Forecast and Assessment of Water and Soil Loss for Hu-Bao Highway Construction

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Abstract: The original earth and vegetation were destroyed in the duration of Hu-Bao highway construction due to excavation, which have caused serious water and soil loss .It brought in the disadvantaged effects on the eco-environment of the areas along the roadsides, increased sand move, deposit to lower reaches and flood damages. This problem makes it difficult to manage and maintenance the highway. The paper analyzed the characteristics, distribution and the causes of water and soil loss in the areas in order to provide references for soil and water conservation on highway construction.
Keywords: highway construction, water and soil loss, characteristic, distribution, cause

1 Summary of the highway construction

The highway from Huhhot to Baotou (HU-Bao expressway for short following) is a part of the national main line from Dandong to Lasa, which is among the highway called *Five Vertical and Seven Horizontal* national main lines according to the nation's plan. It lies in the middle of Inner Mongolia .It is not only an important main highway-connecting north and northwest of China, but also is the main economic highway and the important foreign corridor of Inner Mongolia.

Hu-Bao highway is 151 km long from Luojiaying of northern suburb of Huhhot to Dongxing of Baotou .The highway is designed as a four-motor-route highway with 456 bridges and culverts, 28m wide roadbeds and 15m wide motor route. It extend from west to east with complete close and overpass .The route (one-way) from Huhhot to Baotou being built originally in 1994 has been open to traffic in 1997, which total investment is 1.006 billion Yuan .The other route construction started in July 2000 with 1.520 billion Yuan of total budgetary investment (including interests of the loan).

2 Natural environment in the highway construction areas

Hu-Bao highway lies in the bajada of south foot of the Daqing Mountains with an elevation of about 1,000m.It slopes southward. The construction areas belong to temperate continental climate zone.In the areas the average temperature is 6.2℃ to 6.7℃, rainfall 309mm/a to 418 mm/a, evaporation 1,760mm/s to 2,500 mm/s. Solar energy is rich; annual sunshine time is 2,800 hours to 3,200 hours.

The highway runs across 31 rivers and brooks, which are the first level affluent of the Yellow River. The dry period and the rain period take on an obvious seasonal .In summer, mountain torrents are easy to take place in the rainy season. In winter and spring, riverbed dries up .The type of soil is gray cinnamonic soil. Soil quality is mainly sandy soil with bigger grains and loose structure. Zonal vegetation is temperate steppe mainly including arid grass, half-shrub and shrub.

3 Forecast and assessment of water and soil loss

3.1 Damage to original topographical features and vegetation

Hu-Bao highway includes permanently occupied land and temporarily requisitioned land of the main body of the highway construction project .The former, used for the main body projects such as roadbed, bridges culverts, overpasses, is 1,322.6 hm^2 among which farmland is 828.49 hm^2, forest land 30.81hm^2,orchard land 23.77 hm^2, grassland 389.29 hm^2,others 50.24 hm^2. The latter, used for borrow ground, mixing ground, sand-gravel stock ground and construction service road, is 631.18 hm^2, among which farmland is 144.53 hm^2, grassland is 485.65 hm^2,forest is 1hm^2.

3.2 Waste soil and waste slag

The mount of cubic meter of earth and stone used for roadbed of the finished routes in 1997 is 10,070,000m^3, among which the amounts of druging is 350,000m^3 ,the amounts of filling is 9,720,000m^3. The three figures for the new roadbed project are respectively 7,180,000m^3, 20,000m^3 and 7,160,000m^3. There will be almost no environment effect caused by waste soil and waste slag, because the filling is bigger than the cubage of excavation not permitting waste soil and slag produced.

3.3 Characteristics and distribution of water and soil loss

Water erosion, wind erosion and gravity erosion can be found in the construction areas and they take place mainly on the roadbed side slope, borrow grounds and mixing grounds.

3.3.1 The Roadbed side slope erosion areas

In these areas, because the slope of the roadbed side is bigger and its surface is covered with sub-sandy soil and gravelly soil of loose structure and bad consolidation, wind erosion and water erosion both take place with seasonal alternation .In winter and spring, wind erosion dominates while in summer and autumn water erosion does. Gravity erosion exists at the roadbed side slope where there are higher embankment and deeper highway moat.

3.3.2 Borrowing ground erosion areas

There were 74 borrow grounds occupying land 253.04hm^2 and borrow 8,927 000m^3 of filling for the finished roadbed in 1997.The new routes roadbed is to borrow 11,407,000m^3 with 63 borrow grounds and occupied land 191.93hm^2. Most of the borrow grounds are pits with steep side. Vegetation was destroyed and the topsoil was loosened. So water erosion, wind erosion and gravity erosion (landslip and landslide) is easy to take place if considering load removal and soil body balance destruction.

3.3.3 Erosion areas of mixing ground and stock ground

The construction for building mixing grounds, stock grounds, prefabrication ground, rock- crushing grounds destroyed the original farmland and grassland. The disturbance of the land also caused wind erosion in the areas.

3.4 Formation cause of water and soil loss

The construction of Hu-Bao highway formed a long distance slope (roadbed) and landform of pit (borrowing grounds) and destroyed the vegetation on the earth's surface .The damage to soil and water resources is typical of man-made erosion acceleration.

3.4.1 Erosion agent

High-intensity rainfall is the direct force leading to water erosion .The rainy season of the highway areas is July to September when storms are the main body forming surface runoff and producing water erosion.

Strong wind provides external agents for wind erosion and its days are 35.8d—46.9d on annual average; the biggest wind velocity reaches 28 m/s; sandstorm days are 8.4d—21.6d on average. Because strong wind is in April-May when the earth's surface is driest and vegetation cover is worst, it is easy to produce wind erosion.

3.4.2 Topographical features and topographic forms

The highway construction created artificial landforms such as embankment, highway moat and borrow grounds, with the characters of bigger slope, loose structure of soil body and bare surface. So the erosion-resisting ability of soil is reduced greatly.

3.4.3 Soil

Soil types for the highway construction are mainly sub-sandy soil, gravelly soil. They have the

characters of loose structure, strong erosion resistance and low shear strength leading to water erosion and wind erosion. Furthermore, violent disturbance of the highway construction to soil body weakens soil erosion-resisting capability, aggravating the degree and intensity of wind erosion and water erosion.

3.4.4 Vegetation

In the highway construction areas, original vegetation types were corps, grass and tree land which hold and mitigate wind erosion and water erosion. However, the construction destroyed the vegetation on roadbed, borrow ground and sand-gravel stock ground. Thus soil lost its function of conserving water and soil, and soil erosion was speeded.

All in all, water and soil Loss in the highway construction areas is the consequence of the consolidation of natural and artificial factors. Storm and strong wind are the promoting force to water and soil loss. At the same time, the disturbed soil body and the destroyed vegetation further reduce the soil erosion-resisting capability, aggravating water and soil erosion.

3.5 Forecast of water and soil loss amounts

Based on the nature characters, construction technology and its characters of Hu-Bao highway areas, water and soil loss amounts were forecasted by the methods of combining experimental forecast, model and actual measurement.

By calculation, the total amount of water and soil erosion of the finished project in 1997 is 66,671 t, among which the amount of water erosion is 17,846 t, the amount of wind erosion 12,140 t and the amount of gravity erosion 36,685 t. The four amounts of the new project are respectively 48,273 t, 11,201 t, 9,232 t and 27,840 t (see the following Table in detail).

Table Of the amount of water and soil loss

Erosion places	Erosive modulus ($t/(km^2 \cdot a)$)			Erosion Areas (km^2)		
	Water E	Wind E	G E	Finished Route	New Route	Sub-tatol
Embankment	5,500	1,740		1.75	0.92	2.67
Erosion moat	6,300			0.06	0.03	0.06
Borrowing Grounds	3,100	2,400	14,500	2.53	1.92	4.45
Mixing Grounds		3,250		0.93	0.93	1.86
Total				5.27	3.8	9.07

Amount of Erosion(t)								
Finished Route				New Route				Total
Water E	Wind E	G E	Sub-total	Water E	Wind E	G E	sub-total	
9,625	3,045		12,670	5,060	1,601		6,661	19,331
378			378	189			189	567
7,843	6,072	366,885	50,600	5,952	4,608	27,840	38,400	89,000
	3,023		3,023		3,023		3,023	6,046
17,846	12,140	366,685	66,671	11,201	9,232	27,840	48,273	114,944

Note:G stands for Gravity. E stands for Erosion.

3.6 Damages of water and soil loss

(1) Strong disturbance to the earth's surface of the highway construction area leads to serious damages to vegetation and soil, and increases the erosion amount.

(2) Borrowing excessively in river channels accelerate the downwash to river bank, disadvantage flood discharge and flood passing the river channels, increase sand content in river and bring serious incipient fault for river flood prevention .To some degree, it endanger the highway safe running.

(3) Because the side slope of the mountain front borrow ground is vertical, it is easy to produce mountain slope out-of-balance, evoking landslide and landslip that cover up farmland and grassland affecting the local production and life.

(4) Water erosion of the roadbed side slope will make highway maintenance under pressure.

(5) Wind erosion cause roadbed side slope erosive, making sand rising with the strong wind and low visibility, which affect safe driving and highway running efficiency.

3.7 Results of water and soil loss forecast

By analyzing, calculating, forecasting and assessing the affecting degree of the construction areas, erosion intensity and erosion amount of Hu-Bao Highway, we generalized that the amount of water and soil loss in the construction areas is 114,900 t on annual average, among which the amount of the roadbed side slope is 19,900 t, the amount of the borrowing grounds 89,000 t and the amount of the mixing grounds 6,000 t. During the highway construction period, there is a trend of sharp rise for water and soil loss, and serious places are borrowing grounds and roadbed side slope .So we must take corresponding soil and water conserving measures to regulate the erosion.

Referances

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