

# Lateral Foundation Analysis

Organization: **Engineering Design, Dr. Azizi**  
 Project Name: **Ex. 5-1 2nd Ed, p 291-299**  
 Job #: **1111**  
 Design by: **LAA**  
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## Laterally Loaded Pier/Pile - Structural Data

|                         |                  |                       |                   |
|-------------------------|------------------|-----------------------|-------------------|
| Units:                  | <b>SI</b>        | Pile Length:          | <b>8.000 m</b>    |
| Top of Pier/Pile Cond.: | <b>Free Head</b> | Lateral Load (Shear): | <b>300.0 KN</b>   |
| Passive Wedge:          | <b>2.7</b>       | Moment Load:          | <b>360.0 KN.m</b> |

## General Pile/Pier Properties

|                     |                       |                           |                       |
|---------------------|-----------------------|---------------------------|-----------------------|
| <b>Variable</b>     | <b>Value</b>          | <b>Variable</b>           | <b>Value</b>          |
| Material            | Steel                 | Modulus of Elasticity (E) | 250000.0 MPa          |
| Pile Width/Diameter | 0.500 m               | Moment of Inertia (I)     | 0.0001 m <sup>4</sup> |
| Area                | 0.1964 m <sup>2</sup> |                           |                       |

## Geotechnical Properties

| # | Material Type | USCS | Layer Thick, m | Consistency | Lat. S.G, KN/m <sup>3</sup> | Kp   | F.S. on Kp | Cohesion, KPa | Gamma, KN/m <sup>3</sup> |
|---|---------------|------|----------------|-------------|-----------------------------|------|------------|---------------|--------------------------|
| 1 | Cohesive Soil | CL   | 4.000<br>0 - 4 | Stiff       | 20000.0-<br>20000.0         | 2.60 | 1.33       | 150.00        | 19.0                     |
| 2 | Cohesive Soil | CL   | 4.000<br>4 - 8 | Stiff       | 20000.0-<br>20000.0         | 2.60 | 1.33       | 150.00        | 19.0                     |

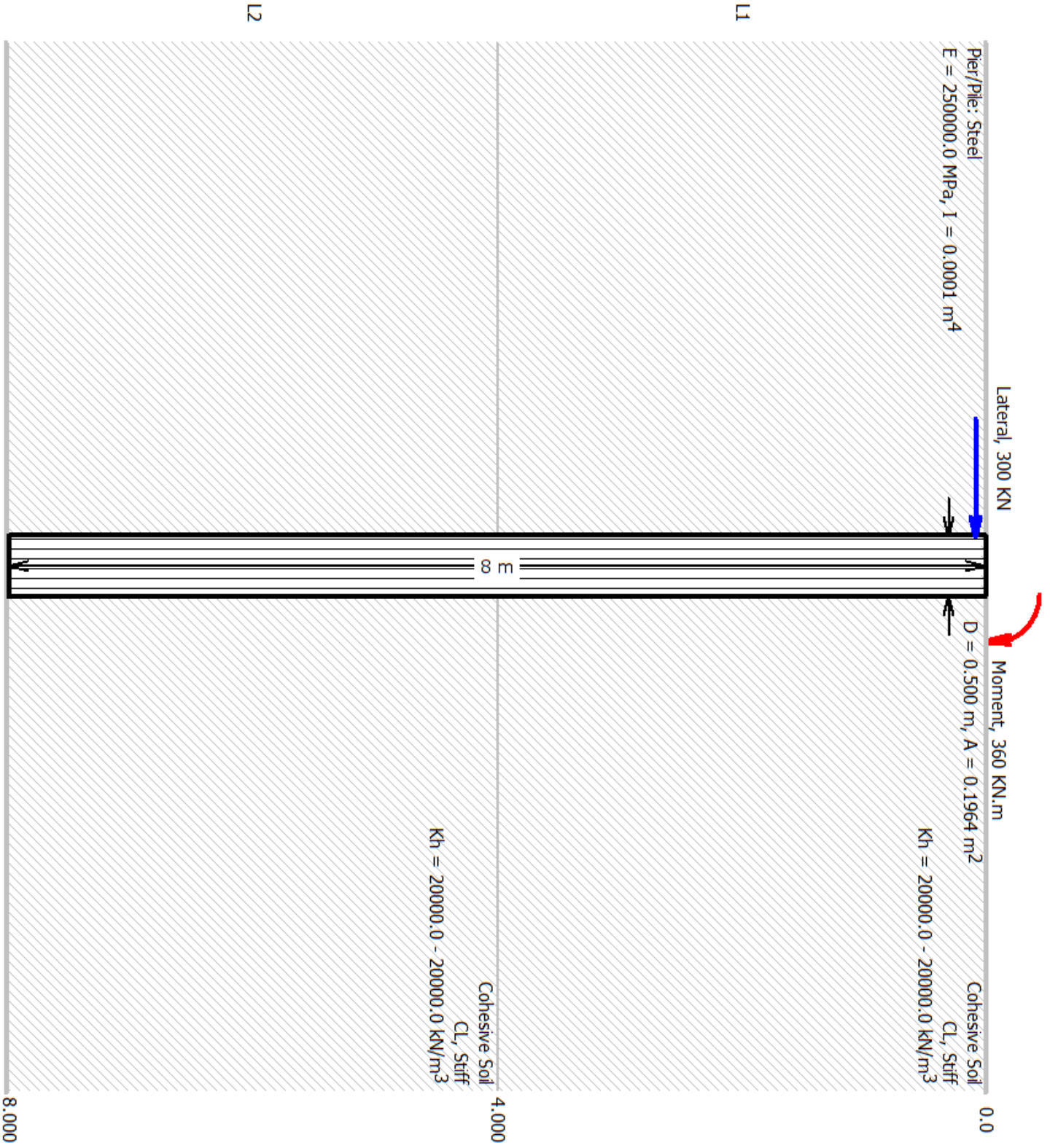
Comparison w/Published Fethi Azizi Book, Engineering Design in Geotechnics, 2nd Ed., 2013

## Results

|  |                    |
|--|--------------------|
| Maximum Deflection is 56.51 mm at 0.00 m                 | 52 mm at 0.00 m    |
| Maximum Moment is 454.50 KN.m at 0.80 m                  | 450 kN.m at 0.75 m |
| Maximum Shear is 300.00 KN at 0.00 m                     | 300 kN at 0.00     |
| Pier/Pile Tip Movement is 0.11 mm at the bottom (8.00 m) | 0 mm at 8.00 m     |

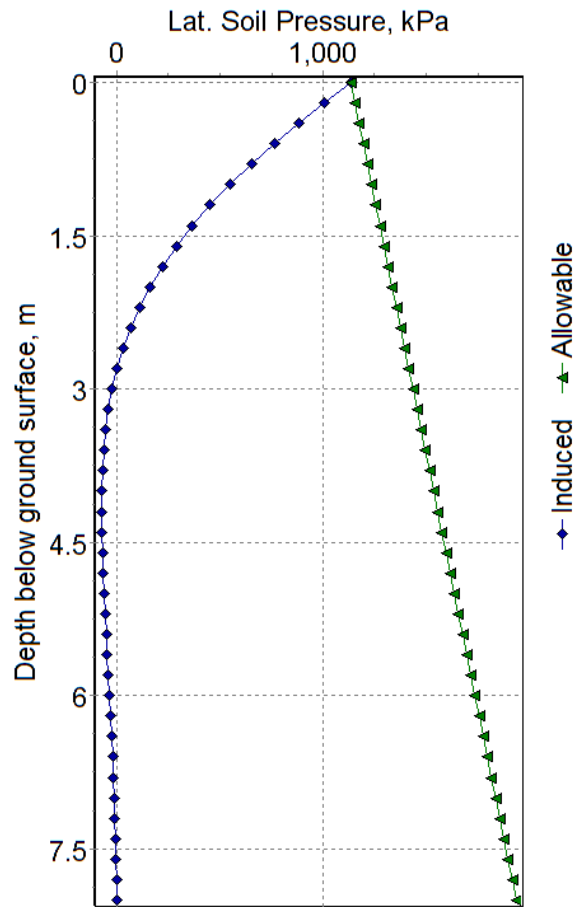
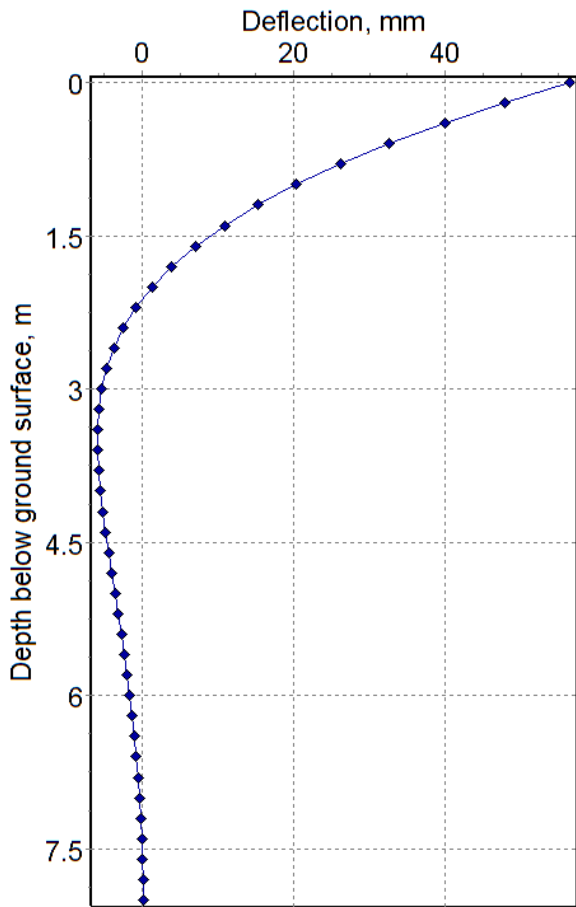
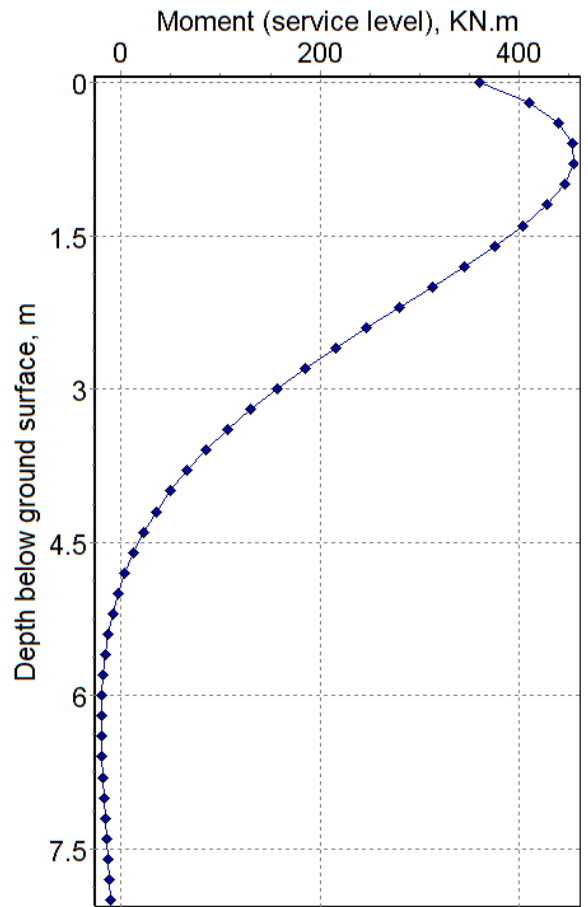
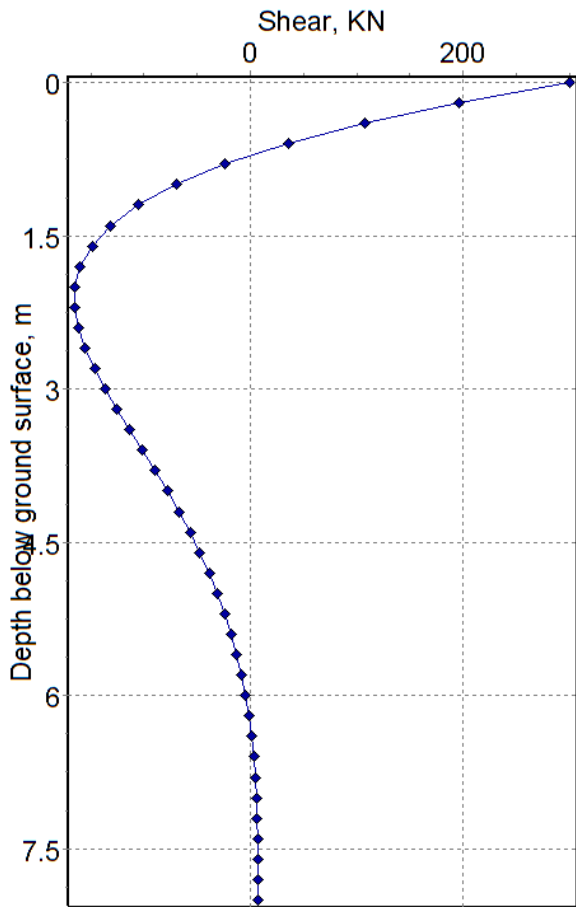
## Conclusions:

1. 17 simultaneous equations with 17 unknowns needed to be solved to get to the correct solution.
2. A 17 x 17 k Matrix needed to be solved with an accuracy of 16 numbers after the decimal place.
3. Equivalent cantilever beam would yield 0.75 m "depth to fixity" but because of non linear soil-pile interaction, the characteristic length is 1.58 m, which is >> 0.75 m. Equivalent cantilever is not valid here.
4. Therefore, using a "depth to fixity" cantilever beam methodology would not work here.
5. The deflection chart is the solution of a 4th order differential equation.
6. The bending moment is the solution of a 2nd order differential equation.
7. This Lateral Foundation Software further calculates the induced passive pressure and this is further compared to allowable lateral bearing soil resistance using C, Phi & Gamma.
8. There is no commercial software or published book that shows you induced passive pressures.
9. We have built in suggestion for lateral subgrade modulus, cohesion and other parameters - this simplifies greatly the calculations. You go from "what value do I use" to "How can I optimize pile design."
10. You can get this new book at our website and read Chapter 5, Numerical Modelling of Laterally Loaded Piles. <http://www.soilstructure.com/publications/engineering-design-in-geotechnics/>



## Table of Test Results

| Soil Modulus,<br>KPa | Node # | Depth,<br>m | Shear,<br>KN | Moment,<br>KN.m | Deflection,<br>mm | Lat. Soil Pr,<br>KPa | Allow. Soil Pr,<br>KPa |
|----------------------|--------|-------------|--------------|-----------------|-------------------|----------------------|------------------------|
| 10000                | 1      | 0.00        | 300.00       | 360.00          | 56.51             | 1130.18              | 1132.52                |
| 10000                | 2      | 0.20        | 195.70       | 409.28          | 47.90             | 1003.57              | 1152.58                |
| 10000                | 3      | 0.40        | 107.98       | 439.39          | 39.93             | 879.79               | 1172.63                |
| 10000                | 4      | 0.60        | 35.50        | 453.49          | 32.67             | 761.04               | 1192.69                |
| 10000                | 5      | 0.80        | -23.19       | 454.50          | 26.14             | 649.01               | 1212.75                |
| 10000                | 6      | 1.00        | -69.54       | 445.04          | 20.33             | 544.88               | 1232.81                |
| 10000                | 7      | 1.20        | -104.97      | 427.42          | 15.23             | 449.40               | 1252.86                |
| 10000                | 8      | 1.40        | -130.90      | 403.68          | 10.81             | 363.00               | 1272.92                |
| 10000                | 9      | 1.60        | -148.64      | 375.60          | 7.04              | 285.79               | 1292.98                |
| 10000                | 10     | 1.80        | -159.45      | 344.69          | 3.87              | 217.68               | 1313.03                |
| 10000                | 11     | 2.00        | -164.48      | 312.21          | 1.25              | 158.36               | 1333.09                |
| 10000                | 12     | 2.20        | -164.77      | 279.21          | -0.87             | 107.41               | 1353.15                |
| 10000                | 13     | 2.40        | -161.28      | 246.55          | -2.55             | 64.30                | 1373.21                |
| 10000                | 14     | 2.60        | -154.85      | 214.90          | -3.82             | 28.42                | 1393.26                |
| 10000                | 15     | 2.80        | -146.21      | 184.76          | -4.76             | -0.88                | 1413.32                |
| 10000                | 16     | 3.00        | -136.01      | 156.51          | -5.40             | -24.26               | 1433.38                |
| 10000                | 17     | 3.20        | -124.79      | 130.42          | -5.79             | -42.37               | 1453.43                |
| 10000                | 18     | 3.40        | -113.01      | 106.64          | -5.97             | -55.89               | 1473.49                |
| 10000                | 19     | 3.60        | -101.04      | 85.23           | -5.97             | -65.41               | 1493.55                |
| 10000                | 20     | 3.80        | -89.20       | 66.21           | -5.84             | -71.54               | 1513.61                |
| 10000                | 21     | 4.00        | -77.73       | 49.53           | -5.61             | -74.82               | 1533.66                |
| 10000                | 22     | 4.20        | -66.82       | 35.08           | -5.30             | -75.74               | 1553.72                |
| 10000                | 23     | 4.40        | -56.59       | 22.75           | -4.93             | -74.77               | 1573.78                |
| 10000                | 24     | 4.60        | -47.14       | 12.39           | -4.52             | -72.30               | 1593.83                |
| 10000                | 25     | 4.80        | -38.53       | 3.84            | -4.09             | -68.70               | 1613.89                |
| 10000                | 26     | 5.00        | -30.78       | -3.07           | -3.66             | -64.26               | 1633.95                |
| 10000                | 27     | 5.20        | -23.90       | -8.53           | -3.23             | -59.27               | 1654.01                |
| 10000                | 28     | 5.40        | -17.86       | -12.69          | -2.81             | -53.95               | 1674.06                |
| 10000                | 29     | 5.60        | -12.64       | -15.73          | -2.42             | -48.47               | 1694.12                |
| 10000                | 30     | 5.80        | -8.18        | -17.80          | -2.05             | -43.01               | 1714.18                |
| 10000                | 31     | 6.00        | -4.44        | -19.05          | -1.70             | -37.67               | 1734.23                |
| 10000                | 32     | 6.20        | -1.35        | -19.62          | -1.39             | -32.55               | 1754.29                |
| 10000                | 33     | 6.40        | 1.15         | -19.63          | -1.11             | -27.73               | 1774.35                |
| 10000                | 34     | 6.60        | 3.12         | -19.19          | -0.86             | -23.26               | 1794.41                |
| 10000                | 35     | 6.80        | 4.62         | -18.41          | -0.64             | -19.16               | 1814.46                |
| 10000                | 36     | 7.00        | 5.72         | -17.37          | -0.46             | -15.45               | 1834.52                |
| 10000                | 37     | 7.20        | 6.46         | -16.15          | -0.29             | -12.14               | 1854.58                |
| 10000                | 38     | 7.40        | 6.91         | -14.80          | -0.16             | -9.22                | 1874.63                |
| 10000                | 39     | 7.60        | 7.11         | -13.40          | -0.05             | -6.69                | 1894.69                |
| 10000                | 40     | 7.80        | 7.12         | -11.97          | 0.04              | -4.51                | 1914.75                |
| 10000                | 41     | 8.00        | 6.95         | -10.56          | 0.11              | -2.67                | 1934.81                |



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