Exam 2018 - Solution

Exercise 1: Axial load (21% + 4% Multiple Choice) ⇒ 25% total.

a) $\frac{2}{3} g m_{dc} h_{dc} k - F_D - F_B = 0$ (3%)

$\Rightarrow F_D = \frac{2}{3} \cdot 9{,}81 \cdot 181{,}7 \cdot 250 \cdot \left(1 - \frac{1180}{7850}\right) - 245 \cdot 10^3$

$\Rightarrow \underline{\underline{F_D = 7{,}4 \text{ kN}}}$

b) 1. $F_A = m_{ds} h_{ds} g \cdot \left(1 - \frac{\rho_m}{\rho_s}\right)$ (3%)

$\Rightarrow F_A = (40 \cdot 2950 + 181{,}7 \cdot 250) \cdot 9{,}81 \cdot \left(1 - \frac{1180}{7850}\right)$

$\Rightarrow \underline{\underline{F_A = 1362{,}2 \text{ kN}}}$

2. At the top. $\underline{\underline{SF}} = \frac{F_y}{F_A} = \frac{1843}{1362{,}2} = \underline{\underline{1{,}32}}$ (3%)

(1843: Found in tables)

c) Need to calculate h_{dc} for both WOB.

- $h_{dc,180} = \underline{\underline{185{,}6 \text{ m}}}$ → (3%)
- $h_{dc,250} = \underline{\underline{254{,}9 \text{ m}}}$ → choose this one because of the variation of forces and to be safe. (0%)

d) From tables: $P_y = 82{,}7$ MPa (3%)

$M_y = 5494$ daNm $= 54{,}94$ kNm

$\Rightarrow \underline{\underline{M_F = 2{,}449 \text{ kNm}}}$

e) 1. $F_F = \frac{k_T - 1}{1 - k_T^{-n}} (F_A + M_g) \Rightarrow n = \frac{\ln\left(1 - \frac{k_T - 1}{F_F}(F_A + M_g)\right)}{-\ln(k_T)}$ (3%)

$\underline{\underline{n \hat{=} 10}} \Rightarrow$ $\underline{\underline{\text{5 sheaves needed.}}}$

2. $\dot{E}\eta = F_F n \cdot \frac{L}{t}$

$\Rightarrow \underline{\underline{\dot{E} = 1403{,}3 \text{ kW}}}$ (3%)

Exercise 2 : Fluids and pumps

(21% + 4% Multiple Choice) ⇒ 25% total

a) $\Delta P_F = (N_2(h - h_{dc}) + N_3 h_{dc})\, \rho_R^{0,8}\, \mu_R^{0,2}$ (2%)

$\Rightarrow \Delta P_F = 126,2 \text{ bar}$

b) 1. $P_p = \Delta P_F + \Delta P_D + \Delta P_A + 0,7$

$\Rightarrow \Delta P_D = 300 - (126,2 - 14 - 0,7) = 188,5 \text{ bar}$ (2%)

2. $F_D = \dot{m} v = \rho Q v = 1180 \cdot \frac{2200}{60000} \cdot 171,6 = 7,425 \text{ kN}$ (3%)

$v = 0,96 \sqrt{\frac{2 \cdot 188,5 \cdot 10^5}{1180}} = 171,6 \text{ m/s}$

3. $A_D = \frac{Q}{v} = \frac{2200/60000}{171,6} = 213,6 \text{ mm}^2$

$A = \frac{A_D}{4} = 53,4 \text{ mm}^2$ (3%)

$\Rightarrow D = \sqrt{\frac{4A}{\pi}} = 8,25 \text{ mm} \Rightarrow 9 \text{ mm}$

c) $D = \sqrt{\frac{4 \eta_P \eta_T \eta_E \dot{E}}{3\pi L n \rho_p}} \Rightarrow D = 5,65'' \Rightarrow 5,5''$ (3%)

d) 1. $Q = \frac{3\pi D^2 \cdot L \cdot \eta_v \cdot n}{4} \Rightarrow Q = 0,02265 \text{ m}^3/\text{s} = 1359,5 \text{ L/min}$ (3%)

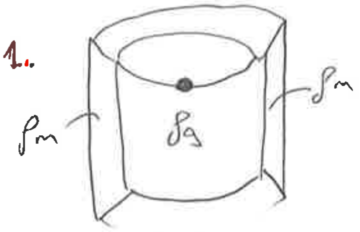
2. $P_p = \ldots \Rightarrow P_p = 317 \text{ bar}$ (3%)

3. $\frac{2200}{1359,5} = 1,6 \Rightarrow$ 2 pumps are needed. (2%)

Exercise 3: Casing

(21% + 4% Multiple choice) => 25% total

a) 1.

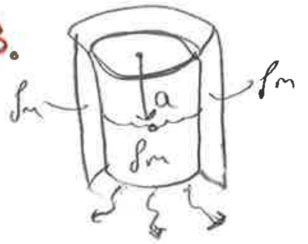


$$\Delta P_B = P_i - P_o$$
$$= (P_F - \rho_g g h) - 0$$
$$= 380 \cdot 10^5 - 230 \cdot 9{,}81 \cdot 3000$$
$$= \underline{312{,}31 \text{ bar}}$$

(2%)

2. At the top (1%)

3.



$$\Delta P_c = P_o - P_i$$
$$= 0{,}4 \cdot 3000 \cdot 1180 \cdot 9{,}81 - 0$$
$$= \underline{138{,}91 \text{ bar}}$$

(2%)

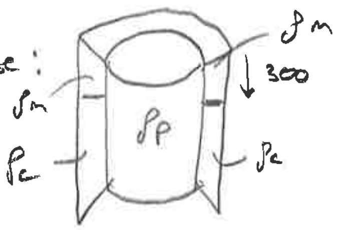
4. At a·h and downwards. (1%)

b) 1. Burst:

$$\Delta P_B = P_i - P_o$$
$$= 1550 \cdot 9{,}81 \cdot 3000 - 1180 \cdot 9{,}81 \cdot 3000$$
$$= \underline{108{,}9 \text{ bar}}$$

← (3%) ↓

Collapse:



$$\Delta P_c = P_o - P_i$$
$$= [1550 \cdot 9{,}81 \cdot (3000 - 300) + 1180 \cdot 9{,}81 \cdot 300]$$
$$- [1050 \cdot 9{,}81 \cdot 3000]$$
$$= 445{,}3 - 309{,}0 \Rightarrow \underline{136{,}26 \text{ bar}}$$

2. At the bottom (1%)

c) 1. Dimensioning burst: $1{,}5 \cdot 312{,}31 = 468{,}465$ bar
Dimensioning collapse: $1{,}2 \cdot 138{,}91 = 166{,}700$ bar

2. Table ⇒ $13^{3/8}$" P110 72 lb/ft (3%)

3. $SF_B = \frac{510}{312{,}31} = \underline{1{,}633} > 1{,}5$ ok. (1%)

$SF_c = \frac{199}{138{,}91} = \underline{1{,}433} > 1{,}2$ ok. (1%)

d) 1. Degenerated: $\underline{\underline{F_{AD}}} = m \cdot h \left(1 - \frac{\rho_{md}}{\rho_s}\right) g$

$= 1051\ N/m \cdot 3000 \left(1 - \frac{1020}{7850}\right) = \underline{\underline{2743,3\ kN}}$

"Mg" from table

(4%)

Cementing: $F_{Ac} = mh\left(1 - \frac{\rho_m}{\rho_s}\right)g + A_i h (\rho_c - \rho_m) g$

Table ≈ $77,25 \cdot 10^{-3}$

$= 1051 \cdot 3000 \left(1 - \frac{1180}{7850}\right) + 77,25 \cdot 10^{-3} \cdot 3000 (1550 - 1180) 9,81$

$= 2679,05\ kN + 841,2\ kN$

$= \underline{\underline{3520,23\ kN}}$

2. F_y (from tables) = 11550 kN

- $\underline{\underline{SF_D}} = \frac{11550}{2743,31} = \underline{\underline{4,21}}$ ok. (1%)
- $\underline{\underline{SF_c}} = \frac{11550}{3520,23} = \underline{\underline{3,30}}$ ok.

3. The axial load during cementing is dimensioning. (1%)

Exercise 4: Kick calculations (21% + 4% Multiple choice) => 25%

a) 1. $P_f = SIDPP + \rho_m g h$ (2%)

$\Rightarrow SIDPP = 400 \cdot 10^5 - 1180 \cdot 9.81 \cdot 3200 = \underline{\underline{29.6 \text{ bar}}}$

2. $\rho_{km} g h = (400 + 5) \cdot 10^5$ (2%)

$\Rightarrow \rho_{km} = \frac{405 \cdot 10^5}{9.81 \cdot 3200} = \underline{\underline{1290.14}} \text{ kg/m}^3$

3. $P_{hyd,km} = \rho_{km} g h \approx \underline{\underline{405 \text{ bar}}}$ (1%)

b) 1. $V_k = 14.7 + \frac{2200}{60\,000} \cdot 86 = 17.853 \text{ m}^3$

$V_{ann,dc} = A_{ann,dc} \cdot L_{dc} = 10.16 \text{ m}^3$ $(V_k > V_{ann,dc})$

$h_k = 250 + \frac{14.7 \cdot \frac{2200}{60\,000} \cdot 86 - 10.16}{0.06192} \approx \underline{\underline{374.25 \text{ m}}}$

(3%)

2. $\rho_i = 1180 - \frac{(32 - 29.6) \cdot 10^5}{9.81 \cdot 374.25} \left(1 + \frac{\frac{2200}{60\,000} \cdot 86}{14.7}\right)$

$\approx \underline{\underline{1100.6}} \text{ kg/m}^3$ (2%)

c) 1. $$\Delta t_{string} = \frac{0.00456 \cdot 250 + 0.01105\,(3200-250)}{\frac{650}{60000}} \quad (2\%)$$

$$= 4061{,}3\text{ s} = \underline{\underline{1\text{ h } 7\text{ min } 41\text{ s}}}$$

2. $$\Delta t_{annulus} = \frac{0.04064 \cdot 250 + 0.06192\,(3200-250)}{\frac{650}{60000}}$$

$$= 17\,799.14\text{ s} = \underline{\underline{4\text{ h } 56\text{ min } 39\text{ s}}} \quad (2\%)$$

3. $$\Delta t_{tot} = \Delta t_{string} + 2 \cdot \Delta t_{annulus} = \underline{\underline{11\text{ t } 59\text{ s}}} \quad (1\%)$$

↑ Driller's method

d) 1. $$\Delta P_{Fm2} = \left(\frac{650}{2200}\right)^{1.8} \cdot 126.2 = \underline{\underline{14.06\text{ bar}}} \quad (1\%)$$

2. $$\Delta P_{Dm2} = \left(\frac{650}{2200}\right)^{1.8} \cdot 188.5 = \underline{\underline{21\text{ bar}}} \quad (1\%)$$

3. $$\Delta P_{F,km} = \left(\frac{129014}{1180}\right)^{0.8} \cdot \left(\frac{26}{12}\right)^{0.2} \cdot 14.06 = \underline{\underline{17.63\text{ bar}}} \quad (1\%)$$

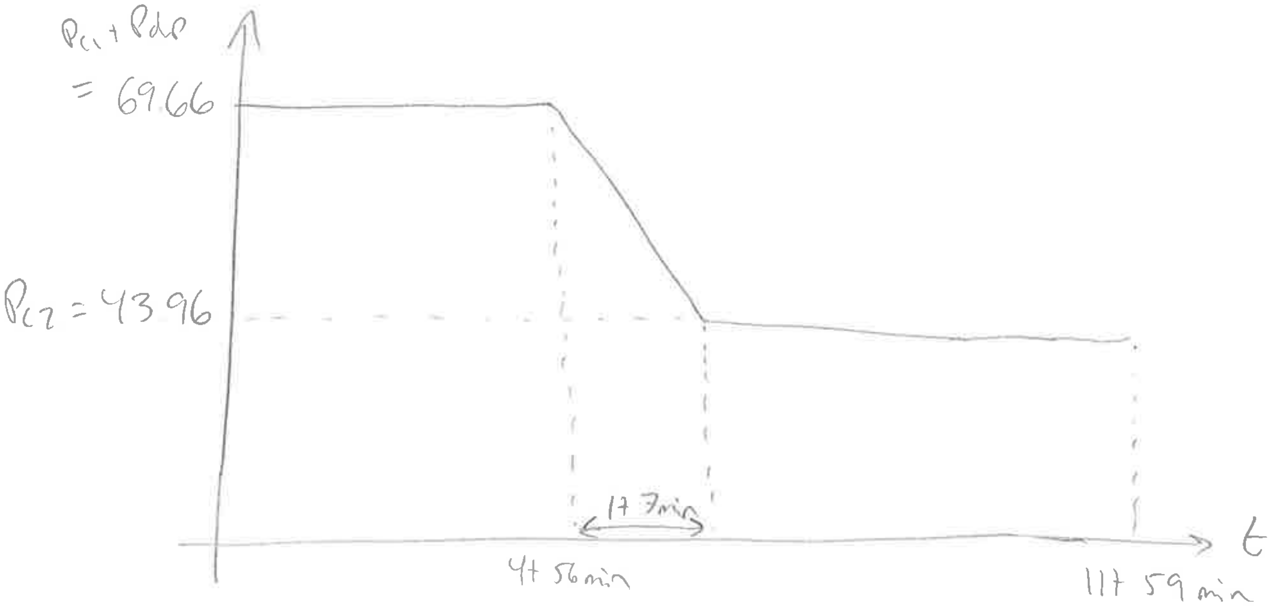
4. $$\Delta P_{D,km} = \left(\frac{1290.14}{1180}\right)^{0.8} \left(\frac{26}{12}\right)^{0.2} \cdot 21 = \underline{\underline{26.33\text{ bar}}} \quad (1\%)$$

5. $P_{c1} = \Delta P_{Fmz} + \Delta P_{Dmz} + \Delta P_s = \underline{40.06 \text{ bar}}$

$P_{c2} = \Delta P_{F,km} + \Delta P_{D,km} = \underline{43.96 \text{ bar}}$

$P_{dp} + P_{c1} = \underline{69.66 \text{ bar}}$

Standpipe pressure



(2%)