ABAQUS simulation for consolidation of saturated soft soil in two-dimensional finite region

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Abstract：For consolidation problem of saturated soft soil in two-dimensional finite region, choosing three different kind of boundary conditions, using finite element software ABAQUS simulated and searched the characteristics and laws of soil settlement under the shear or normal load on the surface. The results show that: both shear load or normal load that the final settlement has no connection with the boundary permeability, but with the load and the soil nature itself. Different boundary conditions that corresponding to the process of settlement are variable. Compared with the shear load, the normal load effect on the vertical displacement is larger and they have orders of magnitude difference. Same for horizontal displacement, the shear load effect on the horizontal displacement is larger and they have orders of magnitude difference.

Key words: two-dimensional finite area; consolidation settlement; loading effect; boundary permeability; ABAQUS simulation

I. Introduction

Nowadays, people pay more attention to the problem of fluid-structure coupling seepage to exploring and researching. It is widely applied to practical engineering problems. Such as soft soil consolidation settlement, subsurface fluid caused the ground settlement, the dam foundation and slope stability problems, biological soft tissue deformation research and so on. Land subsidence is a kind of environmental geological phenomenon due to the earth's crust surface soil compression regional ground elevation to reduce that refers to the natural and human factors. It has characteristics of slow generating, long duration, wide range of influence, causes the the complex and the prevention and control is difficult.

Land subsidence caused great inconvenience to people's production and life. It caused the attention of the governments and scholars. In addition to a large amount of groundwater extraction can cause evident ground subsidence, a large number of engineering construction makes the ground load to be another important influence factors of ground subsidence. In this paper, for the two-dimensional finite rectangle saturated soft soil consolidation problem, to study the soil under loading that different boundary permeability effect on the process and result of consolidation settlement.

ABAQUS is France's DASSAULT that launched a large-scale non-linear finite element engineering analysis software. In addition to simple finite element analysis, it can also simulate special complex and huge models, dealing with highly nonlinear engineering practical problems. Geotechnical engineering for flow fluid-solid coupling has a specific request to numerical simulation analysis of finite element software. ABAQUS is very professional in this field. Its soil constitutive model not only can reflect the soil properties, and to calculate the pore pressure and effective stress that has a strong adaptability in geotechnical engineering. ABAQUS provides the soil pore water pressure unit which is based on the consolidation theory that able to simulate saturated or unsaturated soil. About the constitutive model, the numerical example chose the linear

elastic model, the soil is homogeneous and isotropic. In literature [5] with example 8-1 has been proved the accuracy of the numerical simulation of saturated soil consolidation that using this constitutive model. Therefore, choosing ABAQUS to this article calculation example for simulated research has certain reliability.

II. Example describtion

This case researched the finite two-dimensional rectangular area saturated soft soil of consolidation problem under the action of shear load and normal load respectively. And discussed that under three different boundary conditions to the influence of the load and the result of the consolidation settlement process in this paper. The loading sketch of two-dimensional area is shown in figure 1:
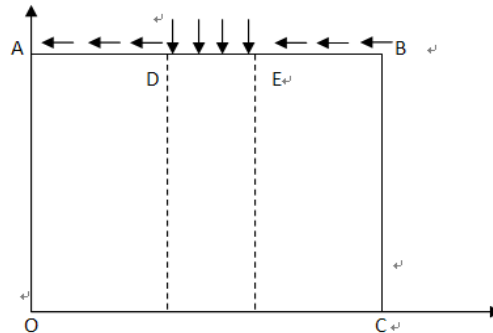

Figure 1 sketch of 2D saturated soft soil layer with surface loading

The two-dimensional soft-ground that AB is 11 m long, BC to 10 m wide of flat rectangular area, applying the normal load with symmetry, and loading width is 1 m, pure shear load and normal load is respectively 50 MPa and 65 MPa. The soil constitutive model selected linear elastic model, and the soil is isotropic and homogeneous quality. Other soil parameters is shown in table 1 :

Table 1 Saturated soft soil parameters

parameter	E	υ	k	
value	3.94945 MPa	0.25	$1.57406 \times 10^{-17} m^2$	
parameter	K_f	ϕ	μ_f	K_s
value	1**3.62** MPa	**0.52**	$2.0 \times 10^{-4} Pa \cdot s$	**48.55** MPa

In this case the three kinds of boundary conditions are as follows:

(1) Soil of upper surface AB and under surface OC are all permeable surface;

(2) Soil of upper surface AB is permeable, the under surface OC is not;

(3) the soil surface AD and EC are permeable, the middle loading position DE is not.

The three kinds of boundary conditions is derived from the literature [7] example of finite two-dimensional region of boundary conditions, but its left and right side boundary is always permeable. It is not take into account the impermeable of the boundary condition of the two sides .Therefore, here we assume that the boundary of OA and the BC are impervious, other things are being equal. Because when the upper and lower surface of AB and OC being impervious that surrounded by impervious boundary conditions, the situation does not conform to the reality. So it is not be into consideration, this article can be considered a complement of literature [7].

III. The process of ABAQUS simulation

(1) Enter the PART module of ABAQUS, drawing a rectangular area according to the given size, this step is relatively easy.

(2) Enter the PROPERTY module, set the parameters given in table 1.

(3) Enter the ASSEMBLY module assembly, then step into the ANALYSIS module, setting up long enough total time of consolidation, to ensure that the consolidation can achieve a stable state.

(4) Enter the LOAD module, set above the given boundary conditions and load size, etc.

(5) Meshing and selecting pore pressure unit.

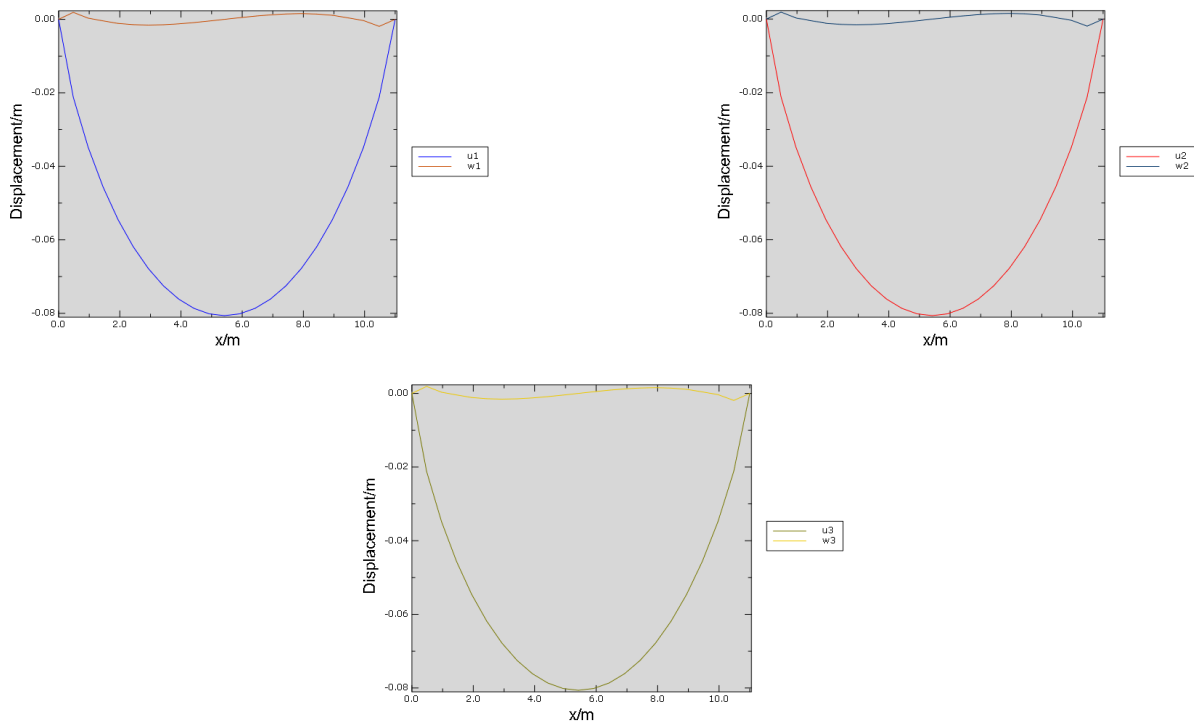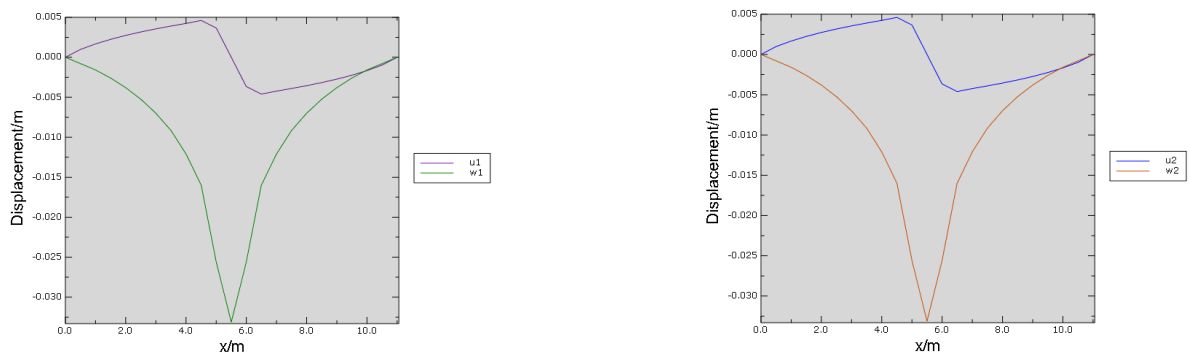(6) Enter the JOB module, to submit a job analysis.

IV. Result and analysis

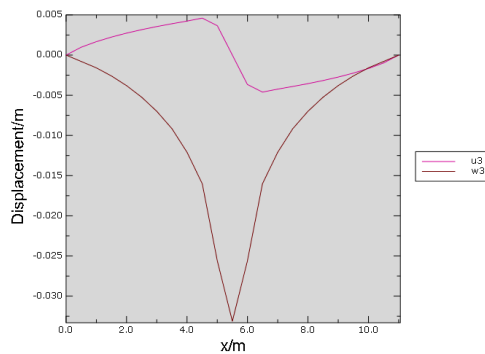**Figure 2 displacement curve of soil on the surface under the action of shear load**

Figure 3 displacement curve of soil on the surface under the action of normal load

In figure 2, the 3 picture are corresponding to three kinds of boundary conditions on the soil of surface settlement curve. We can see clearly that the final settlement of three kinds of boundary conditions, either horizontal or vertical displacement, the result is the same. Therefore, the final settlement of soil is completely unaffected by boundary permeability. Figure 3 are the settlement curve of soil layer under the normal load action alone, the three picture is corresponding to three kinds of boundary conditions, the final settlement of three kinds of boundary conditions, either horizontal or vertical displacement, the result is the same. It also verifies the reliability of the conclusions in the literature [7]. The figure 2 and figure 3 shows that shear load had a greater influence on the horizontal displacement of soil layer, the normal load had a greater influence on the vertical displacement of soil layer .but whatever the load function alone, there are two kinds of displacement exist, it also illustrates the settlement and horizontal displacement of soil is coupled to each other.
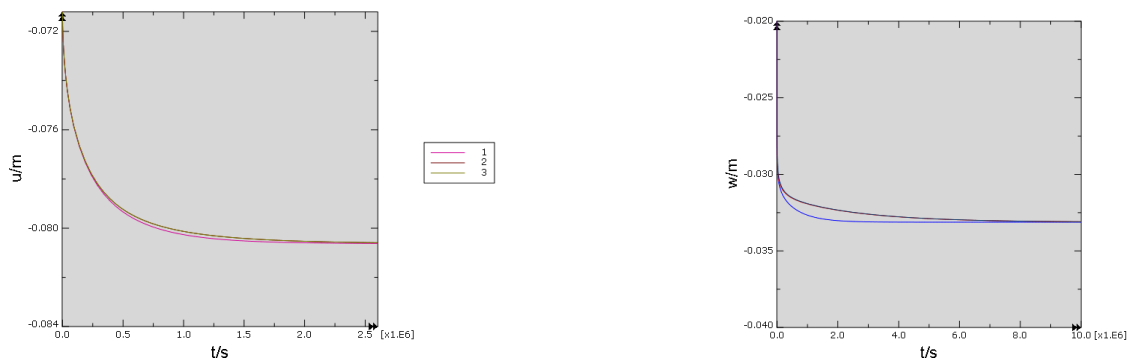

Figure 4 Upper surface central subsidence versus time

In figure 4, the curve 1 to 3 respectively represent three boundary conditions of the change of the center of the soil on the surface subsidence, the left here is that under shear load action alone for horizontal displacement curve of change over time, the graph on the right is that under normal load action alone for vertical displacement curve of change over time. You can see that the boundary permeability has no effect on the soil of the final settlement, but decides the change of settlement patterns. Such as the boundary condition 1 of the displacement curve , the water on both sides of the strongest permeability, consolidation to the stable time is short.

V. Conclusion

In this paper, by using finite element software ABAQUS, selecting 3 different boundary conditions to simulate and research the 2-d finite region under the action of the load of saturated soft soil consolidation problem, obtained the following results:

(1) Shear load or normal load on action separately, the final settlement of soil has nothing to do with boundary

permeability, but the change of the sedimentation process is different, the greater the area of permeability, the soil consolidation the shorter the steady time.

(2) Shear load had a greater influence on the horizontal displacement of soil layer, shear load and normal load has magnitude difference on the horizontal displacement, the normal load had a greater influence on the vertical displacement of soil layer, and the same with magnitude difference .

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