University of Stavanger

FACULTY OF SCIENCE AND TECHNOLOGY

SUBJECT: PET 535: MODERN WELL DESIGN

DATE: MAY 22 , 2017

TIME: 0900 - 1300

AID: CALCULATOR

THE EXAM CONSISTS OF 5 PROBLEMS AND 5 PAGES

REMARKS: PLEASE STATE ASSUMPTIONS

Problem 1. Casing Design

You are asked to design a surface casing. The design parameters are as follows:

Depth of casing:	1100 m
Depth to seabed:	225 m
Depth to sea level:	25 m
Depth to top of tail cement:	1000 m
Depth to top lead cement:	225 m
Depth next open hole section:	1820 m
Design fracture gradient at casing shoe:	1.57 s.g.
Pore pressure gradient, casing shoe:	1.03 s.g.
Pore pressure gradient, next section:	1.40 s.g.
Formation fluid density:	0.76 s.g.
Mud density:	1.20 s.g.
Mud density, next open hole section:	1.50 s.g.
Lead cement density:	1.45 s.g.
Tail cement density:	1.90 s.g.

The casing data are:

18-5/8 in. grade X-70, 84.5 lb/ft. casing

Weight:	186 kg/m
Crossectional inner area:	1527 cm^2.
Burst strength:	197 bar
Collapse resistance:	43 bar
Pipe body yield strength:	800 x 10^3 daN

Remember to define the important assumptions.

a) Prepare a drawing of the situation: the casing during installation. Define two criteria for casing collapse . Compute the design factor for these scenario.

b) Prepare a drawing of the situation: the burst design. Define a burst scenario. Compute the design factor for burst.

c) Define two scenarios for tension design. Compute the design factors.

d) Compute the casing test pressure.

e) Compute the kick margin of the casing section.

f) Define the weak point in the well.

Problem 2: Casing strength

The following casing types are available:

Size(in):	Grade, weight(lb/ft):	Outer diam.(mm):	Inner diam.(mm)
20	P110, 133	508	475,7
13-3/8	K55,88.2	346.1	314.3
10-3/4	N80, 60.7	273	245.4
7	L80, 20	177.8	164

a) Compute the burst strength of each casing. List the casings from strongest to weakest in burst.

b) Are these casings suitable for use in the same well? Explain which of the casings could be replaced, and indicate if it should be stronger or weaker.

c) A closed pipe is pressurized from the inside. Define two failure modes, and show which failure mode is dominating.

Problem 3. Rock Mechanics

The following principal stresses are given: 3, 5 and 7

a) Define the cubic stress equation
b) Determine the 2nd deviatoric invariant.
c) Rank the principal stresses above and define which of them lead to collapse failure.
d) What are the three invariants?

Problem 4: Mud weight optimalization

a) Define the two classical limits for the mud weight. What are the failure mechanisms?

b) Using a simple fracturing equation, define the new optimization criterion presented in this course. What is this criterion called?

c) Define two advantages of using this criterion. Also define two concerns.

~~c) In the figure on the following page propose a mud weight schedule.~~

Problem 5: Fundamentals

Please identify the most correct answer below. Just write answer number, f.eks. a1, b1, and so on.

a) Which equilibrium condition dominate geomechanics:
   1) Stress equilibrium
   2) Newtons 2nd law
   3) Maxwell equations
   4) Conservation of mass

b) Which statement is correct:
   1) The dog leg is the vertical angle
   2) The DLS act in the vertical plane
   3) The DLS is a 3 dimensional parameter
   4) The DL is the derivative of the angle

c) Stresses transforms in space according to:
   1) Linearly
   2) Squared trigonometric law
   3) Cubic trigonometric law
   4) None of the above

d) Replacing the mud in the drill string with sea water leads to:
   1) Reduction in surface pipe tension

2) Increase in surface pipe tension
3) No change in surface pipe tension
4) Differential sticking

e) Surface casing is installed:
1) Through the marine riser
2) Before riser is installed
3) Through the BOP
4) After riser is installed

f) On jack-up rigs
1) Always implement riser margin
2) New rigs uses dynamic positioning
3) Have the weight of the well on mud line suspension system
4) Can work in 200 m of water

g) Wellhead systems
1) Horizontal X-mas trees are mostly used subsea
2) Vertical X-mas trees are mostly used subsea
3) BOP is mainly used during production of the well
4) One well barrier is sufficient for low pressure wells

Some Formulas

$P(bar) = 0.098 \times d(s.g.) \times D(m)$

$P_3 = Cq^m$

$P_2 = \rho q^2/2A^2 0.95^2$

Index:	Equation:	Criterion:	Fraction parasitic pressure loss:	Flow rate:
1	qP_2	Max. HP	$1/(m+1)$	$P_1/C(m+1)$
2	$q\sqrt{P_2}$	Max. jet impact	$2/(m+2)$	$2P_1/C(m+2)$
3	$q3/2\sqrt{P_2}$	New A	$3/(m+3)$	$3P_1/C(m+3)$
4	$q^2\sqrt{P_2}$	New B	$4/(m+4)$	$4P_1/C(m+4)$
5	$q^{5/2}\sqrt{P_2}$	New C	$5/(m+5)$	$5P_1/C(m+5)$

$A = q\{\rho/2P_2\}^{1/2}/0.95$

Using the units of: density(kg/l), flowrate (l/min) and pressure (bar), the nozzle area in in^2 can be obtained by dividing the equation above with 122.4.

$d_{RKB1} = d_{RKB2}D/(D-\delta h)$

$LOT = 2\sigma_a - P_o$

$P_{wf}(\gamma) = P_{wf}(0) + {}^{1}/_{3}\,(P_o - P_o^*)\sin^2\gamma$

$P_{wf}(0) = \{P_{wf}(\gamma) + (\sigma_o - 1/2 P_o)\sin^2\gamma\}/\{1 + 1/2\sin^2\gamma\}$

$\Delta\sigma_a = \Delta P_o(1-2\nu)/(1-\nu)$

$\Delta P_{wf} = \Delta P_o(1-3\nu)/(1-\nu)$

$P_{burst} = 2\sigma_{tensile}\, t/D_o$

$P_{collapse} = \{2CE/1 - \nu^2\}\{1/(D_o/t - 1)^2 D_o/t\}$

$(\sigma_t/\sigma_{yield}) = 1/2(\sigma_a/\sigma_{yield}) \;+/-\{1 - 3/4(\sigma_a/\sigma_{yield})^2\}^{1/2}$

$\rho = (d_p D - 1.03 h_w)/(D - h_f - h_w)$

$$d_{wf2} = d_{wf1}\frac{D_1}{D_2} + d_{sw}\frac{D_{w2} - D_{w1}}{D_2}$$

$$D_2 = D_1 + (D_{w2} - D_{w1}) + (D_{f2} - D_{f1})$$

$$D_2 = D_1 + (D_{w2} - D_{w1}) + (D_{f2} - D_{f1}) + \left(\frac{d_{ob1}}{d_{ob2}} - 1\right)(D_1 - D_{w1} - D_{f1})$$

$$\frac{\Delta V}{V} = \frac{1}{2}\alpha\Delta T$$

$$\Delta P = \left(\frac{-1}{c}\right)\frac{\Delta V}{V}$$

$$I_1 = \sigma_x + \sigma_y + \sigma_z$$

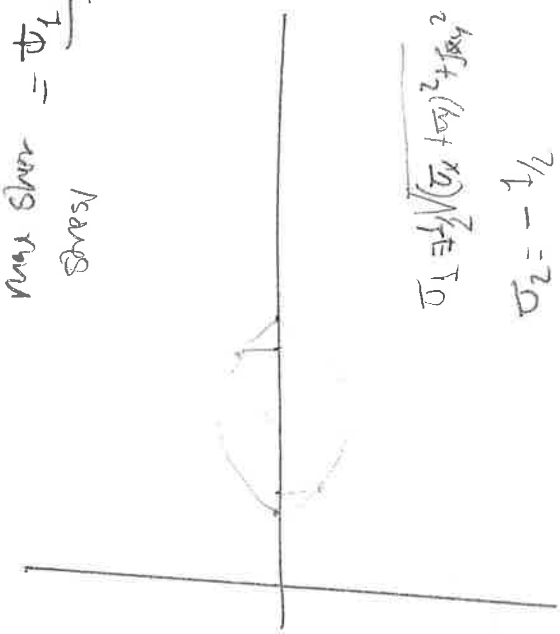
$$I_2 = \tau_{xy}^2 + \tau_{xz}^2 + \tau_{yz}^2 - \sigma_x\sigma_y - \sigma_x\sigma_z - \sigma_y\sigma_z$$

$$I_3 = \sigma_x(\sigma_y\sigma_z - \tau_{yz}^2) - \tau_{xy}(\tau_{xy}\sigma_z - \tau_{xz}\tau_{yz}) + \tau_{xz}(\tau_{xy}\tau_{yz} - \tau_{xz}\sigma_y)$$

$$J_1 = 0$$

$$J_2 = \frac{1}{6}\left[(\sigma_1 - \sigma_2)^2 + (\sigma_1 - \sigma_3)^2 + (\sigma_2 - \sigma_3)^2\right]$$

$$J_3 = I_3 + \frac{1}{3}I_1 I_2 + \frac{2}{27}I_1^3$$



Units

1 bar = 14.5 psi = 10^5 Pa
1 ft = 0.3048 m = 12 in
1 lb_f = 0.454 kp = 4.45