Single Reinforced Concrete Beam Design Tables
An Attempt at Clearing Up Confusion!

Three Similar But Different Design Tables Are Explained

Summary

Wight & MacGregors' Reinforced Concrete Design Textbook **Appendix A-Table A3**	**William's Structural Engineering Reference Manual** **Appendix A**	**PCA's Circular Concrete Tank Without Pre-stressing** **Appendix Table A20**
$\frac{M_u}{\varphi b d^2} \leq R$ or $\frac{M_u}{\varphi b d^2} \leq f_c{}' \omega(1 - .59\omega)$	$\frac{M_u}{f_c{}' b d^2} \leq \varphi\, \omega(1 - .59\omega)$	$\frac{M_u}{\varphi f_c{}' b d^2} \leq \omega(1 - .59\omega)$
Enter table with an 'R' value, which is really $\frac{M_u}{\varphi b d^2}$ and table will give you a rho ρ back out. You can then solve for steel area	Enter the table with un-named variable and get a tension reinforcement index value ω back out. You can then solve for steel area.	Enter the table with un-named variable and get a tension reinforcement index value ω back out. You can then solve for steel area.
The table tells you applicable phi factor.	Need to check strain after arriving at steel area.	Need to check strain after arriving at steel area.
	Note: you can take the table values in the PCA guide and multiply by .90 and you will get the table values in the Structural engineering reference manual.	

I go through entire derivation for Wight & MacGregor, but then skip steps on the other two tables. (since its all the same)

Wight & MacGregors' Reinforced Concrete Design textbook

Tension Reinforcing Index	Flexural Resistance Factor
$\omega = \rho \frac{f_y}{f_c{}'}$	$R = \omega f_c{}'(1 - .59\omega)$

$$A_s f_y = .85 f_c{}' ab \qquad \text{Equation 1}$$

We are assuming steel yields now and will confirm later

$$M_n = A_s f_y \left(d - {}^{a}/_{2}\right) \qquad \text{Equation 2}$$

Solve Equation 1 for a → $a = \frac{A_s f_y}{.85 f_c{}' b}$ and substitute into equation 2

$$M_n = A_s f_y \left(d - \frac{1}{2}\left(\frac{A_s f_y}{.85 f_c{}' b}\right)\right)$$

Multiply by $\frac{bd}{bd}$

Multiply by $\frac{d}{d}$

Multiply by $\frac{f_c{}'}{f_c{}'}$

$$M_n = \frac{A_s f_y}{bd} x \frac{f_c{}'}{f_c{}'} \left(\frac{d}{d} - \frac{1}{2}\left(\frac{A_s f_y}{.85 f_c{}' b\mathbf{d}}\right)\right) x\, bd^{\mathbf{2}}$$

Simplify

$$M_n = \rho f_y \, x \, \frac{f_c{}'}{f_c{}'}\left[1 - .59\left(\rho \frac{f_y}{f_c{}'}\right)\right] bd^2$$

Introduce the Tension Reinforcing Index Omega ω

$$M_n = \omega f_c{}'(1 - .59\omega) bd^2$$

Introduce Flexural Resistance Factor R

$$M_n = Rbd^2$$

$$M_u \le \varphi R(bd^2)$$

$$\frac{M_u}{\varphi bd^2} \le R$$

The flexural resistance factor R can be looked up in design textbook design tables such as Wight & MacGregors' Reinforced Concrete Design Appendix A table A-3. You can enter the chart with an R value and get a reinforcement ratio 'ρ' rho out. The table will tell you if you what phi area you are in.

Structural Engineering Reference Manual Version of Design Table

Starting Point:
(same as Textbook version above)

$$M_n = \omega f_c{}'(1 - .59\omega)bd^2$$

$$M_u \leq \varphi M_n$$

$$M_u \leq \varphi[\omega f_c{}'(1 - .59\omega)bd^2]$$

$$\frac{M_u}{f_c{}'bd^2} \leq \underbrace{\varphi\,\omega(1 - .59\omega)}$$

These are the values on the table which I assume incorporate a phi=.90. I think we should still confirm strain>.005 though after solving for a steel area

You are entering the table with $\frac{M_u}{f_c{}'bd^2}$ and the table gives you the tension reinforcement index 'ω' back out. You use 'ω' to solve for a rho ρ and then you can get the actual required area of steel.

$\omega = \rho\frac{f_y}{f_c{}'}$ therefore..$\rho = \omega\frac{f_c{}'}{f_y}$ which leads you to…….. $A_s = \rho bd$

After to you get the actual area of steel, you need to re-run the equations and check your steel strain to make sure a phi of .90 is okay.

Circular Concrete Tank Without Prestressing Version of Design Table

Similar to above BUT, the Phi factor has been moved to other side of equation…

$$\frac{M_u}{\varphi f_c{}'bd^2} \leq \underbrace{\omega(1 - .59\omega)}$$

These are the values on the table which. I think we should still confirm strain>.005 though after solving for a steel area