ARCH 614: Practice Quiz 7

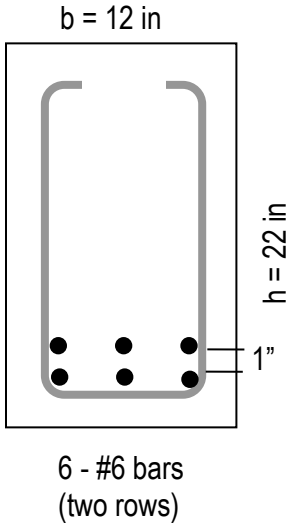
*Note: No aids are allowed for part 1. One side of a letter sized paper with notes is allowed during part 2, along with a silent, **non-programmable** calculator. There are reference charts on pages 2-3 for part 2.*

Clearly show your work and answer.

Part 1) *Worth 5 points*
(conceptual questions)

Part 2) *Worth 45 points*

(NOTE: The member size, load magnitudes, reinforcement, and materials can and will be changed for the quiz! The beam supports will not change.)



A 28 ft simply supported reinforced concrete beam is 12 in. wide by 22 in. deep with 6-#6 bars (two layers). The effective depth, *d*, is 18.875 in. It has 3000 psi concrete and Grade 50 reinforcement (f_y = 50 ksi). There will be #3 U stirrups.

a) Determine if the beam is adequate for flexure and reinforcing requirements when M_u = 165 k-ft.

b) Determine the key values for shear, and determine the lengths over which the beam requires stirrups for strength and stirrups for crack control. $V_{u\text{-}max}$ = 42 k when the beam has a total factored distributed load of 3000 lb/ft. $\lambda = 1$.

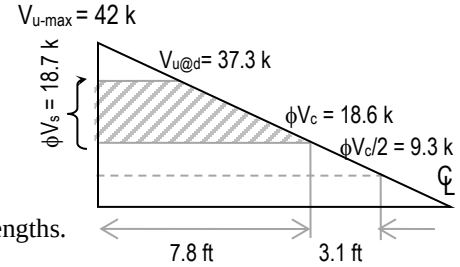
c) Determine the spacing required for strength with the maximum design shear.

A 9 in. thick solid one-way slab with both ends continuous (no figure) supported by beams with a span of 13 ft is to be designed for a maximum factored moment of 19 k-ft/ft of width. It has 3000 psi concrete and Grade 60 reinforcement (f_y = 60 ksi). Assume d = 8 in.

d) Determine the required reinforcement and spacing in both directions. *(Note: checking moment capacity adequacy <u>is not</u> required for this part.)*

Answers – <u>Not provided on actual quiz!</u>

Disclaimer: Answers have NOT been painstakingly researched.



a) ϕM_n = 166 k-ft > M_u and ρ_{min} < 0.012 < $\rho_{max(at\ strain\ of\ 0.005)}$ ∴OK
b) $V_{u@d}$ = 37.3 k , ϕV_c = 18.6 k, ½ ϕV_c = 9.3 k, ϕV_s = 18.7 k. See sketch for lengths.
c) $s_{req'd}$ = 8.33 in (and less than d/2)
d) $R_n \approx 330$ psi, $\rho \approx 0.007$, $A_{smin\text{-}temp}$ = 0.194 in_2/ft.; one possibility is #4 at 3.5 in.

REFERENCE CHARTS FOR QUIZ 7

Maximum Reinforcement Ratio ρ for Singly Reinforced Rectangular Beams (tensile strain = 0.005) for which ϕ is permitted to be 0.9

	f'_c = 3000 psi	f'_c = 3500 psi	f'_c = 4000 psi	f'_c = 5000 psi	f'_c = 6000 psi
f_y	β_1 = 0.85	β_1 = 0.85	β_1 = 0.85	β_1 = 0.80	β_1 = 0.75
40,000 psi	0.0203	0.0237	0.0271	0.0319	0.0359
50,000 psi	0.0163	0.0190	0.0217	0.0255	0.0287
60,000 psi	0.0135	0.0158	0.0181	0.0213	0.0239
	f'_c = 20 MPa	f'_c = 25 MPa	f'_c = 30 MPa	f'_c = 35 MPa	f'_c = 40 MPa
f_y	β_1 = 0.85	β_1 = 0.85	β_1 = 0.85	β_1 = 0.81	β_1 = 0.77
300 MPa	0.0181	0.0226	0.0271	0.0301	0.0327
350 MPa	0.0155	0.0194	0.0232	0.0258	0.0281
400 MPa	0.0135	0.0169	0.0203	0.0226	0.0245
500 MPa	0.0108	0.0135	0.0163	0.0181	0.0196

STEEL REINFORCEMENT INFORMATION

Table 3.7.1
Total Areas for Various Numbers of Reinforcing Bars

Bar Size	Nominal Diameter (in.)	Weight (lb/ft)	Number of Bars 1	2	3	4	5	6	7	8	9	10
#3	0.375	0.376	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88	0.99	1.10
#4	0.500	0.668	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60	1.80	2.00
#5	0.625	1.043	0.31	0.62	0.93	1.24	1.55	1.86	2.17	2.48	2.79	3.10
#6	0.750	1.502	0.44	0.88	1.32	1.76	2.20	2.64	3.08	3.52	3.96	4.40
#7	0.875	2.044	0.60	1.20	1.80	2.40	3.00	3.60	4.20	4.80	5.40	6.00
#8	1.000	2.670	0.79	1.58	2.37	3.16	3.95	4.74	5.53	6.32	7.11	7.90
#9	1.128	3.400	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
#10	1.270	4.303	1.27	2.54	3.81	5.08	6.35	7.62	8.89	10.16	11.43	12.70
#11	1.410	5.313	1.56	3.12	4.68	6.24	7.80	9.36	10.92	12.48	14.04	15.60
#14*	1.693	7.65	2.25	4.50	6.75	9.00	11.25	13.50	15.75	18.00	20.25	22.50
#18*	2.257	13.60	4.00	8.00	12.00	16.00	20.00	24.00	28.00	32.00	36.00	40.00

* #14 and #18 bars are used primarily as column reinforcement and are rarely used in beams.

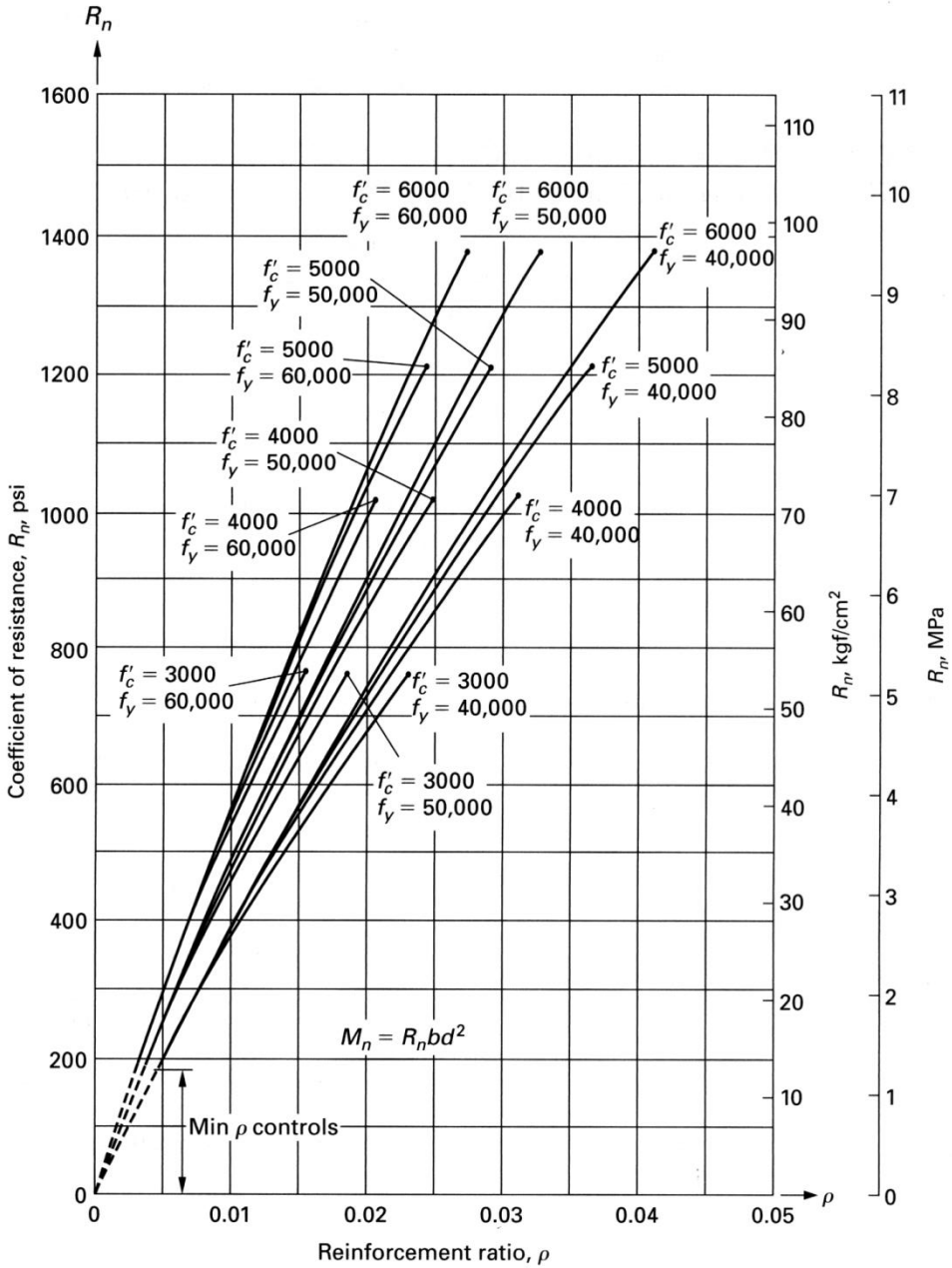


Figure 3.8.1 Strength curves (R_n vs ρ) for singly reinforced rectangular sections. Upper limit of curves is at ρ_{max}.

Worth 50 points

REFERENCE CHARTS FOR QUIZ 7

Table 3-8 ACI Provisions for Shear Design*

		$V_u \le \frac{\phi V_c}{2}$	$\phi V_c \ge V_u > \frac{\phi V_c}{2}$	$V_u > \phi V_c$	
Required area of stirrups, A_v**		none	greater of $\frac{50 b_w s}{f_{yt}}$ and $\frac{0.75\sqrt{f'_c}\, b_w s}{f_{yt}}$		$\frac{(V_u - \phi V_c)s}{\phi f_{yt} d}$
Stirrup spacing, s	Required	—	smaller of $\frac{A_v f_{yt}}{50 b_w}$ and $\frac{A_v f_{yt}}{0.75\sqrt{f'_c}\, b_w}$		$\frac{\phi A_v f_{yt} d}{V_u - \phi V_c}$
	Recommended Minimum†	—	—	4 in.	
	Maximum†† (ACI 9.7.6.22)	—	$\frac{d}{2}$ or 24 in.	$\frac{d}{2}$ or 24 in. for $(V_u - \phi V_c) \le \phi 4\sqrt{f'_c}\, b_w d$	
				$\frac{d}{4}$ or 12 in. for $(V_u - \phi V_c) > \phi 4\sqrt{f'_c}\, b_w d$	

*Members subjected to shear and flexure only; $\phi V_c = \phi 2\lambda\sqrt{f'_c} b_w d$ $\phi = 0.75$ (ACI 22.5.5.1)
**$A_v = 2 \times A_b$ for U stirrups; $f_y \le 60$ ksi (ACI 20.2.2.4)
†A practical limit for minimum spacing is d/4
††Maximum spacing based on minimum shear reinforcement ($= A_v f_{yt} / 50 b_w$ or $A_v f_{yt} / 0.75\sqrt{f'_c} b_w$) must also be considered (ACI 9.6.3.3)

TABLE 13.6 Areas Provided By Spaced Reinforcement

Bar Spacing (in.)	Area Provided (in.²/ft width)								
	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11
3	0.44	0.80	1.24	1.76	2.40	3.16	4.00		
3.5	0.38	0.69	1.06	1.51	2.06	2.71	3.43	4.35	
4	0.33	0.60	0.93	1.32	1.80	2.37	3.00	3.81	4.68
4.5	0.29	0.53	0.83	1.17	1.60	2.11	2.67	3.39	4.16
5	0.26	0.48	0.74	1.06	1.44	1.89	2.40	3.05	3.74
5.5	0.24	0.44	0.68	0.96	1.31	1.72	2.18	2.77	3.40
6	0.22	0.40	0.62	0.88	1.20	1.58	2.00	2.54	3.12
7	0.19	0.34	0.53	0.75	1.03	1.35	1.71	2.18	2.67
8	0.16	0.30	0.46	0.66	0.90	1.18	1.50	1.90	2.34
9	0.15	0.27	0.41	0.59	0.80	1.05	1.33	1.69	2.08
10	0.13	0.24	0.37	0.53	0.72	0.95	1.20	1.52	1.87
11	0.12	0.22	0.34	0.48	0.65	0.86	1.09	1.38	1.70
12	0.11	0.20	0.31	0.44	0.60	0.79	1.00	1.27	1.56
13	0.10	0.18	0.29	0.40	0.55	0.73	0.92	1.17	1.44
14	0.09	0.17	0.27	0.38	0.51	0.68	0.86	1.09	1.34
15	0.09	0.16	0.25	0.35	0.48	0.63	0.80	1.01	1.25
16	0.08	0.15	0.23	0.33	0.45	0.59	0.75	0.95	1.17
18	0.07	0.13	0.21	0.29	0.40	0.53	0.67	0.85	1.04
24	0.05	0.10	0.15	0.22	0.30	0.39	0.50	0.63	0.78