570	≤ 0.2%	≤ 0.25% (and ≤ 1% at saturation)
Glass transition temperature Tg	ASTM E1356 / E1640	105 – 130 °C	≥ 100 °C
Degree of resin cure	ASTM E2160	≥ 95%	≥ 95%
Coefficient of expansion, longitudinal / transverse	ASTM E831	6 – 10 / 21 – 30 $\times 10^{-6}$ /°C	—
Alkali durability (strength retention)	ASTM D7705	≥ 80%	Per project specification

Values are typical ranges of the FRP and GFRP composites industry and are not NABAK COMPOSITE's own laboratory results. Other related standards: CSA S807 (FRP rebar specification), ACI 440.1R-15 (design guide), ACI CODE-440.11 (building code for GFRP-reinforced concrete) and ACI 440.3R (test methods).

Deformed FRP rebar compared with steel rebar

Table 4 — Deformed composite rebar vs S400 steel, epoxy-coated steel and smooth FRP bar

Feature	Deformed GFRP rebar	S400 steel	Epoxy-coated steel	Smooth FRP bar
Tensile strength (MPa)	700 – 1100	Yield 400	Yield 400	700 – 1100
Modulus (GPa)	50 – 60	200	200	50 – 55
Bond to concrete	High (rib + sand)	High	10 – 20% lower	Low
Structural concrete reinforcement	Suitable (ACI 440)	Suitable	Suitable	Not suitable
Corrosion	None	Severe in chlorides	At coating damage	None
Behaviour up to failure	Elastic, no yielding	Ductile	Ductile	Elastic
Bending on site	Not possible	Easy	With care	Not possible

Different design, not one-for-one replacement: deformed composite rebar does not yield and its modulus is about one quarter of steel; design of FRP-reinforced concrete is therefore usually governed by crack, deflection and creep-rupture checks (serviceability), and sections are deliberately designed "over-reinforced" so that failure occurs by concrete crushing. The formulas on pages 4 and 5 are based on ACI 440.1R-15.

Concrete cover and fire protection of composite rebar

Table 5 — Concrete cover guidance for deformed FRP rebar

Member condition	Recommended cover	Remarks
Interior slabs and walls	≥ d_b and ≥ 20 mm	Prevents longitudinal splitting from the transverse expansion of GFRP rebar
Interior beams and columns	≥ 30 – 40 mm	≥ 30 – 40 mm
Exposed to earth or weather	≥ 40 – 50 mm	Benefit: the thick anti-corrosion cover needed for steel is no longer required
Fire-resistance requirement	Per the project fire rating, typically ≥ 50 – 60 mm	Composite rebar temperature at anchorage zones must stay below Tg

Flexural strength formulas for FRP-reinforced concrete

1. Design strength of the bar

$$f_{fu} = C_E \cdot f_{fu}^*$$

C_E = 0.8 for interior concrete and 0.7 for concrete exposed to earth or weather. f_{fu}^* = 800 → f_{fu} = 560 MPa

2. Balanced reinforcement ratio

$$\rho_{fb} = 0.85\,\beta_1\,\frac{f'_c}{f_{fu}} \cdot \frac{E_f\,\varepsilon_{cu}}{E_f\,\varepsilon_{cu} + f_{fu}}$$

f'c = 30, β_1 = 0.85, E_f = 50 GPa, ε_{cu} = 0.003 → ρ_{fb} ≈ 0.0082

3. Bar stress in an over-reinforced section ($\rho_f > \rho_{fb}$)

$$f_f = \sqrt{\left(\frac{(E_f\,\varepsilon_{cu})^2}{4} + \frac{0.85\,\beta_1\,f'_c}{\rho_f}\,E_f\,\varepsilon_{cu}\right)} - 0.5\,E_f\,\varepsilon_{cu} \le f_{fu}$$

Failure by concrete crushing; the composite rebar remains below its ultimate strength.

4. Nominal moment and strength reduction factor

$$M_n = \rho_f\,f_f\left(1 - 0.59\,\frac{\rho_f\,f_f}{f'_c}\right)\,b\,d^2$$

φ = 0.55 for $\rho_f \le \rho_{fb}$; φ = 0.3 + 0.25 ρ_f/ρ_{fb} in the transition zone; φ = 0.65 for $\rho_f \ge 1.4\,\rho_{fb}$

Design example — 200 mm one-way slab with deformed GFRP Ø16 at 125 mm (1 m width)

d = 160 mm ; A_f = 201.1 × 1000/125 ≈ 1609 mm²/m ; ρ_f = 1609 / (1000 × 160) ≈ 0.0101

ρ_f / ρ_{fb} = 0.0101 / 0.0082 ≈ 1.23 → transition zone → φ = 0.3 + 0.25 × 1.23 ≈ 0.61

$E_f\,\varepsilon_{cu}$ = 150 MPa → $f_f = \sqrt{(150^2/4 + 0.85\times0.85\times30/0.0101 \times 150)} - 75 \approx 499$ MPa ≤ 560 ✓

M_n = 0.0101 × 499 × (1 − 0.59 × 0.0101 × 499 / 30) × 1000 × 160² ≈ 115.7 kN·m/m

φ M_n ≈ 0.61 × 115.7 ≈ 70.3 kN·m/m

The section is over-reinforced and failure is controlled by concrete crushing — the desired behaviour for concrete reinforced with composite rebar. Serviceability checks of this slab continue on page 5.

5. Sustained stress limit (creep rupture) and concrete shear strength

$$f_{f,s} \le 0.20\,f_{fu}\,, \quad V_c = 0.4\,\sqrt{f'_c}\cdot b_w \cdot c\,, \quad c = k\,d$$

In the example: $f_{f,s}$ ≤ 0.2 × 560 = 112 MPa; k ≈ 0.179 → c ≈ 28.6 mm → V_c ≈ 0.4 × 5.48 × 1000 × 28.6 ≈ 62.8 kN/m. The concrete shear contribution in FRP-reinforced sections is lower than with steel because the compression zone is shallower.

6. Minimum flexural reinforcement (under-reinforced section)

$$A_{f,min} = \frac{0.41\,\sqrt{f'_c}}{f_{fu}}\,b_w\,d \ge \frac{2.26}{f_{fu}}\,b_w\,d$$

Required only when $\rho_f < \rho_{fb}$, so that the FRP bar does not rupture after cracking.

7. Temperature and shrinkage reinforcement

$$\rho_{f,ts} = 0.0018 \times \frac{414}{f_{fu}} \times \frac{E_s}{E_f}\,, \quad 0.0014 \le \rho_{f,ts} \le 0.0036$$

f_{fu} = 560, E_f = 50 GPa → 0.0053 → capped at 0.0036; 200 mm slab: A = 720 mm²/m → GFRP Ø12 at 150 mm

Crack, deflection and development length formulas for FRP rebar

8. Neutral axis depth of the cracked section

$$k = \sqrt{(2\rho_f n_f + (\rho_f n_f)^2)} - \rho_f n_f, \quad n_f = \frac{E_f}{E_c}$$

$E_c = 4700\sqrt{f'c} \approx 25.7$ GPa → $n_f \approx 1.94$ → $k \approx 0.179$

9. Bar stress under service load

$$f_{f,s} = \frac{M_s}{A_f \cdot d\,(1 - k/3)}$$

$M_s = 25$ kN·m/m → $f_{f,s} \approx 103$ MPa ≤ 112 MPa (creep limit) ✓

10. Crack width (ACI 440.1R)

$$w = 2\,\frac{f_{f,s}}{E_f}\,\beta\,k_b\,\sqrt{(d_c^2 + (s/2)^2)}$$

$\beta \approx 1.30$, $k_b = 1.4$, $d_c = 40$, $s = 125$ → $w \approx 0.56$ mm ≤ 0.7 mm (interior limit) ✓; the exterior limit is 0.5 mm: spacing 100 mm → $w \approx 0.39$ mm ✓

11. Effective moment of inertia (Bischoff)

$$I_e = \frac{I_{cr}}{1 - \gamma\,(M_{cr}/M_a)^2\,(1 - I_{cr}/I_g)}$$

$\gamma = 1.72 - 0.72\,M_{cr}/M_a$. In the example: $I_{cr} \approx 6.2\times10^7$, $I_g \approx 6.7\times10^8$ mm⁴, $M_{cr} \approx 22.6$ kN·m → $I_e \approx 3.0\times10^8$ mm⁴

12. Development length of a straight bar

$$l_d = \frac{\alpha\,\left(\frac{f_{fr}}{0.083\,\sqrt{f'_c}} - 340\right)}{13.6 + C/d_b}\,d_b \geq 20\,d_b$$

Ø16, $f_{fr} = 400$ MPa, $f'c = 30$, $C = 2d_b$, $\alpha = 1$ → $l_d \approx 554$ mm (≥ 320 mm)

13. Strength of the bar at a bend

$$f_{fb} = \left(0.05\,\frac{r_b}{d_b} + 0.3\right) f_{fu} \leq f_{fu}$$

$r_b = 3\,d_b$ → $f_{fb} = 0.45\,f_{fu}$; apply to composite stirrups and hooks.

Installation guide for deformed composite rebar

1 **Bending schedule:** fix all bends, stirrups and lengths before production; GFRP rebar is not bent on site.

2 **Handling and storage:** support on bearers at ≤ 2 m spacing, away from sunlight, and never drag on the ground.

3 **Cutting:** cut with a diamond or abrasive disc and wear a mask and goggles; rebar shears must not be used.

4 **Tying:** tie with coated wire, plastic ties or nylon wire; use plastic spacers to achieve the cover.

5 **Concrete cover:** at least one bar diameter and not less than 20 – 25 mm; anchor the cage against flotation during pouring.

6 **Splices:** lap splices with length ≥ 1.3 l_d; welding and steel mechanical couplers are not applicable to composite rebar.

NABAK COMPOSITE

Request a quote for FRP deformed rebar: send diameters and quantities, the bending schedule, surface type (rib, sand or both), type of structure and service environment.
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Disclaimer: The information in this data sheet is based on general, typical data of the FRP and GFRP composites industry and the ACI 440 and ASTM D7957 standards, and is intended as guidance only. Design examples are for illustration; structural design with composite rebar must be carried out by a structural engineer. NABAK COMPOSITE reserves the right to change technical specifications without notice.