Perhitungan $m$
Perhitungan $m$

- $W_{mesin} = 690$ kN
  
  \[ m_{mesin} = \frac{W_{mesin}}{9,81} = 70,336 \text{ kN}. \frac{\text{det}^2}{\text{m}} \]

- $W_{tangki} = \frac{1}{4} \pi D^2 h \cdot \gamma_{\text{beton}} = 24537,28$ kN
  
  \[ m_{tangki} = \frac{W_{tangki}}{9,81} = 2501,25 \text{ kN}. \frac{\text{det}^2}{\text{m}} \]

  \[ m_{tangki+mesin} = 2571,59 \text{ kN}. \frac{\text{det}^2}{\text{m}} \]

- $W_{liquid} = \frac{1}{4} \pi D^2 h \cdot \gamma_{\text{liquid}} = 13481,76$ kN
  
  \[ m_{liquid} = \frac{W_{liquid}}{9,81} = 1374,287 \text{ kN}. \frac{\text{det}^2}{\text{m}} \]
Perhitungan m

\[ W_1 = \frac{1}{4} \pi D^2 h \cdot \gamma_{beton} = 18384,22 \text{ kN} \]

\[ m_1 = \frac{W_1}{9,81} = 1874,028 \text{ kN. det}^2/\text{m} \]

\[ W_{poer} = \frac{1}{4} \pi D^2 h \cdot \gamma_{beton} = 5876,36 \text{ kN} \]

\[ m_{poer} = \frac{W_{poer}}{9,81} = 599,02 \text{ kN. det}^2/\text{m} \]

Jadi didapat \( m_{tangki} \) secara keseluruhan adalah:

\[ m_{tangki} = m_{tangk+mesin} - m_1 + m_{liquid} \]

\[ = 2071,849 \text{ kN. det}^2/\text{m} \]

\[ m_{total} = m_{tangk} + m_{poer} = 2670,869 \text{ kN. det}^2/\text{m} \]
Vertikal

\[ v_c = \sqrt{\frac{E_p \cdot g}{\gamma_c}} = 3685,7 \text{ m/det}^2 \]

\[ v_s = \sqrt{\frac{E_p \cdot g}{\gamma_s}} = 136,882 \text{ m/det}^2 \]

\[ \frac{v_s}{v_c} = 0,04 \rightarrow \frac{l}{r_0} = 93,33 \]

\[ k_z^1 = \frac{E_p \cdot A}{r_0} f_{18,1} = 877025,092 \text{ kN/m} \]

\[ c_z^1 = \frac{E_p \cdot A}{v_s} f_{18,2} = 3295,117 \text{ kN. det/m} \]

sehingga:
\[ f_{18,1} = 0,028 \text{ dan } f_{18,2} = 0,048 \]
Vertikal

- Menghitung $k_z^g$, $c_z^g$, $k_z^f$ dan $c_z^f$

\[ l/2r_0 = 46,67 \]

\[ \alpha_A \] berdasarkan grafik di bawah

\[ \alpha_A \] untuk tiang pancang 1:

Jarak (S) = 5,2407

\[ 2r/s = 2.0,3/5,2407 = 0,114 \]

\[ \alpha_A = 0,411 \]
Vertikal

Berikut merupakan tabel hasil $\alpha_A$ dari jarak tiang pancang sebanyak 32 buah.

<table>
<thead>
<tr>
<th>Titik</th>
<th>Jarak</th>
<th>$2r/s$</th>
<th>$\alpha_A$</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>5,2407</td>
<td>0,114488523</td>
<td>0,411</td>
</tr>
<tr>
<td>S2</td>
<td>5,2425</td>
<td>0,114449213</td>
<td>0,411</td>
</tr>
<tr>
<td>S3</td>
<td>5,2755</td>
<td>0,113733295</td>
<td>0,407</td>
</tr>
<tr>
<td>S4</td>
<td>5,2424</td>
<td>0,114451396</td>
<td>0,411</td>
</tr>
<tr>
<td>S5</td>
<td>5,2423</td>
<td>0,11445358</td>
<td>0,411</td>
</tr>
<tr>
<td>S6</td>
<td>5,2418</td>
<td>0,114464497</td>
<td>0,411</td>
</tr>
<tr>
<td>S7</td>
<td>5,2419</td>
<td>0,114462313</td>
<td>0,411</td>
</tr>
<tr>
<td>S8</td>
<td>5,2425</td>
<td>0,114449213</td>
<td>0,411</td>
</tr>
<tr>
<td>S9</td>
<td>5,2425</td>
<td>0,114449213</td>
<td>0,411</td>
</tr>
<tr>
<td>S10</td>
<td>5,2427</td>
<td>0,114444847</td>
<td>0,411</td>
</tr>
<tr>
<td>S11</td>
<td>5,2426</td>
<td>0,11444703</td>
<td>0,411</td>
</tr>
<tr>
<td>S12</td>
<td>5,2442</td>
<td>0,114412112</td>
<td>0,409</td>
</tr>
<tr>
<td>S13</td>
<td>5,2438</td>
<td>0,11442084</td>
<td>0,411</td>
</tr>
<tr>
<td>S14</td>
<td>5,242</td>
<td>0,11446013</td>
<td>0,411</td>
</tr>
<tr>
<td>S15</td>
<td>5,2391</td>
<td>0,114523487</td>
<td>0,412</td>
</tr>
<tr>
<td>S16</td>
<td>5,2443</td>
<td>0,114409931</td>
<td>0,411</td>
</tr>
<tr>
<td>S17</td>
<td>3,486</td>
<td>0,17211704</td>
<td>0,513</td>
</tr>
<tr>
<td>S18</td>
<td>3,4747</td>
<td>0,172676778</td>
<td>0,518</td>
</tr>
<tr>
<td>S19</td>
<td>3,5106</td>
<td>0,170910955</td>
<td>0,508</td>
</tr>
<tr>
<td>S20</td>
<td>3,4768</td>
<td>0,17257248</td>
<td>0,513</td>
</tr>
<tr>
<td>S21</td>
<td>3,5113</td>
<td>0,170876883</td>
<td>0,508</td>
</tr>
<tr>
<td>S22</td>
<td>3,4778</td>
<td>0,172522859</td>
<td>0,515</td>
</tr>
<tr>
<td>S23</td>
<td>3,5021</td>
<td>0,171325766</td>
<td>0,513</td>
</tr>
<tr>
<td>S24</td>
<td>3,4907</td>
<td>0,171885295</td>
<td>0,517</td>
</tr>
<tr>
<td>S25</td>
<td>3,5166</td>
<td>0,170619348</td>
<td>0,506</td>
</tr>
<tr>
<td>S26</td>
<td>3,4925</td>
<td>0,171796707</td>
<td>0,516</td>
</tr>
<tr>
<td>S27</td>
<td>3,5011</td>
<td>0,171374711</td>
<td>0,514</td>
</tr>
<tr>
<td>S28</td>
<td>1,7626</td>
<td>0,340406218</td>
<td>0,584</td>
</tr>
<tr>
<td>S29</td>
<td>1,7557</td>
<td>0,341744034</td>
<td>0,586</td>
</tr>
<tr>
<td>S30</td>
<td>1,747</td>
<td>0,343445907</td>
<td>0,588</td>
</tr>
<tr>
<td>S31</td>
<td>1,7353</td>
<td>0,34576154</td>
<td>0,592</td>
</tr>
<tr>
<td>S32</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Jumlah</td>
<td>129,3516</td>
<td></td>
<td>15,562</td>
</tr>
</tbody>
</table>

$$k_z g = \frac{\sum_{1}^{N} k_z^1}{\sum_{1}^{N} \alpha_A} = 1803418,773 \text{ kN/m}$$

$$c_z g = \frac{\sum_{1}^{N} c_z^1}{\sum_{1}^{N} \alpha_A} = 6775,719 \text{ kN. det/m}$$
Vertikal

Angka poison 0,4 maka didapat $S_1 = 2,7$ dan $S_2 = 6,7$ berdasarkan tabel:

<table>
<thead>
<tr>
<th>$v$</th>
<th>$S_1$</th>
<th>$S_2$</th>
<th>$S_{f1}$</th>
<th>$S_{f2}$</th>
<th>$S_{f1}$</th>
<th>$S_{f2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,0</td>
<td>2,7</td>
<td>6,7</td>
<td>3,6</td>
<td>8,2</td>
<td>2,5</td>
<td>1,8</td>
</tr>
<tr>
<td>0,25</td>
<td>2,7</td>
<td>6,7</td>
<td>4,0</td>
<td>9,1</td>
<td>2,5</td>
<td>1,8</td>
</tr>
<tr>
<td>0,4</td>
<td>2,7</td>
<td>6,7</td>
<td>4,1</td>
<td>10,6</td>
<td>2,5</td>
<td>1,8</td>
</tr>
</tbody>
</table>

$k_z^f = G_sh \overline{S}_1 = 186162,94$ kN/m

$c_z^f = h \rho_o \sqrt{G_s \frac{\gamma_s}{\gamma}} \overline{S}_2 = 8139,164$ kN.det/m

Total nilai: $k_z^t = k_z^g + k_z^f = 1989581,713$ kN/m

$c_z^t = c_z^g + c_z^f = 14914,883$ kN.det/m

$D_z^g = \frac{C_z^t}{2 \sqrt{k_z^t \cdot m}} = 0,102$
Vertikal

- Frekuensi Natural

\[ f_n = \frac{1}{2\pi} \sqrt{\frac{k}{m}} = 537,117 \text{ cps}, \text{ sehingga } r = \frac{f_{\text{mesin}}}{f_n} = 0,046 \]

- Menghitung Transmisibility

\[ T_r = \frac{\sqrt{1 + 2 \cdot D \cdot r^2}}{\sqrt{(1 - r^2)^2 + (2 \cdot D \cdot r)^2}} = 1,0023 \]

- Menghitung Transmitted Force (F_t)

Sehingga beban yang diterima tanah dasar adalah :

\[ F_t = T_r \cdot Q_o = 0 \text{ ton} \]

- Menghitung Magnification Factor dan Amplitudo

\[ M = \frac{1}{\sqrt{(1 - r^2)^2 + (2 \cdot D \cdot r)^2}} = 1,00212 < 1,5 \text{ OK!} \]

\[ A = M \frac{Q_o}{k_z} = 0 \text{ in} \]
Horizontal

\[ k_x^1 = \frac{E_p \cdot I}{r_0^3} f_{11,1} \]
\[ = 249466,848 \text{ kN/m} \]

\[ c_x^1 = \left( \frac{E_p \cdot I}{r_0^2} \right) \frac{v_s}{f_{11,2}} \]
\[ = 1297,325 \text{ kN. det/m} \]

Berikut merupakan tabel hasil \( \alpha_A \)

<table>
<thead>
<tr>
<th>Titik</th>
<th>Jarak</th>
<th>s/2ro</th>
<th>( \beta )</th>
<th>( \alpha_L )</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>7,413</td>
<td>12,355</td>
<td>45</td>
<td>0,23</td>
</tr>
<tr>
<td>S2</td>
<td>5,824</td>
<td>9,70667</td>
<td>56</td>
<td>0,202</td>
</tr>
<tr>
<td>S3</td>
<td>8,717</td>
<td>14,52833</td>
<td>34</td>
<td>0,256</td>
</tr>
<tr>
<td>S4</td>
<td>4,011</td>
<td>6,685</td>
<td>67</td>
<td>0,182</td>
</tr>
<tr>
<td>S5</td>
<td>9,686</td>
<td>16,14333</td>
<td>22</td>
<td>0,272</td>
</tr>
<tr>
<td>S6</td>
<td>2,044</td>
<td>3,40667</td>
<td>79</td>
<td>0,326</td>
</tr>
<tr>
<td>S7</td>
<td>10,283</td>
<td>17,13833</td>
<td>11</td>
<td>0,288</td>
</tr>
<tr>
<td>S8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>S9</td>
<td>10,485</td>
<td>17,475</td>
<td>0</td>
<td>0,3</td>
</tr>
<tr>
<td>S10</td>
<td>2,047</td>
<td>3,411667</td>
<td>79</td>
<td>0,326</td>
</tr>
<tr>
<td>S11</td>
<td>10,284</td>
<td>17,14</td>
<td>11</td>
<td>0,288</td>
</tr>
<tr>
<td>S12</td>
<td>4,011</td>
<td>6,685</td>
<td>67</td>
<td>0,182</td>
</tr>
<tr>
<td>S13</td>
<td>9,687</td>
<td>16,145</td>
<td>22</td>
<td>0,272</td>
</tr>
<tr>
<td>S14</td>
<td>5,824</td>
<td>9,706667</td>
<td>56</td>
<td>0,202</td>
</tr>
<tr>
<td>S15</td>
<td>8,719</td>
<td>14,53167</td>
<td>34</td>
<td>0,256</td>
</tr>
<tr>
<td>S16</td>
<td>7,413</td>
<td>12,355</td>
<td>45</td>
<td>0,23</td>
</tr>
<tr>
<td>S17</td>
<td>5,983</td>
<td>9,971667</td>
<td>36</td>
<td>0,254</td>
</tr>
<tr>
<td>S18</td>
<td>4,071</td>
<td>6,785</td>
<td>42</td>
<td>0,237</td>
</tr>
<tr>
<td>S19</td>
<td>7,493</td>
<td>12,48833</td>
<td>25</td>
<td>0,27</td>
</tr>
<tr>
<td>S20</td>
<td>2,205</td>
<td>3,675</td>
<td>29</td>
<td>0,35</td>
</tr>
<tr>
<td>S21</td>
<td>8,445</td>
<td>14,075</td>
<td>12</td>
<td>0,288</td>
</tr>
<tr>
<td>S22</td>
<td>2,405</td>
<td>4,008333</td>
<td>25</td>
<td>0,348</td>
</tr>
<tr>
<td>S23</td>
<td>8,745</td>
<td>14,575</td>
<td>1</td>
<td>0,3</td>
</tr>
<tr>
<td>S24</td>
<td>3,863</td>
<td>6,438333</td>
<td>42</td>
<td>0,237</td>
</tr>
<tr>
<td>S25</td>
<td>8,365</td>
<td>13,94167</td>
<td>14</td>
<td>0,286</td>
</tr>
<tr>
<td>S26</td>
<td>5,78</td>
<td>9,633333</td>
<td>37</td>
<td>0,252</td>
</tr>
<tr>
<td>S27</td>
<td>7,345</td>
<td>12,24167</td>
<td>26</td>
<td>0,268</td>
</tr>
<tr>
<td>S28</td>
<td>5,425</td>
<td>9,041667</td>
<td>19</td>
<td>0,277</td>
</tr>
<tr>
<td>S29</td>
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<td>5,816667</td>
<td>1</td>
<td>0,3</td>
</tr>
<tr>
<td>S30</td>
<td>6,978</td>
<td>11,63</td>
<td>1</td>
<td>0,3</td>
</tr>
<tr>
<td>S31</td>
<td>5,608</td>
<td>9,346667</td>
<td>18</td>
<td>0,278</td>
</tr>
<tr>
<td>S32</td>
<td>5,2425</td>
<td>8,7375</td>
<td>0</td>
<td>0,3</td>
</tr>
<tr>
<td>Jumlah</td>
<td>197,8915</td>
<td>329,8192</td>
<td></td>
<td>9,345</td>
</tr>
</tbody>
</table>
Angka poison 0,4 maka didapat $S_{U1} = 4,1$ dan $S_{U2} = 10,6$ berdasarkan tabel:

<table>
<thead>
<tr>
<th>$v$</th>
<th>$S_1$</th>
<th>$S_2$</th>
<th>$S_{U1}$</th>
<th>$S_{U2}$</th>
<th>$S_{\varphi 1}$</th>
<th>$S_{\varphi 2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,0</td>
<td>2,7</td>
<td>6,7</td>
<td>3,6</td>
<td>8,2</td>
<td>2,5</td>
<td>1,8</td>
</tr>
<tr>
<td>0,25</td>
<td>2,7</td>
<td>6,7</td>
<td>4,0</td>
<td>9,1</td>
<td>2,5</td>
<td>1,8</td>
</tr>
<tr>
<td>0,4</td>
<td>2,7</td>
<td>6,7</td>
<td>4,1</td>
<td>10,6</td>
<td>2,5</td>
<td>1,8</td>
</tr>
</tbody>
</table>

$k_x^f = G_s h S_1 = 282691,87 \text{ kN/m}$

$c_x^f = h r_o \sqrt{G_s \frac{\gamma_s}{g} S_2} = 33330,992 \text{ kN.det/m}$

Total nilai: $k_x^t = k_x^g + k_x^f = 1136938,973 \text{ kN/m}$

$c_x^t = c_x^g + c_x^f = 37773,412 \text{ kN.det/m}$

$D_x^g = \frac{C_x^t}{2 \sqrt{k_z^t \cdot m}} = 0,343$
Frekuensi Natural

\[ f_n = \frac{1}{2\pi} \sqrt{\frac{k_x}{m}} = 10,285 \text{ cps}, \text{ sehingga } r = \frac{f_{\text{mesin}}}{f_n} = 2,431 \]

Menghitung Transmissibility

\[ T_r = \frac{\sqrt{1 + 2 \cdot D \cdot r^2}}{\sqrt{(1 - r^2)^2 + (2 \cdot D \cdot r)^2}} = 0,655 \]

Menghitung Transmitted Force \((F_t)\)

Sehingga beban yang diterima tanah dasar adalah:

\[ m_{\text{agitator}} = 7,034 \text{ ton. det}^2/\text{m} \]
\[ m_{\text{fluida}} = 183,409 \text{ ton. det}^2/\text{m} \]
\[ \omega = 2 \cdot \pi \cdot f = 157,08 \text{ rad/dt} \]
\[ e = 0,008 \text{ in} = 0,0000203 \text{ m} \]
\[ Q_o = m \cdot e \cdot \omega^2 = 953,897 \text{ kN} \]
\[ F_t = T_r \cdot Q_o = 624,506 \text{ kN} \]

<table>
<thead>
<tr>
<th>Operating Speed</th>
<th>Eccentricity, in (double amplitude)</th>
</tr>
</thead>
<tbody>
<tr>
<td>750</td>
<td>0.014-0.032</td>
</tr>
<tr>
<td>1500</td>
<td>0.008</td>
</tr>
<tr>
<td>3000</td>
<td>0.002</td>
</tr>
</tbody>
</table>
Menghitung *Magnification Factor* dan Amplitudo

\[
M = \frac{1}{\sqrt{(1 - r^2)^2 + (2. D. r)^2}} = 0.153 < 1.5 \text{ OK!}
\]

\[
A = M \frac{Q_0}{k_x t} = 1.015 \times 10^{-3} \text{m} = 3.99 \times 10^{-2} \text{ in}
\]
Rocking

Angka poison 0,4 dan $v_s/v_c = 0,04$ maka didapat :

$f_{7,1} = 0,45$ dan $f_{7,2} = 0,314$

$k_{\varphi 1} = \frac{E_p \cdot I}{r_o} f_{7,1} = 254493,89 \text{ kN. m}$

$c_{\varphi 1} = \left( \frac{E_p \cdot I}{v_s} \right) f_{7,2} = 389,197 \text{ kN. m. det}^2$

➢ Menghitung $k_{\varphi g}, c_{\varphi g}, k_{x\varphi 1}$ dan $c_{x\varphi 1}$:

$f_{9,1} = -0,097$ dan $f_{9,2} = -0,141$.

$k_{x\varphi 1} = \frac{E_p \cdot I}{r_o^2} f_{9,1} = -182858,57 \text{ kN. m}$

$c_{x\varphi 1} = \left( \frac{E_p \cdot I}{r_o v_s} \right) f_{9,2} = -0,0291 \text{ kN. m. det}^2$
**Rocking**

\[ Z_c = \text{Jarak tiang dengan titik berat} , \quad Z_c = 7.9205 \text{ m} \]

\[
k_{\phi}^g = \sum_{1}^{N} \left[ k_{\phi}^1 + k_z^1 x_r^2 + k_x^1 z_c^2 - 2 z_c k_{\phi x}^1 \right] + k_{\phi}^f
\]

\[
c_{\phi}^g = \sum_{1}^{N} \left[ c_{\phi}^1 + c_z^1 x_r^2 + c_x^1 z_c^2 - 2 z_c c_{x \phi}^1 \right] + c_{\phi}^f
\]
Dilihat dari tabel di atas didapatkan:

- $k_{\varphi}^g_{total} = 1.116.149.267 \text{ kN.m}$
- $c_{\varphi}^g_{total} = 4.549.932 \text{ kN.m} \cdot \text{det}^2$

Angka poison 0,4 maka didapat:

- $S_{\varphi1} = 2,5$ dan $S_{\varphi2} = 1,8$ serta $S_{u1} = 4,1$ dan $S_{u2} = 10,6$
- $Z_c = 7,9205 \text{ m}$
- $\delta = \frac{h}{r_o} = \frac{2}{6,2425} = 0,32$

$$k_{\varphi}^f = G_s r_o h^2 S_{\varphi1} + G_s r_o^2 h \left[ \left( \frac{\delta^2}{3} \right) + \left( \frac{Z_c}{r_o} \right)^2 - \delta \left( \frac{Z_c}{r_o} \right) \right] S_{u1}$$

$$= 15785361,06 \text{ kN.m}$$

$$c_{\varphi}^f = \delta r_o^4 \sqrt{G_s \gamma_s / g} \left\{ S_{\varphi2} + \left[ \left( \frac{\delta^2}{3} \right) + \left( \frac{Z_c}{r_o} \right)^2 - \delta \left( \frac{Z_c}{r_o} \right) \right] S_{u2} \right\}$$

$$= 1828004,889 \text{ kN.m} \cdot \text{det}^2$$

Total nilai $k_x$ dan $c_x$

- $k_{\varphi}^t = k_{\varphi}^g + k_{\varphi}^f = 1131934628 \text{ kN.m}$
- $c_{\varphi}^t = c_{\varphi}^g + c_{\varphi}^f = 6377937,068 \text{ kN.m} \cdot \text{det}^2$

$$D_{\varphi}^g = \frac{c_{\varphi}^t}{2 \sqrt{k_{\varphi}^t \cdot M_m}} = 0,219$$
Perhitungan \( M_m \) dan \( M_{mo} \)

\[
M_y = M_z = \frac{1}{12} m (3a^2 + L^2)
\]

\[
M_{z'} = I_z + m \left( \frac{1}{2} L \right)^2
\]

\[
W_{poer} = \frac{1}{4} \pi D^2 h \cdot \gamma_{beton} = 5876,36 \text{ kN}
\]

\[
m_{poer} = \frac{W_{poer}}{g} = 599,02 \text{ kN. det}^{-2}/m
\]

\[
M_{mo} = \frac{1}{12} 599,02 (3 \cdot 6,24^2 + 2^2) + 599,02 (1)^2 = 6634,43 \text{ kN. m. det}^2
\]

\[
M_{mo \ tangki} = M_{mo \ tangki + mesin} - M_{mo \ 1} + M_{mo \ liquid}
\]

\[
= 173820,75 \text{ kN. m. det}^2
\]

\[
M_{mo \ total} = M_{mo \ tangki} + M_{mo \ poer} + M_{mo \ mesin}
\]

\[
= 189121,34 \text{ kN. m. det}^2
\]
Perhitungan Titik Berat Pondasi

Perhitungan \( M_m \) dan \( \gamma \)

\[
M_m = M_{mo \ total} - m_{total} \cdot L^2
\]

\[
m_{total} = 2670,869 \text{ kN. det}^2/m
\]

\[
L = \frac{Y_t \cdot m_t + Y_p \cdot m_p + Y_m \cdot m_m}{m_t + m_p + m_m}
\]

\[
= \frac{7,92 \cdot 2501,25 + 1.599,02 + 8,29 \cdot 70,336}{2501,25 + 599,02 + 70,336}
\]

\[
= 6,621 \text{ meter dari dasar}
\]

\[
Y_m = 8.29
\]

\[
Y_t = 7.92
\]

\[
Y_p = 1.00
\]

\[
\gamma = \frac{M_m}{M_{mo \ total}} = \frac{186450,466}{189121,34} = 0,986
\]
Frekuensi natural

\[ f_n = \frac{1}{2\pi} \sqrt{\frac{k_t}{m}} = 324,518 \text{ cps}, \]  
sehingga \[ r = \frac{f_{\text{mesin}}}{f_n} = 0,077 \]

Menghitung Transmisibility

\[ T_r = \sqrt{1 + 2 \cdot D \cdot r^2} \]  
\[ \sqrt{(1 - r^2)^2 + (2 \cdot D \cdot r)^2} = 1,007 \]

Menghitung Transmitted Force (F_t)

\[ Q_o = 953,897 \text{ kN} \]  
Sehingga beban yang diterima tanah dasar adalah :

\[ F_t = T_r \cdot Q_o = 960,285 \text{ kN} \]

Menghitung Magnification Factor dan Amplitudo

\[ M = \frac{1}{\sqrt{(1 - r^2)^2 + (2 \cdot D \cdot r)^2}} = 0,995 < 1,5 \text{ OK!} \]  
\[ A = M \frac{Q_o}{k\phi} = 8,39 \cdot 10^{-7} \text{ m} = 3,303 \cdot 10^{-5} \text{ rad} \]
Perhitungan \(\omega_n\)

Dengan menggunakan persamaan,

\[
\begin{align*}
\omega^4 - & \left[ \frac{\omega_{nx}^2 + \omega_{n\phi}^2}{\gamma} \right] \omega^2 + \frac{\omega_{nx}^2 \omega_{n\phi}^2}{\gamma} \right] \omega^2 + \frac{\omega_{nx}^2 \omega_{n\phi}^2}{\gamma} \\
+ & 4 \left[ \frac{D_x \cdot \omega_{nx} \cdot \omega_{nd}}{\gamma} (\omega_{nx}^2 - \omega_{nd}^2) + \frac{D_{\phi} \cdot \omega_{nd} \cdot \omega_{n\phi}}{\gamma} (\omega_{n\phi}^2 - \omega_{nd}^2) \right] \omega^2 = 0
\end{align*}
\]

Dengan mengabaikan nilai redaman (D), maka :

\[
\omega_n^4 - \left[ \frac{\omega_{nx}^2 + \omega_{n\phi}^2}{\gamma} \right] \omega_n^2 + \frac{\omega_{nx}^2 \omega_{n\phi}^2}{\gamma} = 0
\]

Berikut adalah pehitungan nilai \(\omega_n\) :

misal : \(\omega_n^2 = s\), sehingga :

\[
s^2 - \left[ \frac{\omega_{nx}^2 + \omega_{n\phi}^2}{\gamma} \right] s + \frac{\omega_{nx}^2 \omega_{n\phi}^2}{\gamma} = 0
\]

\[
S_{1,2} = \frac{\omega_{nx}^2 + \omega_{n\phi}^2}{\gamma} \pm \sqrt{\left( \frac{\omega_{nx}^2 + \omega_{n\phi}^2}{\gamma} \right)^2 - 4 \cdot \frac{\omega_{nx}^2 \omega_{n\phi}^2}{\gamma}}
\]

Perhitungan \(S_1\) dan \(S_2\) menggunakan program excel didapat :

\[
S_1 = 6077,524 \quad \rightarrow \quad \omega_{n1} = \sqrt{S_1} = 77,958 \text{ rad/det}
\]

\[
S_2 = 850,444 \quad \rightarrow \quad \omega_{n2} = \sqrt{S_2} = 29,162 \text{ rad/det}
\]
Kopel

Perhitungan $\omega_{nx}$, $\omega_{n\phi}$, $\Delta(\omega)^2$, dan Amplitudo

$\omega_{nx} = \sqrt{\frac{k_x}{m}} = 20,632\text{rad/det}$

$\omega_{n\phi} = \sqrt{\frac{k_{\phi}}{M_{mo}}} = 77,36\text{ rad/det}$

Sedangkan nilai $\Delta(\omega^2)$ didapat dari persamaan:

$$\Delta(\omega^2) = \left[\omega^4 - \left(\frac{\omega_{nx}^2 + \omega_{n\phi}^2}{\gamma} - \frac{4 \cdot D_x \cdot D_{\phi} \cdot \omega_{nx} \cdot \omega_{n\phi}}{\gamma}\right) \omega^2 + \frac{\omega_{nx}^2 \omega_{n\phi}^2}{\gamma}\right]^2$$

$$+ 4 \left\{\left[\frac{D_x \cdot \omega_x \cdot \omega}{\gamma} (\omega_{nx}^2 - \omega^2) + \frac{D_{\phi} \cdot \omega \cdot \omega_{n\phi}}{\gamma} (\omega_{n\phi}^2 - \omega^2)\right]^2\right\}^{1/2}$$

$\Delta(\omega^2) = 615869000000 = 6,159.10^{11}$

Maka nilai amplitudo menjadi:

$$A_{x1} = \frac{F_x}{m \cdot M_m} \left[(-M_m \omega^2 + K_{\phi} + K_x L^2)^2 + 4\omega\left(D_{\phi} \sqrt{K_x M_{mo}} + L^2 D_x \sqrt{K_x m}\right)^2\right]^{1/2}$$

$$= 3,313.10^{-9} \text{ m}$$
Kopel

\[ A_{x2} = \frac{M_y}{M_m} \left[ \frac{(\omega_{nx})^2 + (2 \cdot D_x \cdot \omega_{nx})^2}{\Delta(\omega^2)} \right]^{1/2} = 1.376 \times 10^{-12} \text{ m} \]

\[ A_{\varphi1} = \frac{F_x \cdot L \cdot \omega_{nx} (\omega_{nx}^2 + 4 \cdot D_x \cdot \omega^2)^{1/2}}{M_m \Delta(\omega^2)} = 4.361 \times 10^{-11} \text{ m} \]

\[ A_{\varphi2} = \frac{M_y}{M_m} \left[ \frac{(\omega_{nx}^2 - \omega^2)^2 + (2 \cdot D_x \cdot \omega_{nx} \omega)^2}{\Delta(\omega^2)} \right]^{1/2} = 2.372 \times 10^{-11} \text{ m} \]

Maka nilai amplitudonya adalah:

\[ A_x = 3.313 \times 10^{-9} + 0.00137 \times 10^{-9} = 3.315 \times 10^{-9} \text{ m} \]

\[ A_\varphi = 4.064 \times 10^{-11} + 2.232 \times 10^{-11} = 6.296 \times 10^{-11} \text{ m} \]

- Perhitungan \( \rho \)

\[ \tan A_\varphi = \frac{A_x}{\rho} \]

\[ \rho = \frac{A_x}{A_\varphi} = \frac{3.315 \times 10^{-9}}{6.296 \times 10^{-11}} = 52.64 \text{ m} \]
Dari ilustrasi gambar, maka :
\[ A_H = A_x + S \cdot A_\phi \]
\[ = 3,769.10^{-9} \text{ m} = 1,484.10^{-7} \text{ in} \]
\[ A_V = A_\phi \cdot 1/2 B \]
\[ = 3,930.10^{-10} \text{ m} = 1,547.10^{-8} \text{ in} \]
\[ A_H = 1,484.10^{-7} \text{ in} < A_{H \text{ ijin}} = 70 \mu \text{m} = 2,756.10^{-3} \text{ in} \quad \text{(OK)} \]
• \[ A_V = 1,547.10^{-8} \text{ in} < A_{V \text{ ijin}} = 40 \mu \text{m} = 1,575.10^{-3} \text{ in} \quad \text{(OK)} \]
Didapat kategorji “Not Noticeable to Persons”

➢ Berdasarkan nilai amplitudo, didapat nilai velocity yaitu:
\[ V_H = 2 \cdot \pi \cdot 25 \cdot 1,484.10^{-7} = 2,331.10^{-5} \text{ in/sec} \]
\[ V_V = 2 \cdot \pi \cdot 25 \cdot 1,547.10^{-8} \text{ in} = 2,431.10^{-6} \text{ in/sec} \]

Sesuai dengan tabel 2.1 yaitu ”Extremely Smooth”

\[ K_H = 0,1 \cdot A_H = 0,1 \cdot 1,484.10^{-7} = 1,484.10^{-8} \]
\[ K_V = 0,005 \cdot A_V \cdot f = 0,005 \cdot 1,547.10^{-8} \cdot 25 = 1,934.10^{-9} \]

Nilai K < 0,1 adalah “Lower Limit of Human Perception”. Serta termasuk dalam klasifikasi “Treshold Value-vibration Just Perceptible” dan tidak berpengaruh pada saat mesin beroperasi.
Perhitungan Frekuensi Resonansi

Diketahui data dari perhitungan sebelumnya:

\( \omega_{n1} = 77,958 \text{ rad/det} \)

\( \omega_{n2} = 29,162 \text{ rad/det} \)

\( f_{\text{mesin}} = 1500 \text{ rpm} = 25 \text{ cps} \)

Dengan menggunakan rumus:

\[
\omega_{\text{resonansi}} = \omega_{n1}\sqrt{1 - 2 \cdot D^2}
\]

\[
f_{\text{resonansi}} = \frac{\omega}{2 \cdot \pi}
\]

Tabel di bawah merupakan hasil dari \( f_{\text{mesin}}/f_{\text{resonansi}} \) untuk vertikal, horizontal, dan rocking:

<table>
<thead>
<tr>
<th></th>
<th>Vertikal (z)</th>
<th>Horizontal (x)</th>
<th>Rocking (ϕ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \omega_{n1} = 77,958 \text{ rad/det} )</td>
<td>2,036</td>
<td>2,304</td>
<td>2,120</td>
</tr>
<tr>
<td>( \omega_{n2} = 29,162 \text{ rad/det} )</td>
<td>5,444</td>
<td>6,158</td>
<td>5,666</td>
</tr>
</tbody>
</table>

\( D_z^g = 0,104 \)

\( D_x^g = 0,349 \)

\( D_\phi^g = 0,219 \)
BAB VI
KESIMPULAN
Kesimpulan

1. Tiang pancang yang akan direncanakan adalah sebanyak 32 buah dengan \( Q_{ijin} = 148,14 \) ton yang mampu menahan beban sebanyak \( P_{maks} = 111,82 \) t

2. Nilai Magnification Factor pada arah vertikal sebesar 1,002, horizontal sebesar 0,154, dan rocking sebesar 0,995 sehingga memenuhi syarat yang ditentukan yaitu lebih kecil dari 1,5.

3. Amplitudo yang terjadi yaitu 4,203.\(10^{-10}\) m = 1,655.\(10^{-8}\) in (< \(A_{V_{ijin}} = 40 \mu m = 1,575.10^{-3}\) in) untuk vertikal dan 4,025.\(10^{-9}\) m = 1,584.\(10^{-7}\) in (< \(A_{H_{ijin}} = 70 \mu m = 2,756.10^{-3}\) in) untuk horizontal, sehingga pondasi dapat dikategorikan "not noticeable to person".

4. Nilai velocity untuk arah horizontal 3,614.\(10^{-5}\) in/sec dan 3,725.\(10^{-6}\) in/sec untuk arah vertikal sehingga dapat dikategorikan "extremely smooth" dengan batasan kurang dari 0,005 in/sec.

5. Kemudian untuk nilai frekuensi resonansi juga memenuhi persyaratan yang ditentukan yaitu > 1,2.

<table>
<thead>
<tr>
<th>Vertikal (z)</th>
<th>Horizontal (x)</th>
<th>Rocking (ϕ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(D_g^z = 0,104)</td>
<td>(D_g^x = 0,349)</td>
<td>(D_\phi^g = 0,219)</td>
</tr>
<tr>
<td>(\omega_{n1} = 77,936) rad/det</td>
<td>2,036</td>
<td>2,301</td>
</tr>
<tr>
<td>(\omega_{n2} = 29,952) rad/det</td>
<td>5,415</td>
<td>6,119</td>
</tr>
</tbody>
</table>
BAB VI
TERIMA KASIH