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Prevention partition for land subsidence induced by engineering dewatering in Shanghai

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Abstract. Land subsidence in shanghai has been found for more than 70 years. In the early years, it was mainly caused by groundwater exploitation. In recent years, engineering dewatering in shallow ground (within 90 m) has become a major source for land subsidence in the rapid urbanization course. A management partition of land subsidence induced by foundation pit dewatering for the first confined aquifer was suggested.

1 Introduction

Shanghai is the economic and financial center of China. In 1939, land subsidence was first observed and its maximum value has reached 2.0 m until now. In the early years, the subsidence was caused by groundwater extraction for water supply. Later, the exploitation was restricted in order to control the land subsidence. However, during the rapid urbanization in recent years, lots of underground engineering were constructed, the engineering dewatering in shallow ground (within 90 m) has become a major source contributing to increasing land subsidence.

Xu et al. (2009) analyzed the geohazards which may occur during the construction and maintenance of infrastructures in Shanghai, and the confined water was one of the main causes. Shen and Xu (2011) used numerical simulation to predict the behavior of land subsidence in Shanghai due to pumping of groundwater. Wang et al. (2012, 2013), Zhang et al. (2013), Luo et al. (2008) and Zhou et al. (2010) used numerical simulation to analyze the land subsidence caused by foundation pit dewatering. However, most previous studies focused on a single foundation pit. The land subsidence of engineering dewatering in a city's scale is not concerned too much.

Table 1. Stratigraphic characteristics of central city in Shanghai.

Layer No.	Composition	Note
②	Clay	
③	Muddy clay	
④	Muddy clay	
$⑤_1$	Silty clay	
$⑤_2$	Sandy silt	The micro-confined aquifer
$⑤_{3-4}$	Silty clay	
⑥	Clay	
⑦	Sand	The first confined aquifer
⑧	Clay	
⑨	Sand	The second confined aquifer

2 Geological partition for strata combination

The Quaternary sediments (Table 1) of Shanghai belong to the deposit of Yangtze River and tidal current of East China Sea. The foundation pit dewatering in Shanghai mainly relates to the first confined aquifer (layer ⑦). The aquifer is formed in the Late Pleistocene and mainly consists of sand. In normal deposit environments, layer ⑥ is distributed above layer ⑦, but it is replaced by layers $⑤_2$ and $⑤_{3-4}$ in the ancient river erosion area. Layer ⑧ is distributed between layers ⑦ and ⑨, but in some area, it does not exist where the layer ⑦

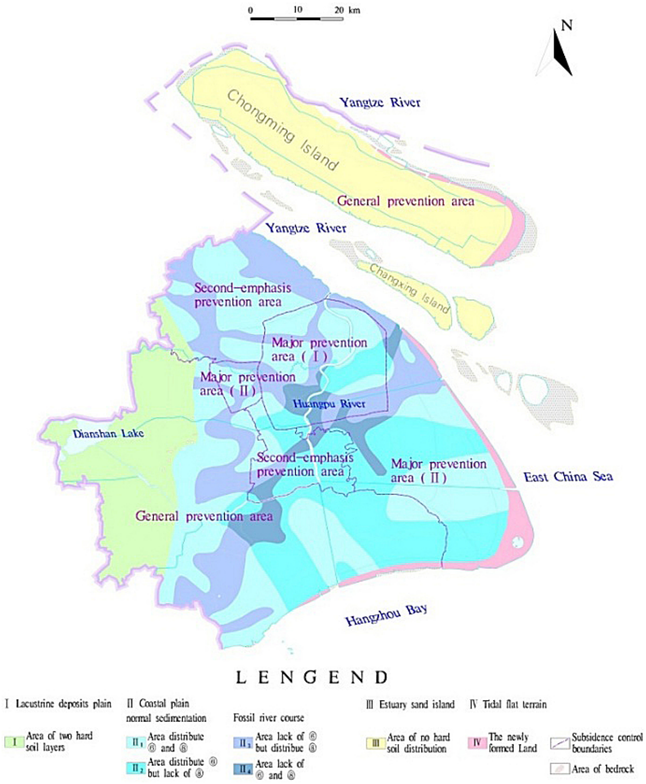

Figure 1. Geological partition for the first aquifer in Shanghai.

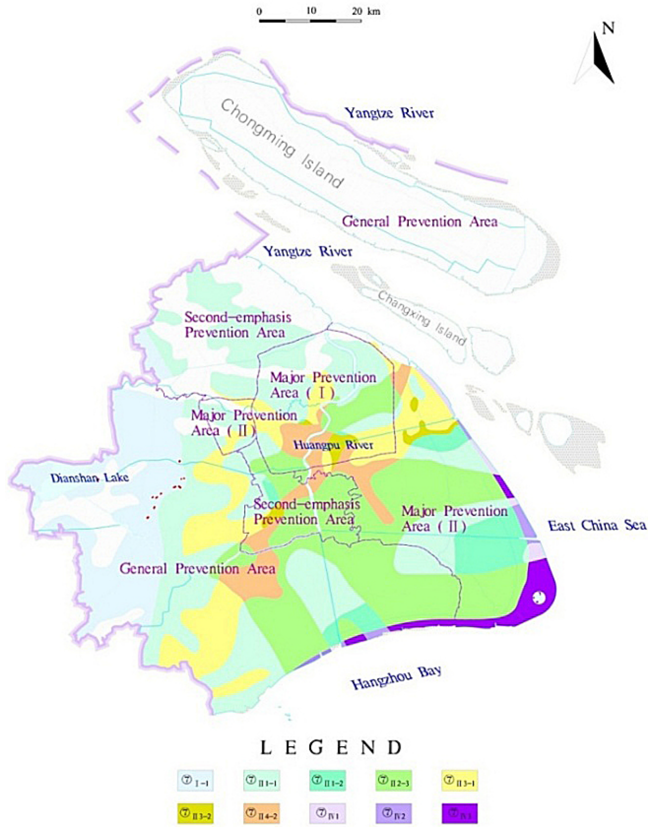

Figure 2. Prevention partition for land subsidence induced by engineering dewatering.

is connected with layer ⑨. So the first confined aquifer was divided into 7 geological partitions (Fig. 1 and Table 2).

3 Prevention partition for land subsidence

According to the urban development planning (SMCPA, 2012), the land subsidence prevention was divided into 4 partitions: emphasized prevention area I, emphasized prevention area II, second emphasized prevention area and general prevention area.

4 Prevention partition for land subsidence induced by engineering dewatering

In foundation pit dewatering, the curtain (diaphragm wall) is the most effective way to control the drawdown and land subsidence outside the pit (Wang et al., 2009). Considering the curtain's depth of present technology, the first confined aquifer was divided into 3 partitions in vertical direction. The dividing depth is 60 and 70 m separately.

A prevention partition for land subsidence induced by engineering dewatering for the first confined aquifer was suggested (Fig. 2). It includes 11 sub-partitions (Table 3). The maximum drawdown for different foundation pits was suggested for each partition (Table 4).

5 Conclusions

Engineering dewatering has become a major factor of land subsidence in Shanghai. A prevention partition of land subsidence induced by engineering dewatering for the first confined aquifer was developed and suggested.

Table 2. Geological partition for strata combination.

Deposit environment			Characteristic	Composition
Partition	Sub-partition			
I (Lacustrine deposits plain)	–		Layers ⑥ and ⑧	Silty sand
II (Coastal plain)	Normal sedimentation	II_1	Layers ⑥ and ⑧	Sand
		II_2	Layer ⑥, without Layer ⑧	
	Ancient river sedimentation	II_3	Layer ⑧, without layer ⑥	
		II_4	without layers ⑥ and ⑧	
III (Estuary sand island)	–		without layers ⑥ and ⑧	Without
IV (Tidal flat terrain)	–		Newly formed land	Sand

Table 3. Prevention partition for land subsidence induced by engineering dewatering.

Sedimentary characteristics and strata combination			Bottom depth of the confined aquifer "*B*" (m)	
Partition	Sub-partition	Combination	Number	Depth (m)
I	–	Layers ⑥ and ⑧	1	$30 < B \leq 60$
II	II_1	Layers ⑥ and ⑧	1 2	$30 < B \leq 60$ $B > 60$
	II_2	Layer ⑥, without Layer ⑧	3	⑦ and ⑨ connected
	II_3	Layer ⑧, without layer ⑥	1 2	$30 < B \leq 60$ $B > 60$
	II_4	Without layers ⑥ and ⑧	3	⑦ and ⑧ connected
IV	–	Newly formed land	1 2 3	$30 < B \leq 60$ $B > 60$ ⑦ and ⑧ connected

Table 4. Control indexes of drawdown for partitions for land subsidence induced by engineering dewatering.

Partition	Prevention partition for land subsidence		
	Emphasized prevention partition (m)	Second-emphasized prevention (m)	General prevention partition (m)
⑦$_{II\ 1-1}$ ⑦$_{II\ 1-2}$	2.0	2.0	2.0
⑦$_{II\ 2-3}$	1.0	1.0	1.5
⑦$_{II\ 3-1}$ ⑦$_{II\ 3-2}$	1.5	2.0	2.0
⑦$_{II\ 4-3}$	0.5	1.0	1.5
⑦$_{IV\ 2}$	1.0	–	1.5

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