

## “Limited Slope” and “Maximum Slope”

—Some thoughts on “limit slope” to “maximum slope”

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**Abstract:** In the main technical standards of railway design for many years, “limit slope” is one of the most important contents. In the era of steam locomotive rule, the maximum traction of the locomotive's specified traction quality on the uphill slope and the calculation speed is the same. The slopes are so close that they are used independently of each other and continue to be used today. However, in recent years, large-scale locomotives have emerged, and the gap between the “limit slope” and the practical “limit slope” concept is now growing. In the “High-speed Railway Design Code” and “Inter-city Railway Design Code”, the term “limit slope” has been abolished, replaced by “maximum slope”, and the “Code for Railway Route Design” implemented by passenger and freight collinear railways still in use, with or without modification, this is a question worth considering.

### 1. Limit slope and maximum traction quality

The “limit slope” in GB/T 50262-2013 of the “Basic Terminology Standards for Railway Engineering” is interpreted as: the slope of a single-machine-drawn freight train running at a constant speed on the upper slope at the calculated speed with the specified traction quality.

Correction and explanation suggestion: The freight of a single-machine-drawn freight train on the upper slope at the same speed as the maximum traction quality that can be achieved at the calculated speed. See Table 1.

Table 1 Maximum traction mass Table at different limit slopes (calculated speed)

Limit slope(‰)	Maximum traction quality(t)	Limit slope(‰)	Maximum traction quality(t)
4	7500	13	2800
5	6350	14	2600
6	5500	15	2450
7	4850	16	2300
8	4350	17	2150
9	3900	18	2050
10	3550	19	1900
11	3250	20	1850
12	3000		

Note: This Table is based on the data in Table 2.4.1 of the Railway Engineering Design Technical Manual - Lines.

### 2. Maximum slope and design (prescribed) traction quality

The “maximum slope” in the Basic Terminology Standard for Railway Engineering GB/T 50262-2013 is interpreted as: the maximum design slope defined on a railway.

Corrective explanation suggestion: The maximum gradient defined by the single-pulleyed cargo train on the upper slope with the specified traction quality. This slope must be less than or equal to the limit slope under the traction mass. It is also the maximum slope of the whole line design, see

Table 2.

Table 2 Actual achievable maximum slope Table under design traction quality (specified)

Design (specified) traction quality(t)	Maximum slope(‰)		Design (specified) traction quality(t)	Maximum slope(‰)	
	Traction calculation	Rounding		Traction calculation	Rounding
7000	4.4	4	4500	7.7	7
6500	4.9	4	4000	8.8	8
6000	5.4	5	3500	10.2	10
5500	6	6	3000	12	12
5000	6.7	6	2500	14.6	14

### 3. Analysis

The two explained the difference between “specified traction quality” and “maximum traction quality achievable”. The specified traction quality is the actual, designed, and specified traction quality, and the maximum traction quality that can be achieved is the true slope of the uphill running at the same speed. The two traction qualities are substantial. Sexual difference.

The traction quality at constant speed during the calculation of the speed is not based on the “regulated” traction quality, but on the “maximum” traction quality.

The slope obtained according to the specified traction quality can only be the maximum slope selected by man. It has a certain difference in traction quality from its true limit slope. This difference is always a negative value or “0” value, that is, the maximum slope. The value is always less than or equal to the limit slope of the traction calculation. See Table 3.

Table 3 Design (specified) Table of the difference between traction quality and maximum traction quality (false value)

Limit slope(‰)		Design (specified) traction quality(t)	Maximum traction quality(t)	False traction quality(t)	Percentage(%)
Rounding	Calculation				
4	4.4	7000	7500	-500	6.7
	4.9	6500	7500	-1000	13.3
5	5.4	6000	6350	-350	5.5
6	6	5500	5500	0	0
	6.7	5000	5500	-500	9.1
7	7.7	4500	4850	-350	7.2
8	8.8	4000	4350	-350	8.1
10	10.2	3500	3550	-50	1.4
12	12	3000	3000	0	0
14	14.6	2500	2600	-100	3.8

Note: imaginary traction quality = maximum traction quality - design (specified) traction quality.

It can be seen from Table 1, Table 2, and Table 3 that “the limit slope is the slope of the freight train running at the same speed on the upper slope at the calculated speed with the specified traction quality”, which is theoretically flawed.

### 4. Conclusion

From the above analysis, it can be known that the limit slope adopted by the railway design is not the limit slope obtained by the traction calculation, but the “maximum slope”. According to the specified traction quality 6000t, 5000t, 4000t, 3000t, etc., the limit slopes obtained by traction calculation are 5.4‰, 6.7‰, 8.8‰, 12‰, etc. The slope after the rounding (maximum slope) is 5‰, 6‰, 8‰, 12‰, etc. see fig. 1.

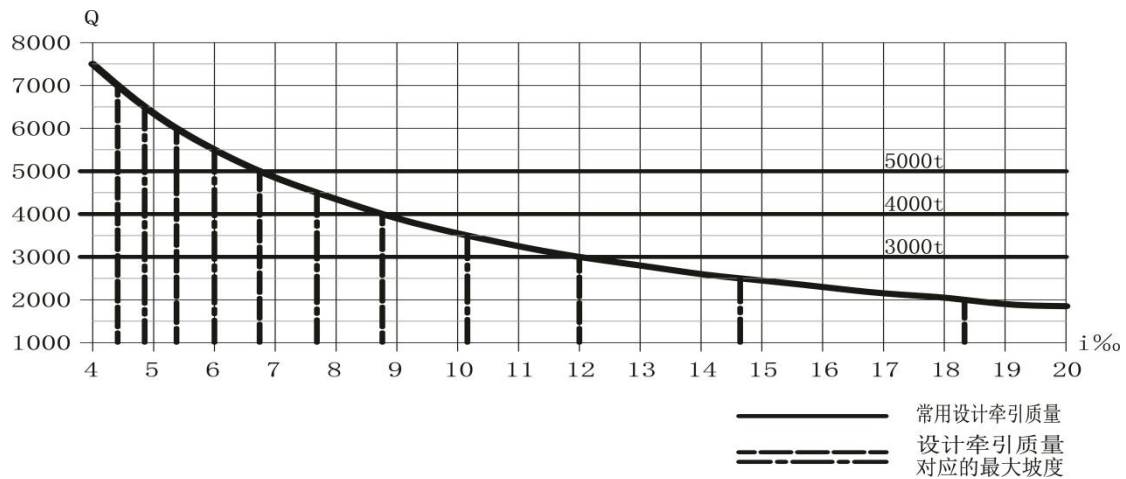


Fig.1 Design (prescribed) traction quality and maximum traction quality of SS4 locomotive under different slopes

Note: This figure is drawn according to the data in Table 2.4.1 of “Railway Engineering Design Technical Manual – Lines”.

From the practice of high-speed railway and inter-city railway, it has been proved that the “limit slope” has been canceled, and the “maximum slope” is completely correct. Therefore, in the continuous use of large-scale traction locomotives, passenger and cargo mixed railways and freight line railways, Under the premise of constantly requesting speed increase, the use of “maximum slope” is also necessary to adapt to the railway development situation.

To sum up, it is advisable to change the “limit slope” to “maximum slope” in the railway design.

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