Potential Soil Erosion Energy Increase of Loess Slop System Caused by Project Construction

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Abstract　The mathematical model of the slope increase was established and the soil erosion caused by the extending in steep slant surface was calculated through analysing the increase of potential loss by project construction and digging stone material. The results show that the surface of steep slant is extended and the erosion is increased with project construction extending.

Keywords　**loess slope system; project construction; slope; surface of steep slant**

Up to now, about the problems of new soil erosion caused by project construction, many experts and scholars have paid attention to the increase of silt content in rivers by throwing waste residue and earth into them, but they have seldom paid attention to the potential soil erosion caused by steeper slope system in project construction and digging stone material. The analysing and calculating show that the potential soil erosion is very serious.

1　Project construction causing the change of erosion basis in slope system

In loess plateau, most rivers and gullies cut into the bedrocks and caused them exposed in different height on both sides. The bedrocks are composed with greyish white and greyish green silicarenite, purplish red sandstone and shale. Because they are very good building material, both sides of the rivers and gullies are the main stone pits. The loess hills are accumulated upon the bedrocks. Because the bedrocks are harder and the resistance erosion is more valid, they become the temporary erosion basis of upper loess slope. Mr. Qi Chuhua had ever said: "The bedrocks under loess hills could protect upper loess slope, slow down its soil erosion speed. and so decrease the soil erosion amount. The study of temporary erosion basis had important significance for soil and water conservation in loess plateau."

As the exploitation of coal resource, the development of the economy and the improvment of the living standards of the people, the requirments for project construction increase day by day. Besides coal mining field project construction, many conveyance system are required, such as highway and railway engineering, industry and enterprise construction projects, civil building construction projects and service building construction projects. Most of the highways and railways were built on the slope along the bank of rivers and gullies. In the course of building highways and railways, on the one hand, waste residue and earth are thrown into the rivers and gullies or piled on slope, which resulted in the new loss of soil and water, on the other hand, some highways and railways cut through the hills or slope, which changed the erosion basis and resulted in potential soil erosion. The houses and buildings construction required a lot of stone material. In the course of the digging stone material, some stone materials were transported away and others were thrown into rivers and gullies as waste residue, which resulted in silt content increase in rivers. Exploding stone material with explosive dicreases the stability of slope which makes the temporary erosion basis of slope drawn back, the degree of slope of upper hills increased and potential soil erosion wors-

ened.

2 Project construction causing the degree of slope system increasing and the potential soil erosion worsening

On the both sides of the rivers and gullies, exploding bedrocks not only cause a lot of waste residue and earth into the rivers and gullies, but also accelerate the soil erosion of slope. The foundation principle of the course is as follows. After slope measured and counted in some sample areas of Xinshui river watershed, the proportion of various shapes of slope is calculated, that straight line shape slope is 10% ~ 15%, convex shape slope is 55%, concave shape slope is 10%, complex shape slope is 20% ~ 25%. The following calculations take convex shape slope as the example (Fig. 1).

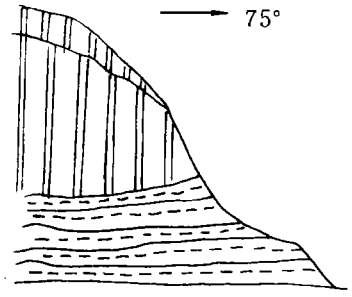

Fig. 1 The stratum structure of excavated steep slop

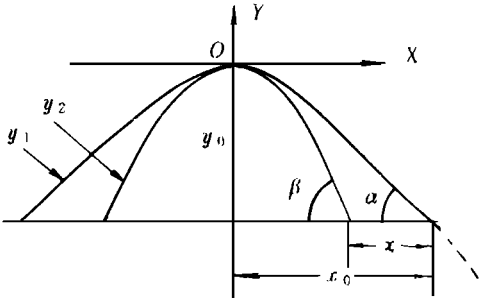

Fig. 2 The cross section of convex shape

Slope cross section of convex shape slope is drawn as a parabolic diagram in the abstract way (see Fig. 2). The parabolic equation of slope no-digged is

$$y_1 = -\frac{y_0}{x_0^2}x_1^2 \tag{1}$$

Suppose the angle of slope no- digged is T. then

$$T = \operatorname{arctg}\frac{y_0}{x_0} \tag{2}$$

The parabollic equation of slope digged is

$$y_2 = -\frac{y_0}{(x_0 - x)^2}x_2^2 \tag{3}$$

Suppose the of slope angle digged is U, then

$$U = \operatorname{arctg}\frac{y_0}{x_0 - x} \tag{4}$$

To differentiate to equation (4), then get the following equation

$$dU = \frac{y_0}{(x_0 - x)^2 + y_0^2}\,dx \tag{5}$$

Therefore

$$U = \int_0^{x_0 - x} \frac{y_0}{(x_0 - x)^2 + y_0^2}dx \tag{6}$$

The conclusion can be got from equation (6) that the degree of U is increase with x. Because the degree of slope is increased, the potential energy of slope increases, the internal friction angle of slope earth decreases, the stabillity of slope decrease and the downward slide power of slope earth increase. Under the conditions of various external power actions, it is inevitable that the erosion of slope worsens rapidly as the degree of slope increases.

On the relationships between the soil erosion and the degree of slope, many scholars

have studied them according to experimental data of soil and water conservation in loess plateau, and some experintial formulas on the relationships between the erosion intensity and the degree of slope have been obtaind. Although the indexes of slope of various experiential formulas are very different, the general trend of soil erosion becomes worse with the increase of the slope degree.

Tab. 1　Soil erosion modulus on different slopes under various I_{30} precipitation intensities　　t/km²

I_{30} (mm/min)	5°	10°	15°	20°	25°	28°
< 0.25	11.7	28.8	51.1	62.3	82.6	68.6
0.25— 0.50	143.6	302.6	497.9	649.2	817.9	844.2
0.50— 0.75	344.4	658.6	1720.7	1767.3	2137.5	2417.9
> 0.75	1265.8	4186.8	6985.6	9763.6	13318.1	13480

(According to experiental data of Jiang Zhongshan in soil erosion experiment station of Ansai.)

The conclusion may be drawn out from table 1, that the relationship between erosion intensity and slope is expontial relation under various precipitation intensities and erosion intensities increases as the largest 30min precipitation intensity I_{30} increase. When $I_{30}>0.75$, the erosion modulus of the slope of 25° is twice more than that of 15°. The above conclusion shows that erosion modulus double increase with the degree of slope increase.

3　Project construction making the surface of steep slant wider and higher and potential gravitation erosion more serious

In the past study, many experts and scholars calculated waste residue and earth according to statistics data, but they seldom studied the amount of slope soil erosion that part S_1 digged caused part S_2 dwonward slid(Fig 3). The calculation mathematics model is as follow.

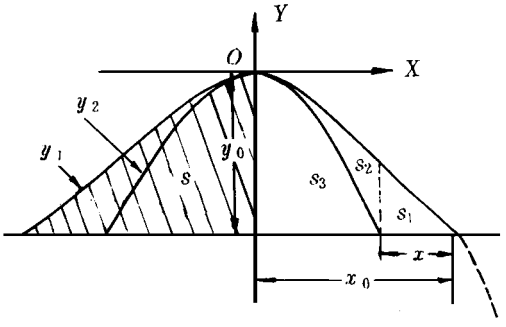

Fig. 3　Diagram of collapse at excavated steep slope

$$S_1=\int_{x_0-x}^{x_0}\left(y_0-\frac{y_0}{X_0^2}x_1^2\right)dx_1=\frac{y_0}{x_0}x-\frac{y_0}{3x_0^2}x^3 \tag{7}$$

$$S_3=\int_{0}^{x_0-x}\left(y_0-\frac{y_0}{X^0-x}x_2^2\right)dx_2=\frac{2}{3}y_0(x_0-x) \tag{8}$$

$$S=\int_{0}^{x_0}\left(y_0-\frac{y_0}{X_0^2}x_1^2\right)dx_1=\frac{2}{3}x_0y_0 \tag{9}$$

$$S_2=S-S_1-S_3=\frac{2}{3}y_0x-\frac{y_0}{x_0}x^2+\frac{y_0}{3x_0^2}x^3 \tag{10}$$

The conclusion may be drawed out from equation (10) that part S_2 increase as x increase and

$$S_1-S_2=-\frac{2y_0x}{3x_0}\left[(x_0-x)^2+x_0x\right]<0 \tag{11}$$

So　　$S_2>S_1$

The conclusion above shows that soil erosion caused by wider and higher steep slant is

much more than the silt content of rivers and gullies caused by waste residue and earth thrown into them.

4 The plan of project construction and stone pits

Project construction and excavating stone material not only made potential erosion energy of slope greater and made the silt content of rivers and gullies much more, but aslo caused land resources worse and land area reduced. The most part of stone pits lied on the both sides of rivers and gullies near towns, cities and regions of industry and mine. The land occupied up by waste residue and earth is main fertile cultivation land. Apart from main parts of highway and railway, the greater part of roads did not take conservation measures.

Mr. Zhang Shengli has measured and counted the waste residue piled up in Tanyaoqu small watershed of 0.9km^2. The result showed that there were 21 020m^3 of waste residue piled up in three years. If waste residue and potential soil erosion of slope were put together to calculate, the amount of new man-made erosion would be much more.

To build highways and railways is the base of developing economy. Project construction, cities and towns developing and coal mining are the foundation of developing mountain areas economy and the sign of rising the living standards of people, so it is impossible that not to build highways and railways, not to develop cities and towns, not to exploit resources. For this reasons, the requirement of stone material and bricks increase day by day. Some effective management measures must be put into effect, which can both make stone material exploitation increase, and do not cause the degree of slope steeper and waste residue do not bury cultivation land. According to the basic theory and the experiences of soil and water conservation for many years, some details managment measures are suggested for some relevant departments to reference. (1) Stone pits must be distributed over barren hills and gullies where rocks exposed; (2) In some covered rock regions, if stone material must be excavated, in gullies some dams and weires should be set up, waste residue should be thrown into the bottom of dams and waste earth should be covered over waste residue. By this way, the new cultivation can come into being and total area of cultivation may not be decreased. (3) Making the best use of waste residue repeatedly. (4) In both sides of highways and railways, some protective building projects should be put up, which may prevent the new loss of soil and water, and prevent roads and railways destruction and traffic accidents.

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