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Research on the Planning of Municipal Pipe in Tibet Bayi Town Center Area Based on Fractal

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In this paper, to achieve rational distribution of municipal pipe network in Bayi Town Centre Area, Box dimension and Rank dimension are used to carry out evaluation studies on the planning of water supply network and drainage network in Bayi Town. The results show that Box dimension and Optimization dimension of Water supply network are roughly equal and water supply network planning is reasonable. The Rank dimension of drainage network meets the law of optimization, so there is no problem that drainage network can achieve its basic functions, but the Length ratio and Branch ratio of it are small. Combining the pipeline network with actual situation and analyzing the causes, we find that drainage network planning has a large space for optimization.

1. Introduction

At present, the urbanization in Tibet has been 17 years, and the cumulative investment of it has been reached to tens of billions. The layout of Lhasa as the center, town as sub-centers, the county town and key port as Level 3 towns has been initially formed. In the process of the urbanization, many questions have been exposed such as unreasonable municipal pipe network layout and imperfect infrastructure.
Bayi town is now divided into three areas which are the central area, northwest area and Yongjiu area, Specific conditions of three areas is showed in Table 1.

Table 1: Specific condition of three areas

Area	Feature	Number of the population(Ten thousand)	Area (Km^2)
central area	Administrative, commercial, cultural, commercial, Tibetan medicine	7	12.38
northwest area	Science, life	0.8	13.63
Yongjiu area	Public services, logistics	0.2	12.18

The studied area is central area of Bayi Town, which now has a population of 70 thousand. Existing water supply network was built in the 1990s and from 2002 to 2005, the main problems at this stage are that the diameter of pipe is too small, and the pressure of some regional is too low, and pipe leakage is serious, and the layout of pipeline is irrational.

2. The theory of fractal

Li Fengdao, Zhu Jinzao and Zhu Qingke (2002) reported, Fractal is a science of nonlinear systems, which was proposed by Benoit Mandelbrot in 1973 at the College de France for the first time. In 1977, Mandelbrot put forward the measures of fractal—dimension.
Cui Lingzhou, Xiao Xuenian and Li Zhanbin (2004) reported the classic method of calculating the fractal dimension is Box dimension. This is a common method of calculating the fractal dimension, its approach is to take a different side length of a square box on covering graphics and covering graphics length (l) changes

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when the number of boxes ($N(l)$) also change accordingly, La, Barbera, P., Rosso, R (1989) reported, the following formulas (1) can be given on the basis of fractal theory.

$$N(l) \propto l^{-D} \tag{1}$$

Chen Jianan (1999) reported, when the length of the boxes were l_1, l_2, l_3,…, l_k,r_1 the number of boxes were $N(l_1)$, $N(l_2)$, $N(l_3)$,…$N(l_k)$ $N(r_1)$,after Logarithmic obtained we can get the following formula:

$$\lg N(l) = -D \lg l + A \tag{2}$$

Wherein, A is the constant to be determined, and D is Box dimension or absolute value of slope. Also with least square method and one-variable linear regression, the estimated value of dimension D can be available

3. Study on planning of the water supply network

Planning of Population in Bayi town center area is 90 thousand, and planning map is shown in Figure 1.

Figure 1: Planning map of Water supply network

3.1 Box dimension of the water supply network

Hu Lifeng (2010) reported, the method of Box dimension was used to calculate Fractal of water supply network, and the process is shown in table 2.

Table 2: Statistics box of Water supply network

Decile	Length(L)	Ln(L)	Number of box(N)	Ln(N)
2	13426.00	9.5049	3	1.0986
4	6713.00	8.8118	9	2.1972
8	3356.50	8.1187	24	3.1781
16	1678.25	7.4255	70	4.2485
32	839.13	6.7324	217	5.3799
64	419.56	6.0392	497	6.2086

Using the data in Table 2, Fig. 2 is fitted with Ln (L)$LN(L)$ for x-axis and Ln(N) for y-axis.

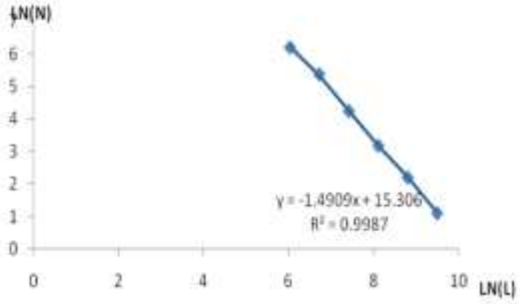

Figure 2: Fitting a straight line on box dimension of Water supply network

After the function fitting, Box dimension of Water Supply Network in Bayi Town Center Area is 1.4909.

3.2 Analysis and discussion

Zhao Peng and Zhang Hongwei (2007) reported the fractal properties of the water supply network, and thought that water supply network as the lifeline of the city and other network systems have an optimized structure and dimension of the water supply network have the relationship with the area of water supply and a population following relationship after a large study.

$$D = 1.51 - \frac{0.72}{S^{2.33}} + 0.1\left(\frac{Q}{S}\right)^{0.92} \quad (3)$$

In the formula, D_O is the dimension of water supply network, S is the area of water supply, and Q is a population.

When S equals to 12.38 k**m**^{2} and Q equals to 90000, we can get that D is 1.5825. We find that the value of DO is the same as the value of Box dimension. The absolute difference is only 0.0916, and the relative difference is 5.78%. So we have reason to believe the planning of water supply network in Bayi Town center stage Area is almost optimal, and it is reasonable.

4. Study on planning of drainage network

The planning of drainage network is separate drainage system. Panning map is shown in Fig. 3.

4.1 Box dimension of drainage network

The method of Box dimension was used to calculate Fractal of drainage network which was confirmed (Cheng Yongqian, Zhang Yue and Song Qianwu (2012)), and the process is shown in table 3.

Figure 3: The planning of drainage network

Table 3: Statistics box of drainage network

Decile	Length (L)	Ln (L)	Number of box (N)	Ln (N)
2	13426.00	9.5049	3	1.0986
4	6713.00	8.8118	9	2.1972
8	3356.50	8.1187	22	3.0910
16	1678.25	7.4255	72	4.2767
32	839.13	6.7324	202	5.3083
64	419.56	6.0392	466	6.1442

Using the data in Table 3, Fig. 4 is fitted with Ln (L)LN(L) for x-axis and Ln (N) for y-axis.

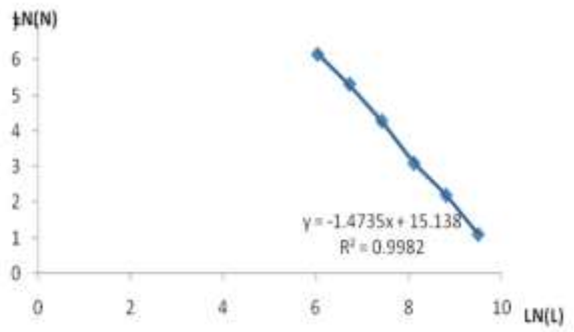

Figure 4: Fitting a straight line on box dimension of drainage network

After the function fitting, Box dimension of drainage network in Bayi Town Center Area is 1.4735. Cheng Yongqian, Song Qianwu and Zhang Yue (2011) reported, So planning of drainage network is reasonable because there is no big difference between water supply network and drainage network, the absolute difference is only 1.2%, comparing with water supply network in that area.

4.2 Rank dimension of drainage network

Rank dimension is based on which both the drainage network and rivers belong to the gravity flow, and river systems can meet level of law, so it can be considered the drainage network is tree system and meet the level of law which was confirmed (He Longhua and ZhaoHong (1996)). There are three laws of Branch Ratio, length ratio, and Rank dimension in the law of aqueous.

The law of Branch Ratio:

$$r_b = \frac{N_{m-1}}{N_m} \tag{4}$$

In the formula, r_b is Branch Ratio, N_m is the number of m-level drains.

The law of length ratio:

$$r_L = \frac{L_{m-1}}{L_m} \tag{5}$$

In the formula, r_L is length ratio, L_m is the length of m-level drains.

Rank dimension

$$D = \frac{\mathrm{lnr_b}}{\mathrm{lnr_L}} \tag{6}$$

In the formula, D_R is Rank dimension.

In order to research on Rank dimension of drainage network, we use which was confirmed (Feng Jinliang and Zhang Wen (1999)) Classification scheme to analyze branch-off drainage network. We don't draw classification of FIG. 3 in order to sake of brevity, and the number of m-level drains N_m $\mathrm{N_m}$ and the length of m-level drains $L_m$$\mathrm{L_m}$ are shown in table 4 and 5.

Table 4: Statistics of branching ratio on network

m	1	2	3
N_m	82	23	12
lnN_m	4.4067	3.1355	2.4849

Table 5: Statistics of length ratio on network

m	1	2	3
L_m	292.6098	500.2174	614.5833
lnL_m	5.6788	6.2150	6.42094

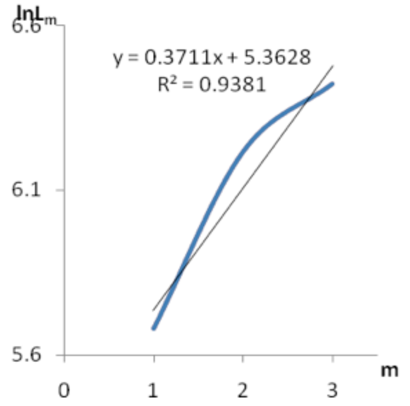

Figure 5: Linear fitting of Branch ratio

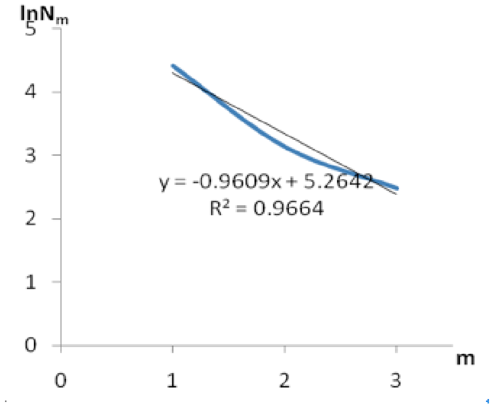

Figure 6: Linear fitting of Rank ratio

From the Fig. 5 and Fig. 6, we find that Lnr$_L$$\mathrm{lnr_L}$ is 0.3711 and Lnr$_b$ $\mathrm{lnr_b}$ is 0.9609, and Rank dimension of drainage network D_R is 2.589, and Branch Ratio r_b is 2.614 and length ratio $\mathrm{r_L}$ is 1.449.

4.3 Analysis and discussion

Chen Yanguang and Liu Jisheng (2001) reported, It is well known that Branch Ratio of river is 3~5 and length ratio of river is 1.5~3 and Rank dimension of river is 2~3. Zhang Mingsheng (2010) reported it is found that Branch Ratio and length ratio of drainage network is less than Branch Ratio and length ratio of river. According to Rank dimension, we also find that the planning of drainage network is close to the laws of nature fractal optimization and the structure of planning is within optimization theory. In other words, the function of drainage network can be realized in the water of gravity. Meanwhile, Rank dimension is almost the same with Box dimension of drainage network as well as dimension of the water supply network, but drainage network isn't improved and economic enough because Branch ratio and Length ratio is small.

Analyzing Fig. 3, we can find that Drainage network are constrained because Tibet Bayi town is surrounded by 318 national Road, mountains, and Niyang river. And so Branch Ratio is small. The second reason is that different levels of length pipeline have not yet reached to mix a more ideal state. This is also the main cause of low length ratio.

5. Conclusions

In this paper, Box dimension D and Rank dimension D_R are used to research on planning of water supply network and drainage network in Bayi Town Center Area, the findings show that planning of water supply network is reasonable because Box dimension D and Optimization dimension D_O of Water Supply Network in Bayi Town Center Area are almost equal, and that planning of drainage network may meet the functional of own weight flow because Rank dimension D_R of drainage network meet the relevant requirements, but drainage network can be continued to optimize because Branch ratio r_b and Length ratio r_L are not big enough.

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