



## Development length of FRP

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Development length of a FRP system is dependent on the bond capacity between the FRP and substrate. To develop the bond-dependent, required FRP stress needed for strengthening a member the development length is governed by ACI 440.2R-08, equation 13-2:

$L_{df} = 0.057 \cdot \sqrt{n \cdot E_f \cdot t_f / \sqrt{f'_c}}$  where:

$L_{df}$  = Development length

$n$  = the number of FRP layers

$E_f$  = the tensile modulus of elasticity of the FRP

$t_f$  = the thickness of one FRP layer

$f'_c$  = the compressive strength of concrete

If additional stresses on the FRP are required, or where substrate (concrete or masonry) crushing is the desired failure mode, mechanical anchorages are recommended. FRP fan-type anchors, perpendicular FRP bonded wraps, and groove-and-dowel anchors are a few types of suitable anchors. In addition, Fortress has developed a unique mechanical anchorage using a special version of its carbon staple and has been recently specified as the FRP anchor for a blast-resistant reinforcement upgrade at a petro-chemical facility in Ohio.

If you are interested, the design of externally applied FRP systems, including development length is available as a spread sheet-based application at [www.FRPcalc.com](http://www.FRPcalc.com).