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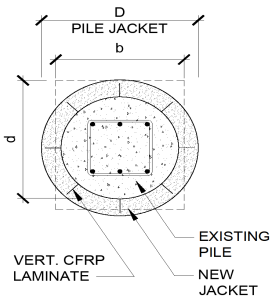
Flexural Strengthening of a Concrete Pile using the SCS System

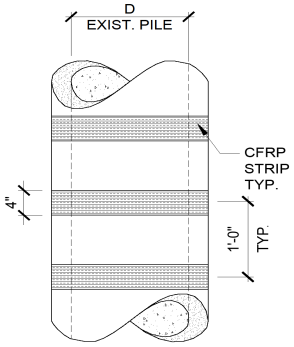
Existing pile size, properties and capacity:

$D_{Existing\ Pile}$=	24	in	24" Dia. w/ 6 #8 & #3 ties @12"oc
$f'_{c,\ Existing\ Pile}$=	4,000	psi	Existing concrete compressive strength
$f_{y,\ Existing\ Pile}$=	60,000	psi	Yeild Strength of existing Reinforcement
$A_{s,Tension}$=	2.36	in^2	Area of existing Reinforcement in tension
$\phi M_{n,Existing}$=	92	ft-kip	Original Flexural capacity of existing pile



New epoxy grout Jacket & CFRP Laminate size & properties:

f'_c=	9,500	psi	Compressive strength (7 Days)
$E_{c,comp}$=	2,500,000	psi	Compressive modulus
$\varepsilon_{c,u}$=	0.0038		Ultimate compressive strain
$D_{pile\ Jacket}$ =	32	in	
Cover=	0.75	in	FRP epoxy positioner
A_{pile}=	804	in^2	
Thk. $_{F.\ LAM}$ =	0.055	in	Nominal Thickness
Width $_{F.\ LAM}$ =	3.15	in	Nominal Width
n=	3		# of Long. CFRP lamintae in tension
A_f=	0.173	in^2	Area of each CFRP Laminate
ΣA_f=	0.520	in^2	Total CFRP area in tension
E_f=	23,000,000	psi	Modulus of Elasticity
$\alpha_{(Deg)}$=	45.0	Deg.	α = Angle vertical axis to center of CFRP
$Y=Y_{eq}$=	9.67		Dist. from centroid of reinf. to pile center
$\Sigma A_f Y$=	5.03	in^3	
$d=D_{pile\ Jacket}/2+Y_{eq}$=	25.67	in	



Determine flexural strength:

C_E=	0.8		ACI 440.1R Table 9.4
f_{fu}*=	390,000	psi	Ultimate Tensile Strength of CFPL
$f_{fu}=C_E.\ f_{fu}$*=	312,000	psi	Design Tensile Strength of CFPL per ACI 440.1R Table 6.2a
β_1=	0.65		
ρ_f=	0.0006		$\rho_f=\Sigma A_f / A_{pile}$ per ACI 440.1R Table 7.2.1a
ρ_{fb}=	0.0037		$\rho_{fb}=0.85\beta_1(f'_c/f_{fu})(E_f\varepsilon_{cu}/(f_{fu}E_f\varepsilon_{cu}+f_{fu}))$
ρ_f/ρ_{fb}=	0.2	<1	Section is tension controlled
f_f=	312,000	psi	$f_f=Min[((E_f\varepsilon_{cu})^2/4+0.85\beta_1 f'_c E_f\varepsilon_{cu}/\rho_f)^{(0.5)}-0.5\ E_f\varepsilon_{cu}, f_{fu}]$
=> f_f=	312	ksi	For Tension controlled section => $f_f=f_{fu}$
$\varepsilon_{fu}=f_f/E_f$=	0.0136		
$C_b=(\varepsilon_{cu}/(\varepsilon_{cu}+\varepsilon_{fu}))$=	5.62	in	ACI 440.1R (7.2.2h) for $\rho_f < \rho_{fb}$
$M_n=\Sigma A_f f_f\ (d-\beta_1 C_b/2)$=	3,866,603	in-lbs	ACI 440.1R (7.2.2g) for $\rho_f < \rho_{fb}$
ϕ =	0.55		Strength Reduction Factor for $\rho_f < \rho_{fb}$
$\phi M_{n,\ Jacket}$=	177	ft-kip	Design strength for tension controlled section ($\rho_f < \rho_{fb}$)

Comparison of flexural strength (Existing pile vs. SCS system):

$\phi M_{n,Existing}$=	92	ft-kip	Flexural capacity of existing Pile (Original)
$\phi M_{n,Jacket}$=	177	ft-kip	Flexural capacity of new SDS jacket system only
$n=M_{n,Jacket}/M_{n,Existing}$=	192%		Strength increase ratio (%)