ARCH 331: Practice Quiz 6

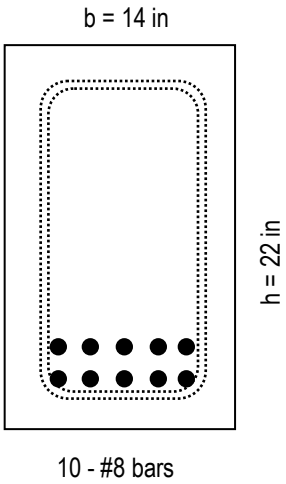
*Note: No aids are allowed for part 1. One side of a letter sized paper with notes is allowed during part 2, along with a silent, **non-programmable** calculator. There are reference charts for part 2, shown on pages 2-3.*

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 (shown) is 14 in. wide by 22 in. deep with 10-#8 bars (two layers). The effective depth, *d*, is 17.625 in.. It has 3000 psi concrete and Grade 40 reinforcement (f_y = 40 ksi). The beam has a total factored distributed load of 3000 lb/ft. There will be #3 U stirrups.

a) Determine if the beam is adequate for flexure and reinforcing requirements when M_u = 294 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.

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

A 9 in. thick solid one-way continuous slab (no figure) with a 13 ft span 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.)*

e) Find the minimum thickness if deflection will not be computed.

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

Disclaimer: Answers have NOT been painstakingly researched.

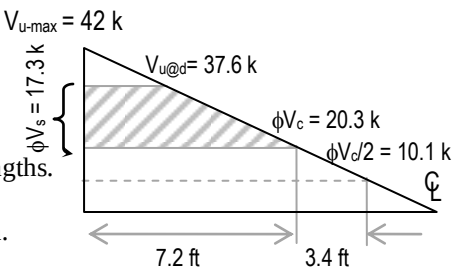
a) ϕM_n = 313 k-ft > M_u $\rho_{min} < 0.032 \not\leq \rho_{max}$ ∴ Not OK.

b) $V_{u@d}$ = 37.6 k, ϕV_c = 20.3 k, ½ ϕV_c = 10.1 k, ϕV_s = 17.3 k. See sketch for lengths.

c) $s_{req'd}$ = 6.72 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.

e) t = 6.5 in.



REFERENCE CHARTS FOR QUIZ 6

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[a]	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[a]	2.257	13.60	4.00	8.00	12.00	16.00	20.00	24.00	28.00	32.00	36.00	40.00

[a] #14 and #18 bars are used primarily as column reinforcement and are rarely used in beams.

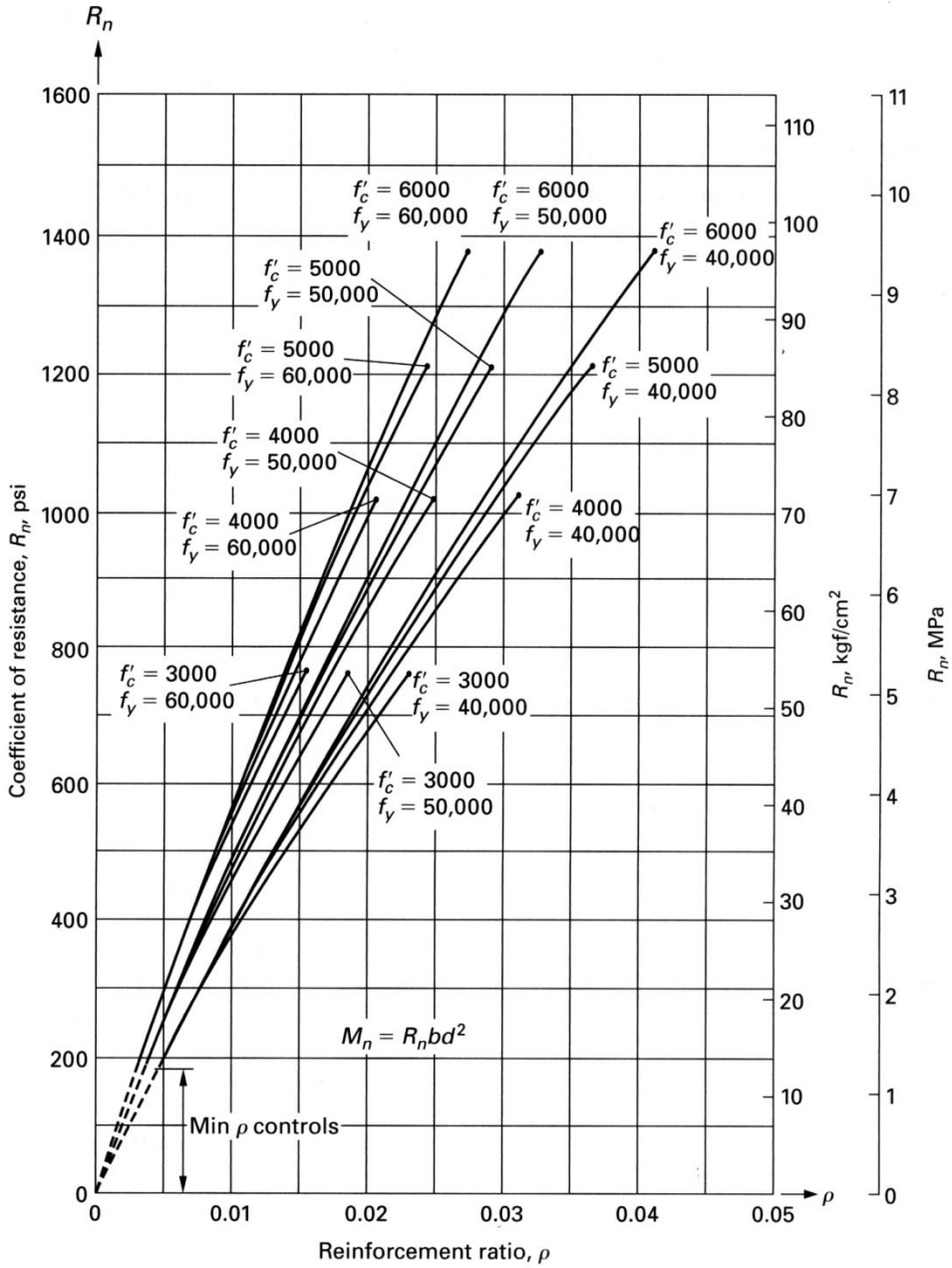


Figure 3.8.1 Strength curves (R_n vs ρ) for singly reinforced rectangular sections. Upper limit of curves is at ρ_{max} (tensile strain of 0.004)

REFERENCE CHARTS FOR QUIZ 6

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	$\frac{50 b_w s}{f_y}$	$\frac{(V_u - \phi V_c)s}{\phi f_y d}$
Stirrup spacing, s	Required	—	$\frac{A_v f_y}{50 b_w}$	$\frac{\phi A_v f_y d}{V_u - \phi V_c}$
	Recommended Minimum†	—	—	4 in.
	Maximum†† (ACI 11.5.4)	—	$\frac{d}{2}$ 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; $\phi V_c = \phi 2\sqrt{f'_c}\, b_w d$, $\phi = 0.75$ (ACI 11.3.1.1)
**$A_v = 2 \times A_b$ for U stirrups; $f_y \le 60$ ksi (ACI 11.5.2)
†A practical limit for minimum spacing is d/4
††Maximum spacing based on minimum shear reinforcement (= $A_v f_y / 50 b_w$) must also be considered (ACI 11.5.5.3).

TABLE 9.5(a)—MINIMUM THICKNESS OF NONPRESTRESSED BEAMS OR ONE-WAY SLABS UNLESS DEFLECTIONS ARE COMPUTED

	Minimum thickness, *h*			
Member	Simply supported	One end continuous	Both ends continuous	Cantilever
	Members not supporting or attached to partitions or other construction likely to be damaged by large deflections.			
Solid one-way slabs	$\ell/20$	$\ell/24$	$\ell/28$	$\ell/10$
Beams or ribbed one-way slabs	$\ell/16$	$\ell/18.5$	$\ell/21$	$\ell/8$

Notes:
1) Span length ℓ is in inches.
2) Values given shall be used directly for members with normalweight concrete (w_c = 145 lb/ft^3) and Grade 60 reinforcement. For other conditions, the values shall be modified as follows:
a) For structural lightweight concrete having unit weight in the range 90-120 lb/ft^3, the values shall be multiplied by $(1.65 - 0.005 w_c)$ but not less than 1.09, where w_c is the unit weight in lb/ft^3.
b) For f_y other than 60,000 psi, the values shall be multiplied by $(0.4 + f_y/100{,}000)$.

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