Poeng:

Fasit – Boring H17, PET100

1a)1. Må ikke frakturere formasjonen ved 3200 m

$$p_{frac} = \rho_{max} g h$$

$$\rho_{max} = \frac{p_{frac}}{gh} = \frac{502.3 \cdot 10^5 \text{ Pa}}{9.81 \text{ m/s}^2 \cdot 3200 \text{ m}} = \underline{\underline{1600 \text{ kg/m}^3}}$$

1a)2. Må ikke få innstrømning ved 4300 m

$$p_{pore} + p_s = \rho_{min} g h$$

$$\rho_{min} = \frac{p_{pore} + p_s}{gh} = \frac{(464 + 10) \cdot 10^5 \text{ Pa}}{9.81 \text{ m/s}^2 \cdot 4300 \text{ m}} = \underline{\underline{1124 \text{ kg/m}^3}}$$

1a)3. Formel har blitt utledet på forelesning og oblig II

$$m_v = \rho_v \left(\frac{\rho_2 - \rho_1}{\rho_v - \rho_2} \right) V_1 = 4200 \left(\frac{1130 - 1030}{4200 - 1130} \right) 1 \text{ kg} = \underline{\underline{137 \text{ kg}}}$$

1b)1. Bruker tabell $\longrightarrow$ $m_{dp} = 36.33 \text{ kg/m}$

$$F_A = \left(m_{dp} (h - h_{dc}) + m_{dc} h_{dc} \right) g \left(1 - \frac{\rho_m}{\rho_s} \right)$$

$$= \left(36.33 (3200 - 350) + 207.44 \cdot 350 \right) 9.81 \left(1 - \frac{1130}{7850} \right)$$

$$= \underline{\underline{1479.2 \text{ kN}}}$$

1b)2. $SF = \frac{F_Y}{F_A} = \frac{1941}{1479.2} = \underline{\underline{1.31}}$ (F_Y fra tabell)

1c) $F_E = \frac{2}{3} m_{dc} h_{dc} g k - F_N - F_B = 0$

$$h_{dc} = \frac{F_N + F_B}{\frac{2}{3} m_{dc} g k} = \frac{(7200 + 300\,000) \text{ N}}{\frac{2}{3} \cdot 207.44 \cdot 9.81 \cdot 0.8560 \text{ N/m}} = \underline{\underline{264.5 \text{ m}}}$$

1d) M_Y og P_Y fra tabell $\longrightarrow$ $M_Y = 68.42 \text{ kNm}$, $P_Y = 688 \text{ bar}$

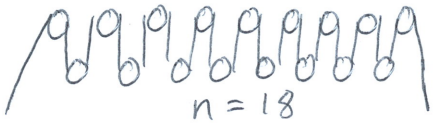
$$\frac{1}{SF^2} = \left(\frac{\Delta P}{P_Y} \right)^2 + \left(\frac{F_E}{F_Y} \right)^2 + \left(\frac{M}{M_Y} \right)^2$$

$$\Rightarrow \quad M = M_Y \sqrt{\frac{1}{SF^2} - \left(\frac{\Delta P}{P_Y} \right)^2 - \left(\frac{F_E}{F_Y} \right)^2}$$

$$= 68.420 \sqrt{\frac{1}{1.25^2} - \left(\frac{310}{688} \right)^2 - \left(\frac{1479.2 - 7.2 - 300}{1941} \right)^2}$$

$$= \underline{\underline{18.405 \text{ kNm}}}$$

1e) Løpeblokka har 8 trinser
→ Kronblokka har 9 trinser



$$F_F = \frac{k_T - 1}{1 - k_T^{-n}} (Mg + F_A) = \frac{1.042 - 1}{1 - 1.042^{-18}} (4{,}600 \cdot 9.81 + 1479.236)$$

$$= \underline{122.38\ kN}$$

1f) 1 stand er 3 rørlengder → 30 m

$$\dot{E}\eta = F_F v_F = F_F n v_{trip} = F_F n \frac{L}{t}$$

$$\Rightarrow t = \frac{F_F n L}{\dot{E}\eta} = \frac{122.38 \cdot 10^3 \cdot 18 \cdot 30\ W \cdot s}{750 \cdot 10^3 \cdot 0.75\ W} = \underline{117.5\ s}$$

2a) Bruker tabell → $N_2 = 85 \frac{kPa}{100\,m}$, $N_3 = 941 \frac{kPa}{100\,m}$

$$\Delta P_{F,string} = (N_2 (h - h_{dc}) + N_3 h_{dc}) \cdot \rho_{Rm}^{0.8} \cdot \mu_{Rm}^{0.2}$$

$$= (85 \cdot (4300 - 350) + 941 \cdot 350) \cdot 10^{-4} \cdot 1.130^{0.8} \cdot 15^{0.2}$$

$$= \underline{126.1\ bar}$$

2b)1. $\Delta P_D = P_p - \Delta P_{F,string} - \Delta P_{F,ann} - \Delta P_{goose}$

$$= 306 - 126.1 - 19 - 1.1 = \underline{159.8\ bar}$$

$$\frac{\Delta P_D}{P_p} = \frac{159.8}{306} \cdot 100\% = \underline{52.2\%}$$

2b)2. $v_0 = C_0 \sqrt{\frac{2\Delta P_D}{\rho_m}} = 0.95 \sqrt{\frac{2 \cdot 159.8 \cdot 10^5}{1130}} = \underline{159.8\ m/s}$

2b)3. $F_D = \rho_m Q v_0 = 1130 \cdot \frac{2400}{60\,000} \cdot 159.8 = \underline{7222.4\ N}$

2c)1. $\dot{E}_E \eta_{el} \eta_T \eta_v \eta_m = P_p Q = P_p \cdot 3 \cdot \frac{\pi}{4} D^2 L n \eta_v$

$$\Rightarrow D = \sqrt{\frac{\dot{E}_E \eta_{el} \eta_v \eta_T \eta_m}{3 \frac{\pi}{4} \cdot P_p \cdot L \cdot n \eta_v}} = \sqrt{\frac{1250 \cdot 10^3 \cdot 0.97 \cdot 0.85 \cdot 0.8 \cdot 0.92}{3 \frac{\pi}{4} \cdot 306 \cdot 11 \cdot 0.254 \cdot \frac{140}{60} \cdot 0.97}}$$

$$= 0.129\,m = 5.078'' \quad \underline{\text{Runder ned til } 5''}$$

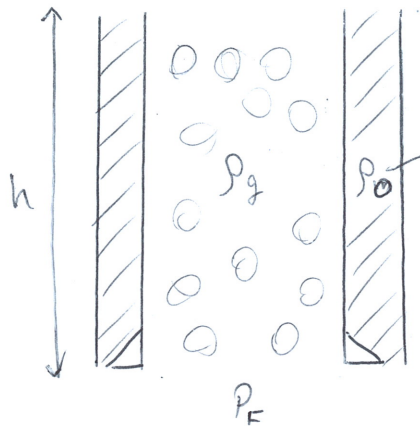
2c)2. $Q = 3 \frac{\pi}{4} D^2 L n \eta_v = 3 \frac{\pi}{4} \cdot 5^2 \cdot 11 \cdot 0.254^3 \cdot \frac{140}{60} \cdot 0.97$

$$= 0.02403\ m^3/s = \underline{1442\ l/min}$$

2c)3. $P_p = \frac{\dot{E}\eta_{el}\eta_v\eta_T\eta_m}{Q} = \frac{1250 \cdot 10^3 \cdot 0.97 \cdot 0.85 \cdot 0.8 \cdot 0.92}{0.02403} = \underline{315.6\ bar}$

2c)4. Trenger 2400 l/min → antall $= \frac{2400}{1442} = 1.6 \rightarrow \underline{2\ pumper}$

3a)1.

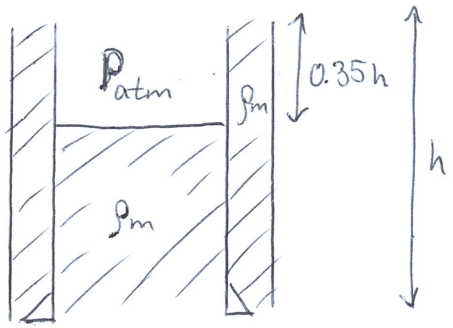


Det er ikke viktig hva som er utenfor i dette scenario.

$$\Delta P_b = P_F - \rho_g g h - 0 = 464 - 300 \cdot 9.81 \cdot 4300 \cdot 10^{-5} = \underline{337 \text{ bar}}$$

3a)2. Størst belastning i toppen

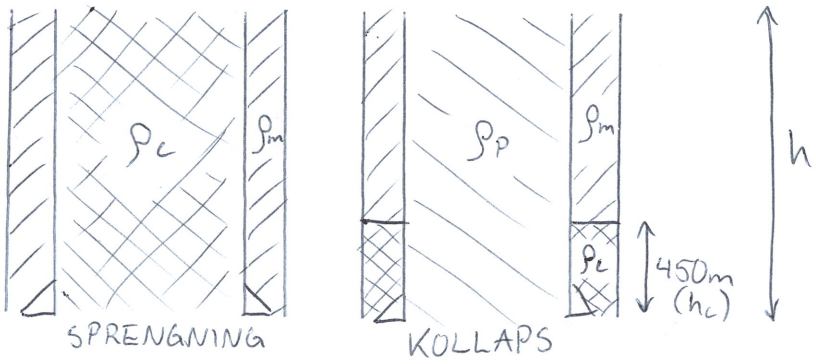
3b)1.



$$\Delta P_c = \rho_m g \cdot 0.35h - 0 = 1130 \cdot 9.81 \cdot 0.35 \cdot 4300 = \underline{167 \text{ bar}}$$

3b)2. Størst belastning ved 0.35h og ned.

3c)1.



$$\Delta P_b = (\rho_c - \rho_m) g h = (1490 - 1130) \cdot 9.81 \cdot 4300 = \underline{152 \text{ bar}}$$

$$\Delta P_c = \rho_c g (h_c) + \rho_m g (h - h_c) - \rho_p g h$$
$$= 1490 \cdot 9.81 \cdot 450 + 1130 \cdot 9.81 (4300 - 450) - 1050 \cdot 9.81 \cdot 4300$$
$$= \underline{49.6 \text{ bar}}$$

3c)2. Størst belastning i bunnen for begge scenarier.

3d)1. Største $\Delta P_b \rightarrow$ 337 bar, $\Delta P_b \cdot SF_b = 337 \cdot 1.1 = \underline{371 \text{ bar}}$

Største $\Delta P_c \rightarrow$ 167 bar, $\Delta P_c \cdot SF_c = 167 \cdot 1.1 = \underline{184 \text{ bar}}$

3d)2. Tabell $\rightarrow$ 40 lb/ft, L80 Quality, 9.625"

3d)3. $SF_b = \frac{\Delta P_{br}}{\Delta P_b} = \frac{396}{337} = \underline{1.17}$, $SF_c = \frac{\Delta P_{cr}}{\Delta P_c} = \frac{213}{167} = \underline{1.28}$

3e)1. Sementering: Vekt fra tabell $m = 584$ N/m, $A_i = 0.03955$ m²

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

$$= 584 \cdot 4300\left(1 - \frac{1130}{7850}\right) + 0.03955 \cdot 4300(1490 - 1130)9.81$$

$$= \underline{2750 \text{ kN}}$$

Degenerering:

$$F_{Ad} = mh\left(1 - \frac{\rho_{md}}{\rho_s}\right) = 584 \cdot 4300 \cdot \left(1 - \frac{1030}{7850}\right) = \underline{2182 \text{ kN}}$$

3e)2. $SF_{Ac} = \frac{F_Y}{F_{Ac}} = \frac{4080}{2750} = \underline{1.48}$ (F_Y fra tabell)

$$SF_{Ad} = \frac{F_Y}{F_{Ad}} = \frac{4080}{2182} = \underline{1.87}$$

3e)3. Lavest SF gir dimensjonerende scenario
→ Sementering

4a)1. $P_{bh} = P_{dp} + \rho_m g h = 13.3 + 1130 \cdot 9.81 \cdot 4300 \cdot 10^{-5} = \underline{489.97 \text{ bar}}$

4a)2. $\rho_{km} = \frac{P_{bh} + \Delta P_s}{gh} = \frac{(489.97 + 10) \cdot 10^5}{9.81 \cdot 4300} = \underline{1185 \text{ kg/m}^3}$

4b)1. $V_k = \Delta V_i + Q_m \Delta t = 5.75 + \frac{2400}{60000} \cdot 110 = 10.15 \text{ m}^3$

$V_{ann,dc} = A_{ann,dc} h_{dc} = 0.009116 \cdot 350 = 3.191 \text{ m}^3$

→ dvs. $V_k > V_{ann,dc}$ (kick over vektrør)

$$h_k = h_{dc} + \frac{\Delta V_i + Q_m \Delta t - V_{ann,dc}}{A_{ann,dp}}$$

$$= 350 + \frac{5.75 + \frac{2400}{60000} \cdot 110 - 3.191}{0.02422} = \underline{637.3 \text{ m}}$$

4b)2. $\rho_i = \rho_m - \frac{P_{ann} - P_{dp}}{g h_k}\left(1 + \frac{Q_m \Delta t}{\Delta V_i}\right)$

$$= 1130 - \frac{(25 - 13.3) \cdot 10^5}{9.81 \cdot 637.3} \cdot \left(1 + \frac{\frac{2400}{60000} \cdot 110}{5.75}\right) = \underline{799.7 \text{ kg/m}^3}$$

4b)3. $P_{frac} = 502.3$ bar (gitt i oppg-1) ved 3200 m

$$P = P_{ann} + \rho_m g h_{frac} = 25 + 1130 \cdot 9.81 \cdot 3200 \cdot 10^{-5}$$

$= \underline{379.7 \text{ bar}} < P_{frac}$ → Ingen fraktuering

4c)1. $\Delta t_{string} = \frac{A_{i,dp}(h - h_{dc}) + A_{i,dc} h_{dc}}{Q_m}$

$= \frac{0.01157(4300-350) + 0.003973 \cdot 350}{680/60\,000} = \underline{1t\ 9min\ 15s}$

$(= 4155s)$

4c)2) $\Delta t_{ann} = \frac{A_{ann,dp}(h - h_{dc}) + A_{ann,dc} h_{dc}}{Q_m}$

$= \frac{0.02422(4300-350) + 0.009116 \cdot 350}{680/60\,000} = \underline{2t\ 25min\ 23s}$

$(= 8722s)$

4d)1. $\Delta P_{F,km} = \frac{\rho_{km}^{0.8} \mu_{km}^{0.2} Q_k^{1.8}}{\rho_m^{0.8} \mu_m^{0.2} Q_m^{1.8}} \cdot \Delta P_{F,m,1}$

$= \frac{1185^{0.8} \cdot 24^{0.2} \cdot 680^{1.8}}{1130^{0.8} \cdot 15^{0.2} \cdot 2400^{1.8}} \cdot 126.06\,bar = \underline{14.861\,bar}$

$\Delta P_{D,km} = \frac{\rho_{km} Q_{km}^2}{\rho_m Q_m^2} \Delta P_{D,m,1}$

$= \frac{1185 \cdot 680^2}{1130 \cdot 2400^2} \cdot 159.84\,bar = \underline{13.456\,bar}$

$P_{c2} = \Delta P_{F,km} + \Delta P_{D,km} = \underline{28.317\,bar}$

4d)2. $\Delta P_{F,m,2} = \frac{Q_k^{1.8}}{Q_m^{1.8}} \cdot \Delta P_{F,m,1} = \frac{680^{1.8}}{2400^{1.8}} \cdot 126.06\,bar = \underline{13.023\,bar}$

$\Delta P_{D,m,2} = \frac{Q_k^2}{Q_m^2} \cdot \Delta P_{D,m,1} = \frac{680^2}{2400^2} \cdot 159.84\,bar = \underline{12.832\,bar}$

$P_{c1} = \Delta P_{F,m,2} + \Delta P_{D,m,2} + \Delta P_s = \underline{35.855\,bar}$