Repair and rehabilitation of structures

Homework no.4

During the renovation of a concrete building it is determined that one of the building's circular spirally-reinforced concrete columns requires strengthening. It is subsequently decided to use Glass FRP wraps to increase the axial load capacity of the column, by wrapping the column in the circumferential direction. Determine the number of layers of GFRP wrap that are required to increase the factored axial load capacity of the column by 15%. The column dimensions, reinforcement details, and material properties are as follow:

- Unsupported column length, $l_u = 8.2\,'$ (250 cm)
- Column diameter, $D_g = 1.5\,'$ (45 cm)
- Column gross cross-sectional area, $A_g = 250\ in^2$ (1600 cm²)
- Area of longitudinal reinforcing steel, $A_{st} = 4\ in^2$ (25 cm²)
- Steel yield strength, $f_y = 58\ ksi$ (400 MPa)
- Concrete compressive strength, $f_c' = 4350\ psi$ (30 MPa)
- FRP ultimate strength, $f_{frpu} = 87\ ksi$ (600 MPa)
- FRP thickness, $t_{frp} = 0.004"$ (0.1 mm)
- FRP resistance factor, $C_E = 0.75$
- Steel elastic modulus, $E_s = 29000\ ksi$ (200 GPa)
- FRP elastic modulus, $E_{frp} = 11150\ ksi$ (76.9 GPa)
- FRP failure strain, $(\epsilon_u)_{frp} = 1.26\ \%$