12 Plane Strain and Axially Symmetric Consolidation of Clay Stratum (McNamee's Problem)

12.1 Problem Description

In this verification plane strain and axially symmetric consolidation of a clay stratum is analyzed. Two models are used for this verification:

1. The stratum is loaded by a uniform normal stress along a strip.
2. The stratum is loaded by a uniform normal stress over a circular area.

Two cases are considered for each model: with and without drainage at the surface.

12.2 Model Properties

The material is set to be "Mohr Coulomb" and the hydraulic behaviour is "isotropic". Field stress is assigned in the form of gravity.

Strip Load Model:

The geometry of the strip model is shown in Figure 12-1. Figure 12-2 illustrates the boundary conditions and the mesh. The normal load is shown and a refined mesh is applied near the applied load for better accuracy. The input parameters are listed in Table 12-1.

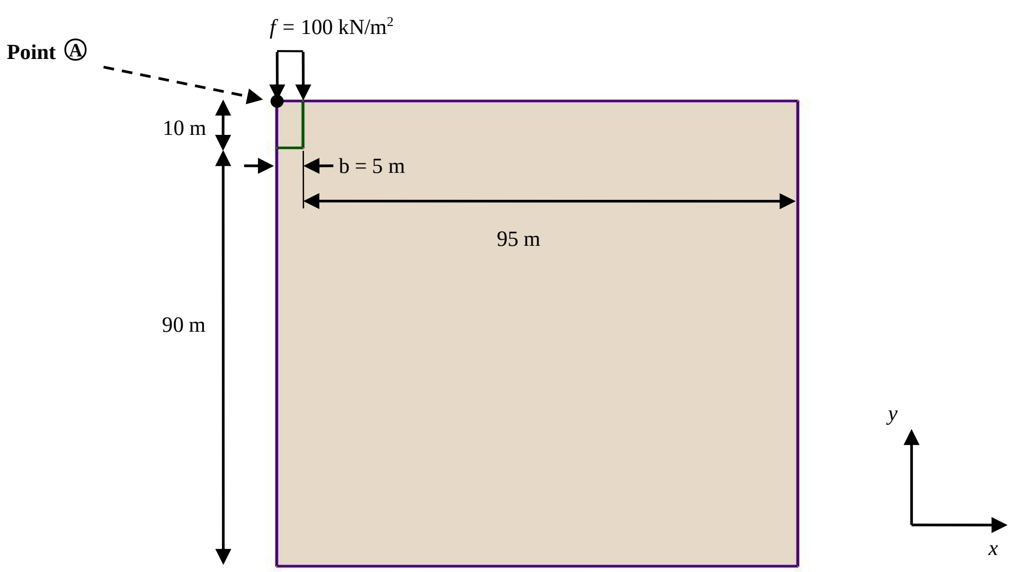

Figure 12-1: Geometry of the strip model

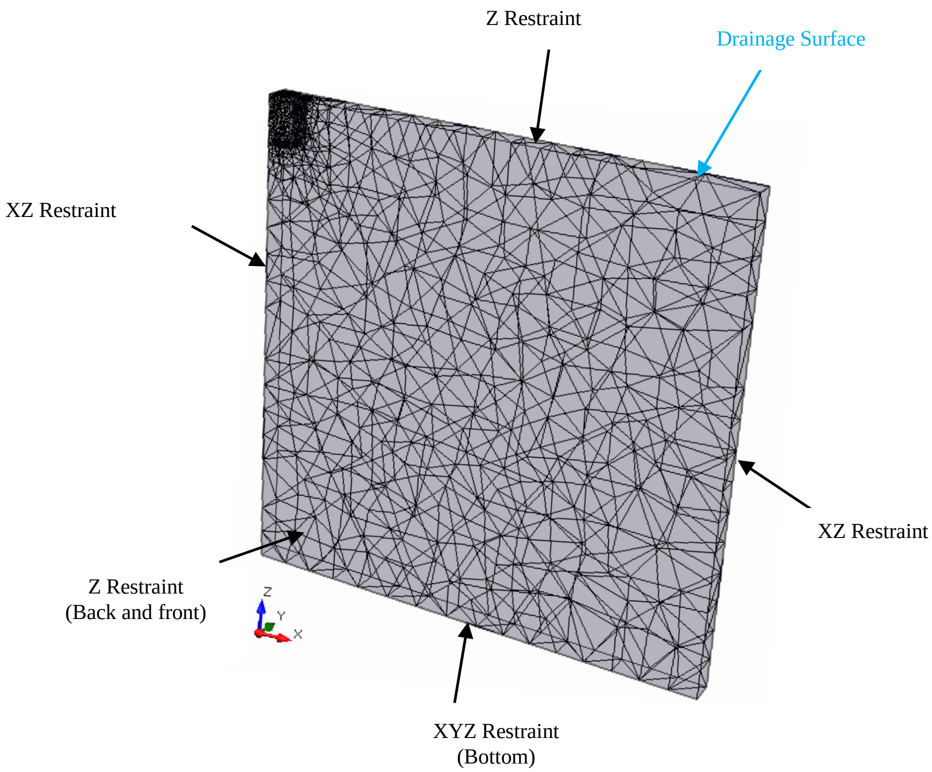

Figure 12-2 : Mesh and boundary conditions

Table 12-1: Table of input parameters for strip model

Parameter	*Value*
Young's Modulus (E)	40000 kPa
Shear Modulus (G)	20000 kPa
Poisson's Ratio (*v*)	0.0
Permeability (k)	9.81e-6 m/s
Initial Element Loading	None
Fluid Bulk Modulus	2200000 kPa

Circular Model:

The geometry of the circular model is shown in Figure 12-3. The mesh and boundary conditions are shown in Figure 12-4. Refined mesh is applied near the normal load. The model parameters are listed in Table 12-2.

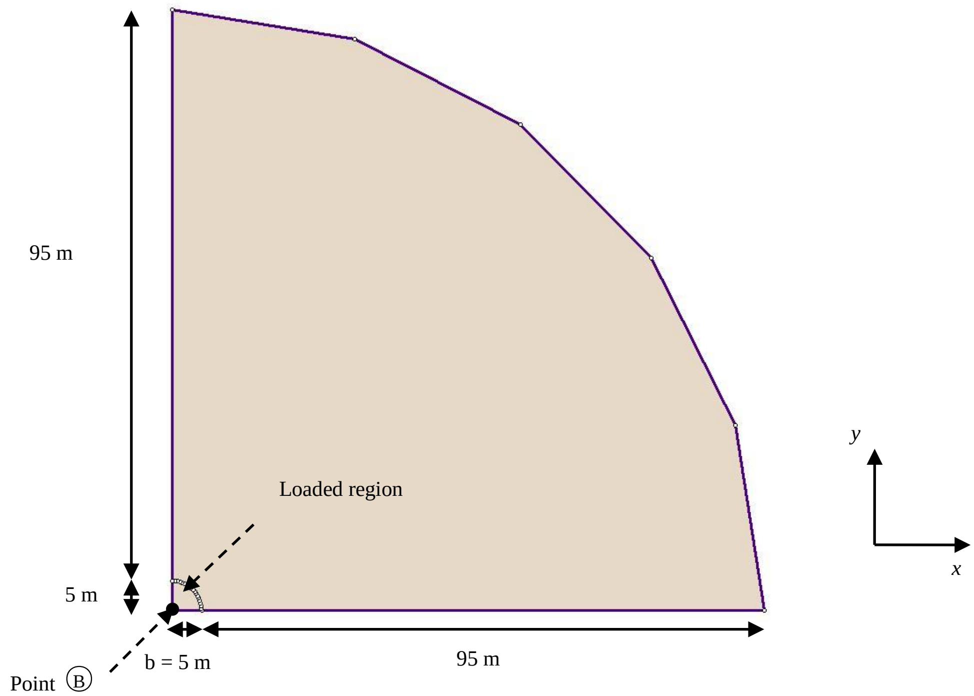

Figure 12-3 : Geometry of the circular model

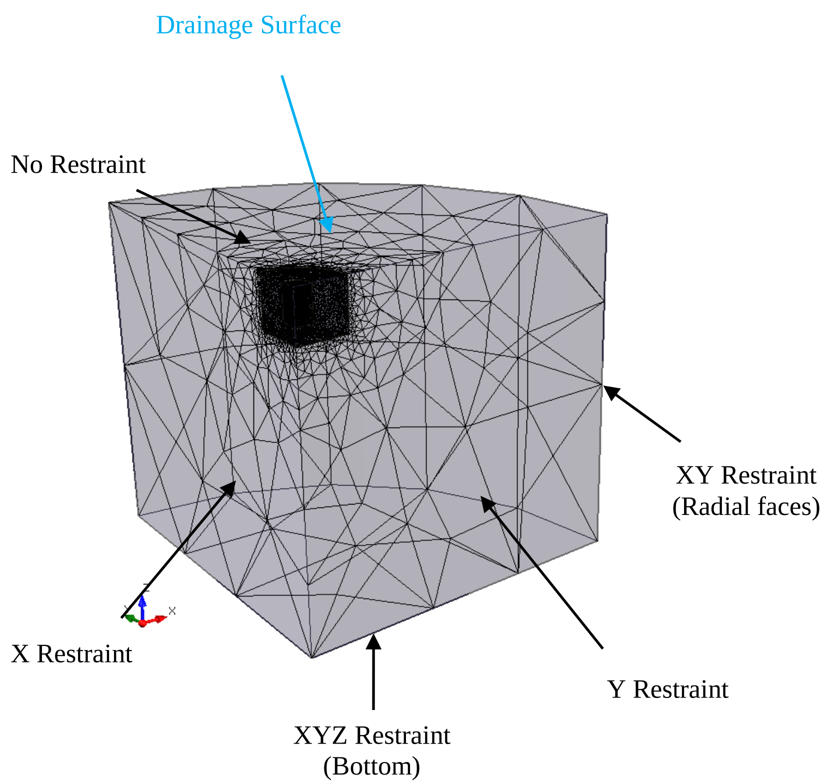

Figure 12-4 : Mesh and boundary conditions

Table 12-2 : Table of input parameters for circular model

Parameter	*Value*
Young's Modulus (E)	40000 kPa
Shear Modulus (G)	20000 kPa
Poisson's Ratio (*v*)	0.0
Permeability (k)	9.81e-6 m/s
Initial Element Loading	None
Fluid Bulk Modulus	2200000 kPa

12.3 Results

Results for the strip model are shown in Figure 12-5 and Figure 12-6 and results for the circular model are shown in Figure 12-7 and Figure 12-8.

Figure 12-5 to Figure 12-8 show the relation between normalized settlement that is evaluated as ($\frac{2G}{fb}(\omega - \omega_{t=0})_{z=0}$) versus normalized time that is evaluated as ($\frac{dt}{b^2}$). *G* is the shear strength, *f* is the distributed normal load, *b* is the width of the section under normal load, ω is the displacement at time t, $\omega_{t=0}$ is the initial displacement, *d* is the coefficient of consolidation defined in Equation 1.

$$d = \frac{2GK}{g} \quad (\frac{m^2}{s}) \qquad (1)$$

k is the coefficient of permeability and *g* is the gravity constant.

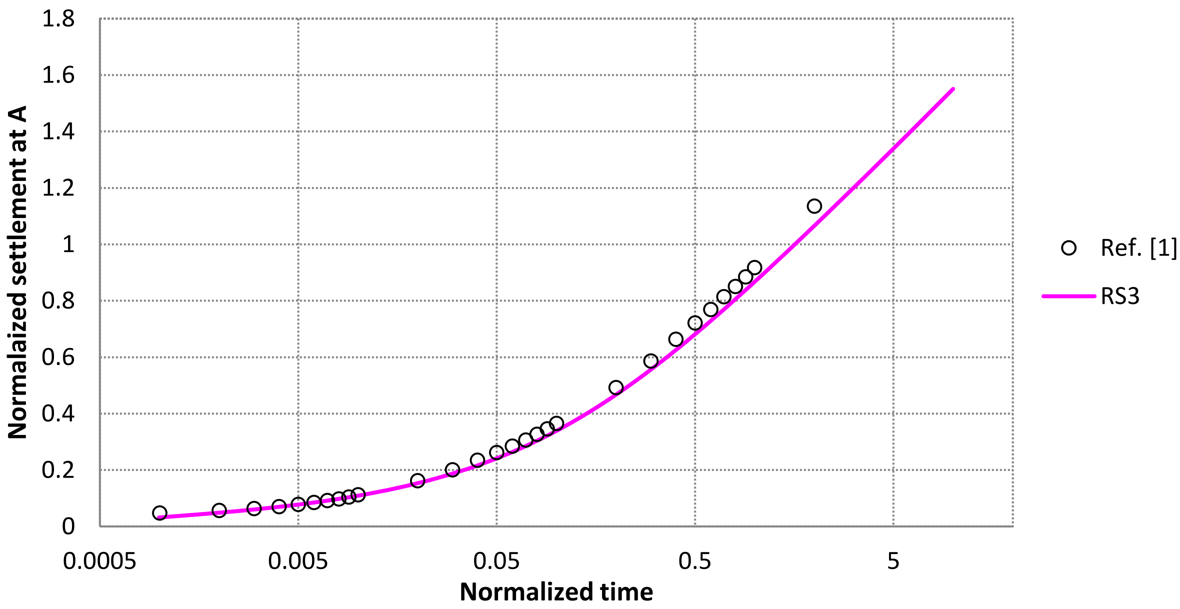

Figure 12-5 : Settlement at location point A (strip model) – with drainage

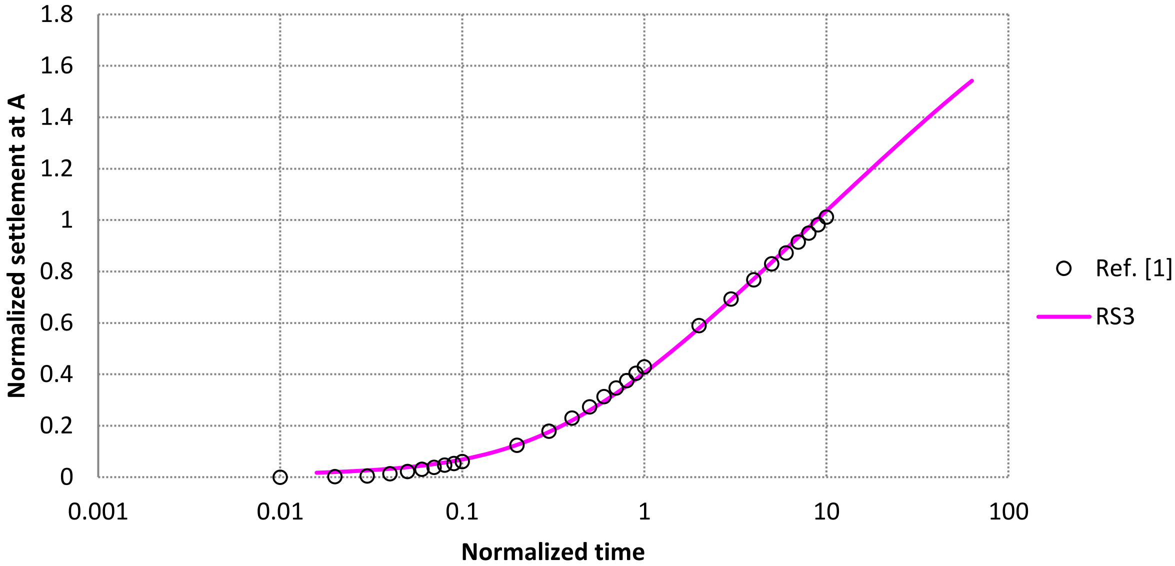

Figure 12-6 : Settlement at location point A (strip model) – without drainage

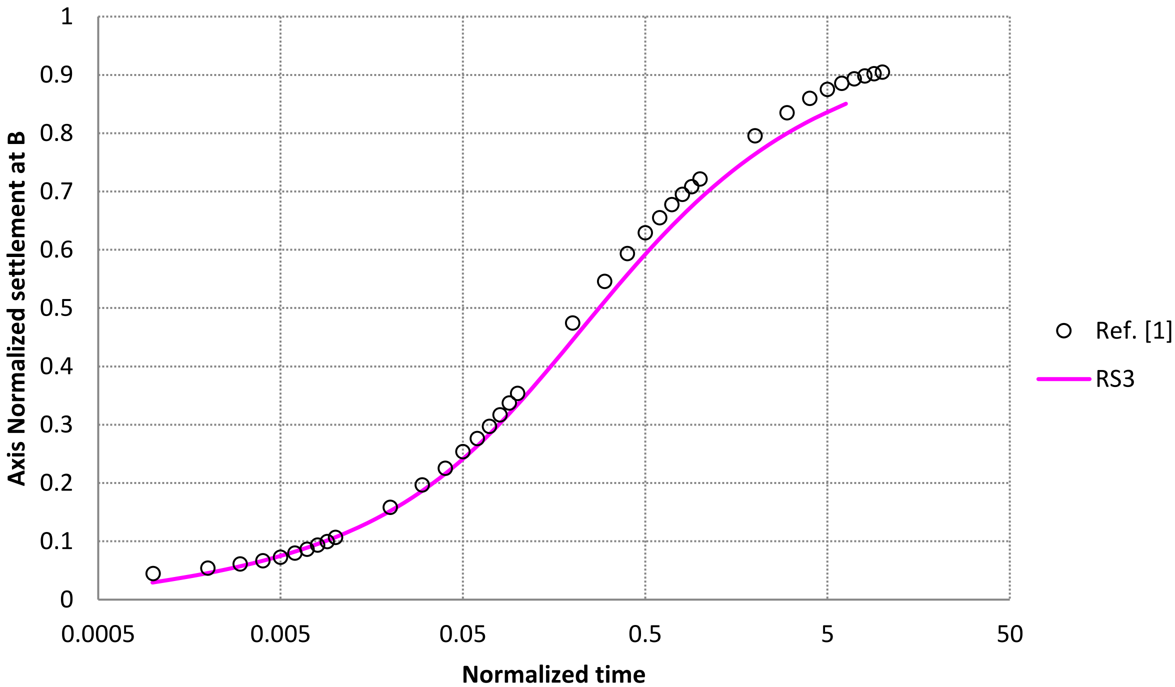

Figure 12-7 : Settlement at location point B (circular model) – with drainage

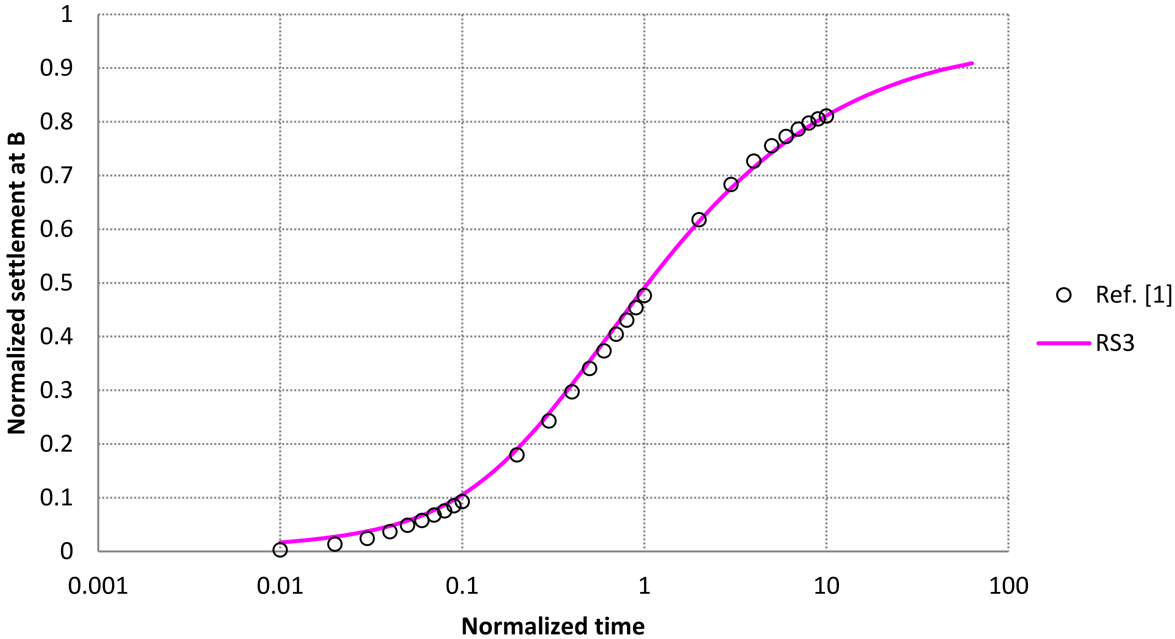

Figure 12-8 : Settlement at location point B (circular model) – without drainage

12.4 References

1. Mcnamee, J., & Gibson, R. E. (1960). Plane strain and axially symmetric problems of the consolidation of a semi-infinite clay stratum. Quarterly Journal of Mechanics and Applied Mathematics, 13(2), 210-227.

12.5 Data Files

The following input data files can be found in the ***RS3*** installation folder:

- **V012 Circular, No drainage.rs3model**
- **V012 With drainage.rs3model**
- **V012 Strip, No drainage.rs3model**
- **V012 Strip, With drainage.rs3model**