



Journal of Applied Sciences

ISSN 1812-5654

science
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Research for Development and Utilization of Underground Space in World

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Abstract: In order to grasp the current research trends of underground space, through to literature study of the underground space, the study sums up the research of the underground space planning and design which is based on demand database of underground engineering forecast and the underground space in rail transportation planning, on the basis of the construction of infrastructure, achieve integrated planning of ground and underground; By means of the vertical stratification function and with complex index system of underground development, there are some supervision and implement of underground space planning and management regulations for urban ecological sustainable development.

Key words: Current research trends, underground space, urban planning, literature study algorithms

INTRODUCTION

The detailed Study of underground space around the world can make the scholars quickly grasp the research level of the underground space, the research important and difficult. We can know the underground space problem in different countries, especially China's underground space problems, understand the discipline and trend of underground development. Now, the related Research is very lack, in this paper, on the basis of a large number of literature data analysis, we can obtain the idea of research and development of underground space.

INTERNATIONAL SITUATION OF UNDERGROUND SPACE PLANNING

From 19th, there are a lot of researches on underground space, but in western, because of the Private land ownership, many countries did not make the master planning of underground space. And also have less theory for underground space planning. Sun (2007) and some others just do some special underground planning, such as Underground street planning and underground utility tunnel planning. Necessary of underground space development is depended on which country and its laws or government rights. In china, it is public land ownership, the governments play a main role in the urban land using, so the master and comprehensive planning of underground space is still necessary and valuable.

CHINA'S RESEARCH IN UNDERGROUND APCCE

Like western, China has old history of using underground space. The first study of underground is from 1949 when the defent engineering used for public in the peace time.

To 1980s, with the international transformation and the growth need of underground space, The situation that underground space mainly using in civil air defence has been changed, instead of comprehensive planning of urban underground space largely used in the urban development.

Hou (2005) pointed out that the development of underground space is only way of urban development. And Proposed pattern or strategy of underground space development in china. Peng (1990) demand forecasting of urban underground space, decision-making and benefit evaluation on the system research and puts forward the corresponding system model, we study the urban underground space development and utilization patterns and the contradiction between supply and demand of urban land analysis obtains urban underground space development and utilization of the total demand. Tong (1994) points out that the development of urban underground space should be coordinated with ground, should developed step by step in the form of "dot, line, face, development axis". Shu (2002) systematically puts forward the content and practical techniques of the urban underground space planning.

Table 1: Analysis of research papers in china (Source: according to the CNKI database)

Research field	Research contents	Papers	Proportion (%)	Papers	
				Master	Doctor
Underground space planning and design research	Underground space planning and design	62	37.60	13	
	Underground complex/underground street design	11	6.60	6	
	City's three-dimensional design	3	0.00	3	
	Underground space and ecological city	5	3.00	0	1
	Sloping residential design (including mountain residence)	11	6.60	2	0
	Underground space environment design	10	6.00	2	0
	Existing building (civil air defence) underground space utilization	8	4.80	6	0
	Factors of Underground space development	4	2.40	3	1
	Deeper underground space development and utilization	0	0.00	0	0
	Aggregate (article)	111	67.30	32	5
Underground space management	Administration of Underground space planning	8	4.80	8	
	disaster prevention management of Underground space	9	5.40	2	1
	the property of underground space	14	8.40	4	
	Underground engineering digital	1	0.60	1	2
	Aggregate (article)	32	19.40	15	3
Underground space planning And design evaluation	Technical and economic evaluation for Urban underground space project	17	10.30	0	
	index system of Underground space planning	2	1.20	1	1
	Underground space demand forecasting	3	1.80	2	
	Aggregate (article)	22	13.30	3	1
Total	165	100%	50.00	6	
Technical research of underground space	Underground construct, underground space equipment protection, underground municipal facilities, underground traffic and tunnel, Underground engineering construction technology, underground energy circulation system, waster mine, the development and utilization of natural cave	There are not belong to my research			

Chen (2009) analyse the role and effect of underground space investment behavior and development policies by game theory. Zhu *et al.* (2004) study the Promoting mechanism of underground space development in Shanghai.

Tong (2005) research the function, composition, quantitative of index system which are used in urban underground space planning and raised its conceptual framework. Zhang *et al.* (2006) proposed the concept of "Underground engineering digital" and points out that it is an important part of the digital earth. Chen (2005) suggested that we should use ecology theory to analysis the development and utilization of underground space. Yi (2009) research the city's three-dimension form which formed by the development of underground space. He point out that the systematic and three-dimensional development is the main way of urban developed in future and will create aggregation modle.

ANALYSIS OF RESEARCH IN CHINA

Through The analysis of research papers from CNKI, we know that there are four filed research in underground, underground space planning, underground space technical project, underground space management, underground space planning and valuation. There is more research in the underground space planning and underground space technical project.

CONCLUSION

Through the literature study of the development and utilization of underground space, sums up the research route of the underground space planning and design as follows: Underground space should develop by the base of to underground engineering database and underground space demand forecast; should develop by the rail transportation planning for the development of shaft, on the basis of the construction of underground infrastructure; should make underground integrated planning (the old district on the basis of the ground space planning, the new city underground integrated planning); develop by method of function of the vertical stratification; develop by underground complexes for the development of the main subject; With the index system of the underground space planning and management regulations for the supervision; Aim to establish ecological sustainable city.

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