Research on the Calculation Method of Single-track Railway Station Spacing

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Abstract: The fuzzy mathematics method is used to determine the relationship between station distance and passenger and freight volume under the determination of railway main technical standards. It can be used to test the station distribution problem in the early stage of research on the layout of the long trunk railway project.

1. Introduction

The distribution of railway stations must meet the annual transportation capacity and the number of passenger trains required by the railway line [1]. In the preliminary work of railway design, it is necessary to calculate the distance between stations in combination with the arrangement of the flat longitudinal section of the line. In order to improve the balance of the ability of the railway section to pass.

The rational distribution of single-track railway stations is the result of continuous integration of design and calculation to find the best combination. In order to make the line straight and the slope smooth, the location of the station needs to consider various factors such as topography, geology, and human requirements. In addition, the stations that are open in the near and long term should be based on the near and long term passenger and freight traffic and transportation. Requirements for nature and local transportation are determined. In the early stage of the railway project, especially in the pre-feasibility study and feasibility study stage, the design of the flat section of the line plan needs to focus on the factors of station distribution, and the reasonable station distribution is to ensure the station spacing is close under the condition of ensuring the railway capacity. The economic distance from the train to the shortest round trip. Therefore, in the layout of the long trunk route, the calculation process of the railway station distribution is very complicated and cumbersome.

In order to simplify the station distribution calculation problem in the design process, the author tries to use the fuzzy mathematics method to quickly solve the reasonable inter-station distance under the condition of the volume and traction quality to provide the railway with non-strict distribution requirements. The convenience of line selection work.

2. The Establishment of a computational model

2.1 Fuzzy mathematics and its calculation principle

The method of fuzzy mathematics is the process description of people using concept to judge, evaluate, reason, decide and control. It is based on the theory of "fuzzy set" and is a new method to deal with the problem of uncertainty and inaccuracy [2]. In multi-variable, nonlinear, time-varying large systems, complexity means many factors and large time-varying factors. Some of these factors and their changes are difficult to grasp accurately, and people often cannot make all the factors and processes. All of them are accurately examined, and only the main part can be grasped, and the so-called secondary part is ignored. In this way, in fact, it gives a ambiguity to the description of the system.

On the issue of railway station distribution, the reasonable choice of station spacing is the ambiguity subject under multi-factor control. Under the control of many factors such as topography, geology, hydrology, man-made requirements, transportation volume, traction quality, locomotive type and operating conditions, in the feasibility study stage of railway projects, the two main

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variables of transportation volume and traction quality are selected. Using fuzzy mathematics method to study its influence on reasonable station spacing, it has certain value in practical operation.

2.2 The Determination of the calculation model

Under the assumption that the basic conditions of the main technical standards of the railway are determined, as shown in Table 1, the distance between stations can be set as follows:

$$S = f(T) \quad (1)$$

In the formula, S is the distance between stations, km; T for passenger and cargo volume, 10,000 tons.

Based on an example of a new railway project, the calculation process of reasonable station spacing is described. According to Table 1, the main technical standards for new railways are proposed, and the initial traffic volume for each year is estimated. See Table 2.

Table 1 Main technical standards for the proposed new railway

Railway grade	National Railway I
Number of positive lines	Single line
Traction type	Internal combustion
Locomotive type	Dongfeng 8B
Traction quality	4000t
Limit slope	12‰(Dual machine)
Station length	1600m

Table 2 Initial traffic of the proposed new railway

Design year	**Freight volume(t/ year)**	**Bus logarithm (pair / day)**	**LTL logarithm (pair / day)**
Initial	500	2	1
Recent	1000	3	1
Long term	1500	4	1
Vision	2000	5	1

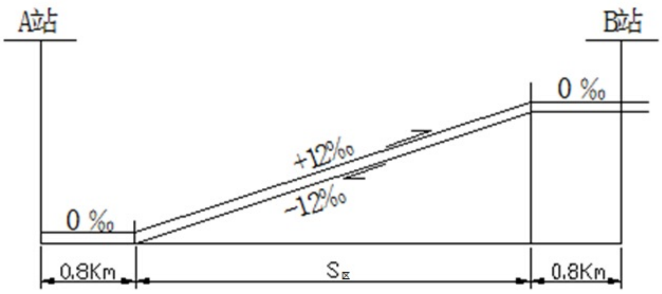

Figure 1 Schematic diagram of parallel train operation

According to Table 1 and Table 2, a schematic diagram of parallel train operation is shown, as shown in Figure 1. According to the calculation method of station distribution [3], the calculation process of the distance between economic stations in each stage is as follows:

2.2.1 Freight train logarithm calculation

$$N_{zh} = \frac{\Gamma \cdot K_b \cdot 10^6}{365G \cdot \gamma_j} - (u_1 \cdot N_1 + u_z \cdot N_z + N_t) \quad (2)$$

In the formula, N_{zh} is the logarithm of the freight train, the pair; the Γ annual freight volume in the direction of the heavy truck, t/year; the K_b fluctuation coefficient of the cargo flow; the net load coefficient of the train N_1, N_z, N_t the train logarithm of the zero load, the pick-up truck and the express freight train respectively , right; u_1, u_z is the axis coefficient of the zero load and the trailer.

2.2.2 Need to pass capacity calculation

$$N_{xu} = (N_{zh} + N_y + N_j \cdot \sum_j + N_k \cdot \varepsilon_k + N_t \cdot \varepsilon_t + N_1 \cdot \varepsilon_1 + N_z \cdot \varepsilon_z) \cdot (1 + a_c) \quad (3)$$

In the formula, the N_y number of the empty car in the direction of the heavy vehicle, the pair; the train N_k train logarithm; the heavy-duty ε_j train deduction coefficient; the passenger ε_t train deduction coefficient; the express freight ε_t train deduction coefficient; the zero-load, the pick-up $\varepsilon_1, \varepsilon_z$ train deduction coefficient; The reserve a_c capacity is 100%, and the single-track railway is 20%.

2.2.3 When the train travels to and from the city (economic time)

$$t_{wf} = \frac{1440 - t_{fc}}{N_x} - T_z \quad (4)$$

Where is the train travel time t_{wf} , min; the time to open the "skylight" for the line maintenance, min; t_{fc} the train stay time in the station, min T_z including the time interval between the arrival of the train at different times, the interval between the train station and the start, Additional time for parking.

Another cause $t_{wf} = \sum (t_{上} + t_{下})$, From Figure 1, we can find the station interval distance S (economic interval distance)

$$S_{区} = \frac{t_{wf} - t_{fc}}{t_{上} + t_{下}} \quad (5)$$

Then, the maximum inter-station distance of the train on the tight slope is the distance between the economic stations of the section.

$$S = S_{区} + S_{站} \quad (6)$$

According to the relevant norm requirements [4], the query can get the time of the train running every 12 kilometers on the slope of 12‰, and then calculate the economic interval distance.

2.2.4 Distance calculation between economic stations in each stage

According to Table 2, the 1 pair/day passenger car is converted into 1 million t/year freight volume. The calculation results according to formula (2)(3)(4)(5) are as follows:

Table 3 Calculate the distance between economic stations at each stage according to the formula method (unit:km)

project stage	Need to pass ability N_y	When the train travels to and from the train t_{wf} (min)	Economic intervalS区 (km)	Economic distance between stationsS(km)
Initial	11	113.45	36.06	37.66
Recent	18	64.67	20.38	21.54
Long term	26	41.07	12.79	13.95
Vision	33	29.82	9.17	11.77

2.3 Establishment of a computational model

According to the calculation results in Table 3, using the above method to calculate the railway line spacing between 500 and 25 million tons, the mathematical model between the traffic volume and the economic zone spacing can be established. The figure is shown in Figure 2.

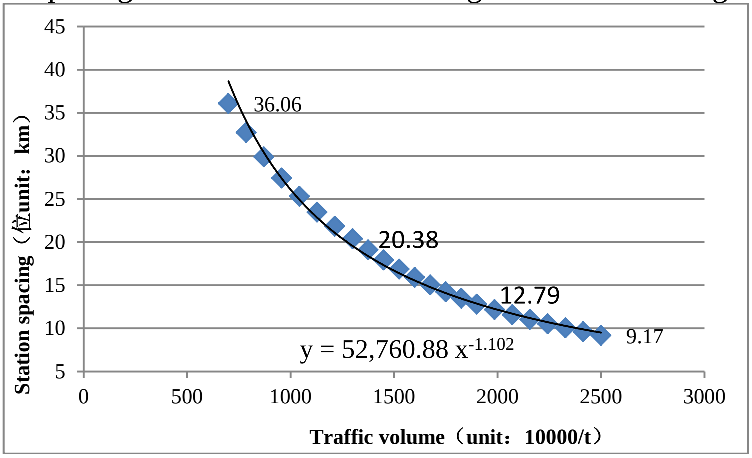

Figure 2 Relationship between distance between economic stations and traffic volume

It can be seen from Fig. 2 that there is a good functional relationship between the distance between the economic stations and the traffic volume. If a certain function is used, when the slope and the traffic volume are determined, when selecting the railway line, Reasonable selection of station spacing provides a basis for reference selection.

Analysis of the above figure data, combined with formula (1), can be used to obtain the trend equation between economic station distance and traffic volume:

$$S=26063\cdot T^{-0.998} \tag{7}$$

In the formula, *S* is the economic interval distance, km; *T* for the comprehensive traffic volume, of which 1 pair/day passenger car is converted into 1 million t/year freight volume, 10,000 tons.

Further simplify the formula (7) to get the relationship:

$$S = 256 / T \tag{8}$$

3. The Application of computational models

3.1 Economic station spacing

According to the above calculation method, using formula (8), for the single-track railway with a slope of 12‰ (double-machine slope), the calculation of the distance between stations is not less than 8km, and the calculation of different passenger and freight traffic and different traction quality can be calculated. The lower (approximate) reasonable inter-station distance, the results are shown in Table 4.

Table 4 Economic station spacing under different traction qualities and different conveying capacities (unit:km)

Conveying capacity (10000t) Traction quality(t)	750	1000	1500	2000	2500	3000
5000	42.6	32.0	21.2	16.0	12.7	10.6
4000	34.1	25.6	17.0	12.8	10.2	8.5
3500	29.8	22.4	14.9	11.2	8.9	--
3000	25.5	19.2	12.8	9.6	--	--
2500	21.3	16.0	10.6	8.0	--	--
2000	17.0	12.8	8.5	--	--	--
1500	12.7	9.6	--	--	--	--
1000	8.5	--	--	--	--	--

Note: This Table does not consider the LTL train in the calculation.

3.2 Influence of different slopes in the interval

In the case of the same technical standard, the smaller the profile slope is, the larger the distance between the economic stations can be utilized. For different sections of different slopes, the economic station spacing can be appropriately modified, namely:

$$S = \alpha \cdot 256 / T \tag{9}$$

In the formula, to limit the slope correction factor, the following Table is used.

Table 5 Table of different slope correction factors (unit:1)

slope (‰)	12	11	10	9	8	7	6	5	4	3	2	1
Correction factor	1.0	1.1	1.2	1.2	1.3	1.4	1.5	1.7	1.8	1.8	1.9	1.9

An example is as follows:

For example, the average slope of the two stations in AB is 10‰, and the correction value of the Table is 1.2, while the distance between the 12 stations of the limited slope (20 million tons of goods, 5 pairs of passengers) is 10.24 km. Then the distance between the intervals is km.

The distance between stations is 12.28+1.6 (station length)=13.84 km $\approx$ 13.5 km

3.3 Error calculation

According to the above method, the conventional formula method and the error check between the simplified equations are performed. The trend equation uses the formula (7), the simplified equation uses the formula (8), and the error calculation is shown in Table 6.

Table 6 Error comparison Table (unit:km)

Traffic volumeStation distance	goods	500(10000 t)	1000(10000 t)	1500(10000 t)	2000(10000 t)	difference (biggest smallest)
	customer	2 Right/day	3 Right/day	4 Right/day	5 Right/day	
Actual calculation		36.06	20.38	12.79	9.17	0/0
Trend equation		37.72	20.34	13.92	10.58	1.66/0.04
Simplified equation		36.57	19.69	13.47	10.24	1.07/0.51

Note: The LTL train is not considered in the calculation of this Table.

As can be seen from the above Table, the maximum error after verification is 0.04~1.66 km, which is accepTable in practical applications.

4. Conclusion

In this paper, the fuzzy calculation method is used to calculate the reasonable inter-station distance of single-track railway with different traffic volume and different traction quality, and the factors affecting the slope-to-station spacing are considered. The rationality of the simplified equation is verified by error calculation and the following conclusions are obtained:

1) Under the basic conditions of the main technical standards of railways, the distance between stations has a good function relationship with the volume of passengers and freight. This result has certain guiding significance for the distribution of single-track railway stations when the layout of the long-main railway system is planned.

2) Due to the large number of influencing factors in the calculation of reasonable inter-station distance, the simplified method proposed in this paper can be used in the research stage of the plan for the flat section of the project in the early stage of the project, which provides a basis for quick decision of the station plan layout.

It should be noted that the calculation method is limited to the use of the line plan research stage in the early stage of the project. The perfect station distribution design also needs to be combined with the driving profession. After the field investigation and correction, the implemenTable plan can be obtained.

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