# 南京大学研究生毕业论文英文摘要首页用纸

THESIS：**Research on the Land Subsidence and its Numerical Simulation in the Su-Xi-Chang Area and Shanghai City**

SPECIALIZATION: **Hydrology and Water Resources**

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# Abstract

The land subsidence induced by the excessive pumping of groundwater is a severe geohazard. The occurrence precondition of the land subsidence includes the compressible soil layers and the groundwater overpumping. Though the mechanism of the land subsidence is simple in the view of the soil mechanics, it continued to be a hot issue because of the complexity of the soil deformation feature and the pumping condition.

The land subsidence induced by groundwater over-pumping is usually explained by the consolidation of aquitards. In the traditional view, the sandy aquifer is uncompressible and its deformation is elastic. However, the sandy aquifer in the field is mingled with the clay grains more or less, instead of being pure. An aquifer is often imbedded with thin clay interlays or lens. The complex geological condition and the groundwater level variation lead to the complex soil deformation features in the field. In the study region, the great exploitation of the groundwater results in the huge regional subsidence depression cone. In such condition, it is necessary to simulate the subsidence regionally, not limited by the separated district division.

This dissertation contains two parts. One is the analysis on the complicated deformation features of the soil layers in the study region during the land subsidence in the field. In Chapter 3, the compact deformation features of the clay aquitards and the sandy aquifers are analyzed based on the field observation data including the extensometer data and the groundwater level variation. The result indicates 1) Sandy layers exhibited significant compressin deformation. The deformation is related not only with the soil compressibility but also with the layer thickness. The

compression of some aquifers (e.g., sandy layer) may be quite significant if its thickness is large .2) The deformation feature is related with the experienced groundwater level change. The preconsolidation head (critical head) has the control effect on the soil deformation. When the groundwater level is below the critical head, the soil deformation is plastic for both aquitard and aquifer. There is an obvious lag phenomenon. When the level keeps rising and being stable, the deformation of the sandy aquifer and the hard clay layers is mainly elastic. When the level drops greatly or is below the historical lowest head, the tardy continuous compact deformation occurs. If the level drops but is still higher than the historical lowest head, the soil behaves the plastic deformation without lag phenomenon. 3) The different layers have the different deformation features. The same soil layers in the different location have different deformation features. For instance, the soil behaves elastic deformation in the brim of the depression cone. The same soil has the plastic involving creep deformation in the center of the cone. More over, the same soil layer in the same location has different deformation features in the different stage.

The analysis on the field data shows the soil has the complicated deformation features. So experiments are done to further invest the mechanism and features of subsidence. This study took the undisturbed soils in the study area to examine the compressibility of aquifer and aquitards induced by groundwater withdraw using laboratory tests, which simulates the groundwater variation. The experiments results demonstrate not only the clay but also the sand layer have the unignored compaction deformation involving the creep feature because of the drop of the groundwater level. Under the periodical loading/unloading cycles, the deformation of the sandy aquifer is not rheological but elastic. The lag phenomenon in the land subsidence in the field is related with the rheology feature of the sand layer, as well as with the mingled thin clay in the aquifer. The results of laboratory test were also compared with field data to verify the validity of the laboratory model test.

The other part of this dissertation is the numerical simulation of the regional land subsidence including Chapter 5 and 6. Based on the analysis on the field observation data and the results from the experiments, the regional land subsidence model, which includes the three dimensional groundwater model with varying parameters and one dimensional elastic-plastic and creep deformation model, is built in the section 1 in Chapter 5.. According to the different deformation features (elastic, visco-elastic, elastic-plastic or visco-elasto-plastic), the groundwater flow

equation and the subsidence model based on the corresponding strain-stress relationship are adopted. This model allows the coupling of the equations describing the hydraulical and mechanical mechanisms, in a nonlinear fashion where the parameters vary with pore pressure. The model is solved by the iterative method. In the section 2 of Chapter 5, the multiscale Finite Element Method and the improvement and optimization of the algorithm are introduced. In Chapter 6, the numerical simulation of the land subsidence during the 1995~2002 is presented. The simulation results match well with the observed data after calibration and verification. As a result, the model could be used as a tool to predict and give some reasonable advices on groundwater exploitation and the related land subsidence in future pumping scenarios. Meanwhile, the analysis and comparison on the reasonability of the simulation result are discussed. At the end of the dissertation, the main conclusions and the prospect of the future research are presented.

**Key words**: regional land subsidence, aquifer, aquitard, deformation features, numerical simulation, coupling, varying parameters, rheology