CHAPTER 1 STEADY-STATE HEAT CONDUCTION

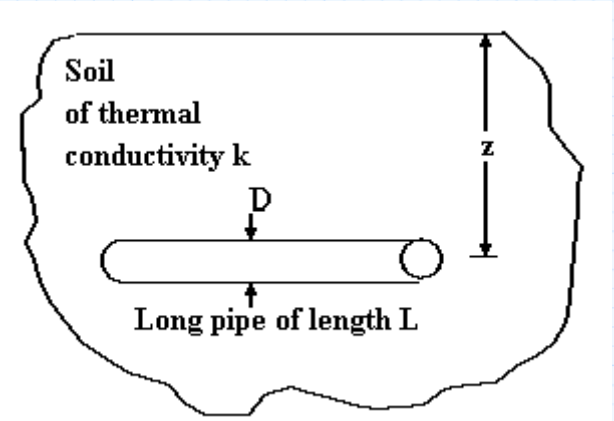
1.4 Conduction Shape Factors - Pipe Buried in Soil

Conduction shape factors are convenient parameters for expressing the effect of geometry in two-dimensional heat transfer problems, usually involving a source and a sink. The conduction shape factor S is defined based on the relationship:

$$q = k \cdot S \cdot \Delta T$$

where q is heat flow, k the thermal conductivity and ΔT the temperature difference between source and sink. The factors S have been determined for various situations with analytical techniques.

Example: Consider a long pipe of diameter D, length L and temperature Tp buried horizontally at a depth z in soil with constant surface temperature Ts.



$L := 10\ m$ $k := 0.4\ \frac{W}{m \cdot \Delta°C}$

Consider different depths: $z := 0.1\ m, 0.2\ m .. 0.9\ m$

$D := 0.10\ m$ pipe diameter

$Tp := 60\ \Delta°C$ $Ts := 0\ \Delta°C$

$$S(z) := 2 \cdot \pi \cdot \frac{L}{\operatorname{acosh}\left(2 \cdot \frac{z}{D}\right)}$$

$$q(z) := k \cdot S(z) \cdot (Tp - Ts)$$

$$S(z) = \begin{bmatrix} 47.71 \\ 30.45 \\ 25.357 \\ 22.694 \\ 20.991 \\ 19.781 \\ 18.863 \\ 18.135 \\ 17.537 \end{bmatrix} m \qquad q(z) = \begin{bmatrix} 1.145 \cdot 10^3 \\ 730.802 \\ 608.568 \\ 544.655 \\ 503.793 \\ 474.753 \\ 452.716 \\ 435.229 \\ 420.896 \end{bmatrix} W$$