Response to guozigou highway avalanche disasters Prevention and control of case study research

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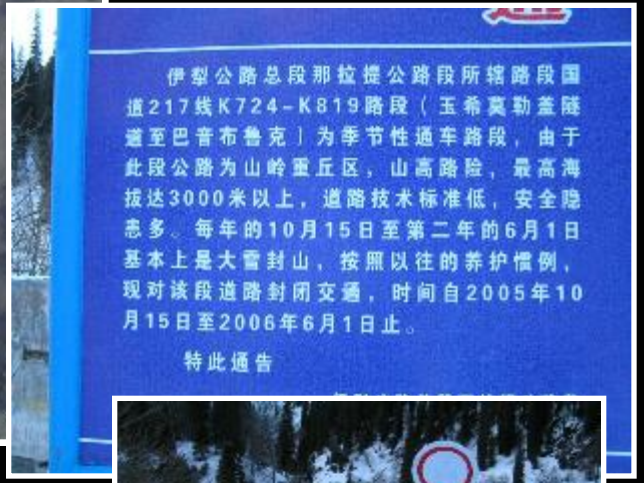
目　　录

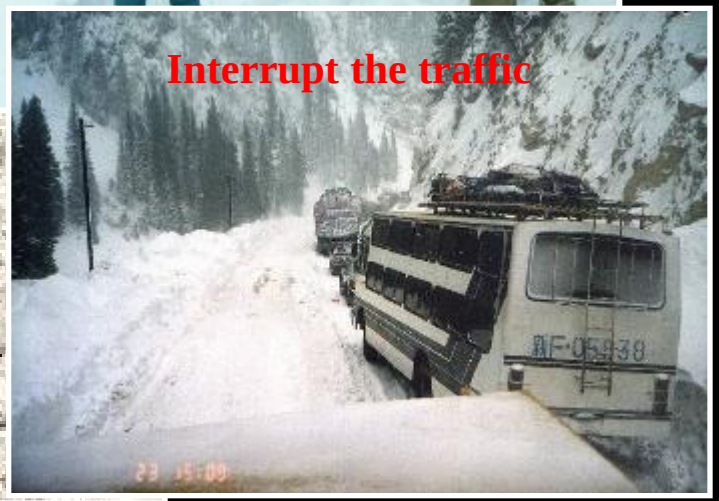
1. Project background—Avalanche hazard

Avalanches are deadly ice natural disasters. It is called "white death". Avalanche happened very suddenly, movement speed, a large quantity of collapse. It can destroy forest, destroyed or lost houses, roads, traffic, safety of life at, infrastructure and vehicles, etc. To the human production activities and a large impact on the natural environment.

1. Project introduction—Avalanche hazard



1. Project introduction—Avalanche hazard



According to our survey statistics, since the 70 s, national highway 312 line guozigou sections for highway avalanche disaster death toll at 63, cut off traffic 172 hours per year on average, each block 11000 vehicles, is the winter of 1994, K4769 + 560, a huge avalanche, the avalanche 100000 m3, a minibus in gansu province were buried, 17 people inside the car only three people live, the other 14 people died of cold or suffocate.

1. Project introduction—Avalanche hazard

10 PM on March 13, 2008, xinjiang in the northwest guozigou avalanche happened about 13 kilometers distance from state road 312 line, undertake in fruit valley inside a tunnel in the second line of west-east gas project construction of 22 workers were buried, so far, a total of 6 people were rescued and 16 people were killed.

2. Causes and mechanism of an avalanche

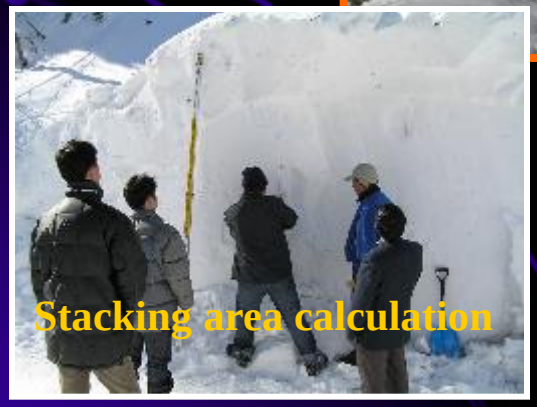
Field survey research, collect the basic data of highway avalanche.

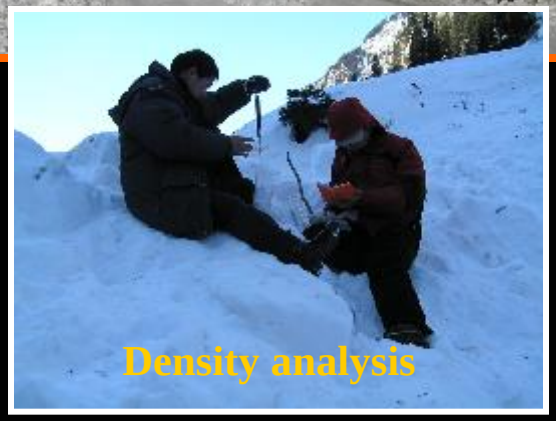

Fracture research


Strength analysis


Trace survey


Damage investigation


Stacking area calculation


Density analysis


Path divided

2. Causes and mechanism of an avalanche

Highway cause an avalanche

Through a lot of investigation, field test and data analysis, highway avalanche causes mainly summarized as the internal factors and external factors.

Internal factors

Highway avalanche happened must have three basic conditions: snow thickness, slope gradient and slope vegetation conditions, these conditions determine the avalanche happened inevitability.


The thickness of the

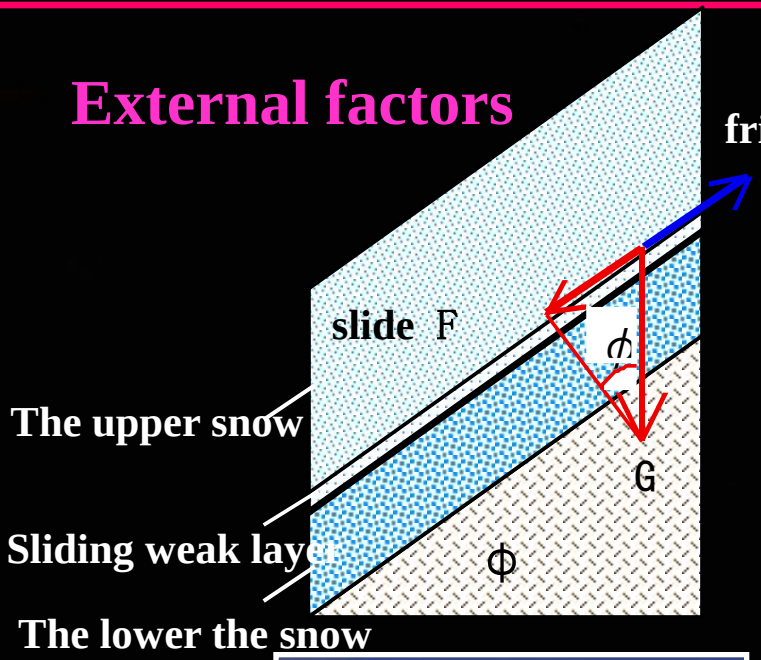

slope


Slope condition

And avalanche paths within the remit of snow area, internal stress and strength against snow, layers structure conditions and other factors.

2. Causes and mechanism of an avalanche

External factors



Is the causative factor of cause an avalanche activity outside conditions. Inductive avalanche of highway development in the process of the main inducing factors are:

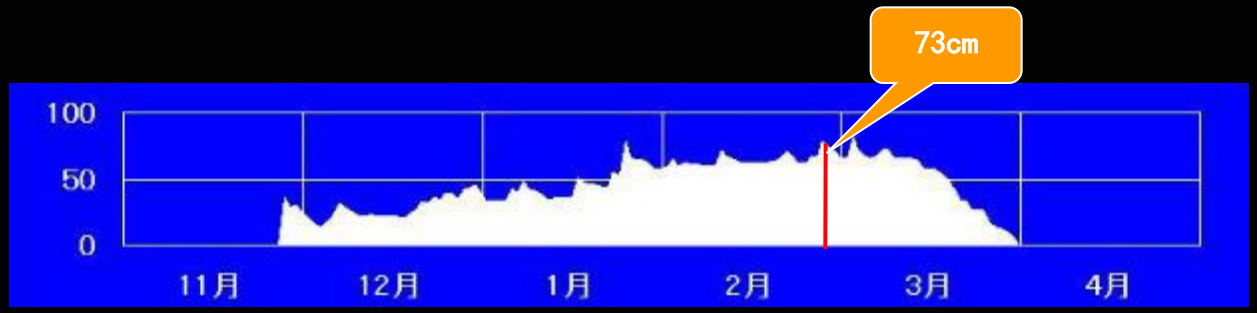
①The role of the spring melting. From the function type can be divided into osmotic stress, physical chemistry, etc., and is often said that the spring snow inducing factors, is actually through the snow, such as temperature, density, crystal changes in the way.

②The outside dynamic action. Mainly include earthquake, human engineering activities, etc. Human engineering activities on the snow slope destruction is through the trees down, skiing, blasting operation, changes made to the original condition of the stability of the slopes of snow or redistribute changes in surface snow, trigger avalanches occur.

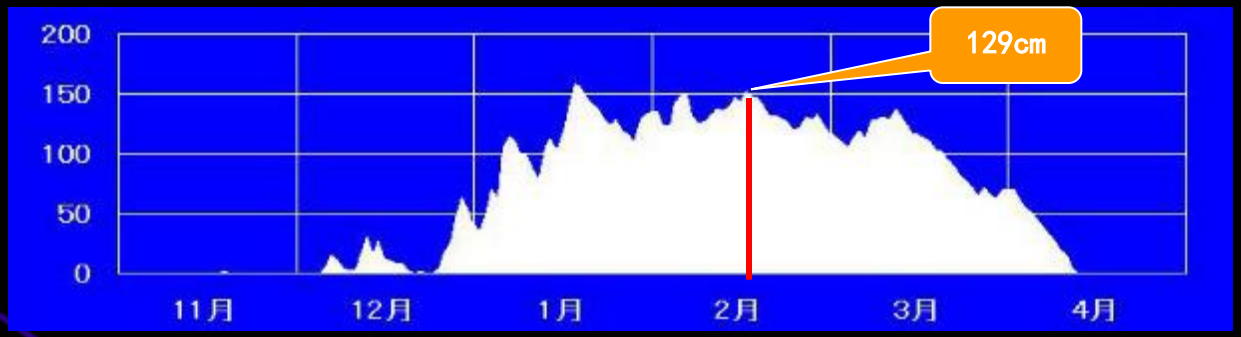
2. Causes and mechanism of an avalanche

Ⅱ Snow thickness threshold slope stability

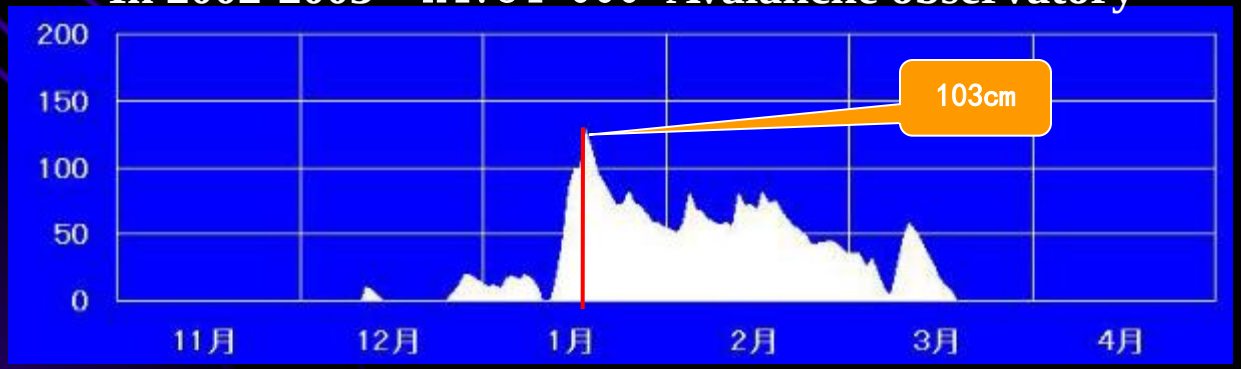
Snow thickness of observation



In 2002-2003 K4739+500 Snow cross section observation



In 2002-2003 K4754+000 Avalanche observatory



In 2002-2003 K4771+000 Snow cross section observation

2. Causes and mechanism of an avalanche

II Snow thickness threshold slope stability

From G312 line Guozigou avalanche observatory in 1996 ~ 2015 data: fruit valley avalanche sections of a snow thickness more than 30 cm is the avalanche risk threshold, snow accumulated more than 80 cm depth on average, the groove avalanche fruit valley.

Slopes of snow on the critical thickness we cant through stable snow cover the force balance equation of calcul

$$h_k \sin\alpha \cdot \gamma = C + F \cdot \cos\alpha \cdot \gamma$$

In the formula： C：**Snow cover and the frictional resistance between the hills;**

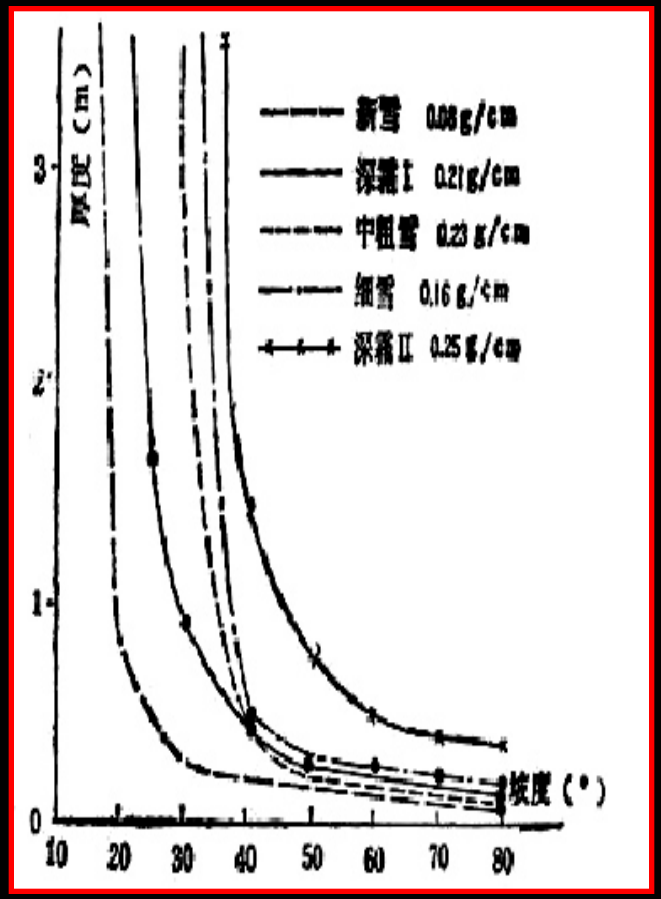
γ：**The density of snow cover** (g/cm3)；

F：**The internal friction coefficient of snow;**

α：**Slope gradient Angle** (°)。

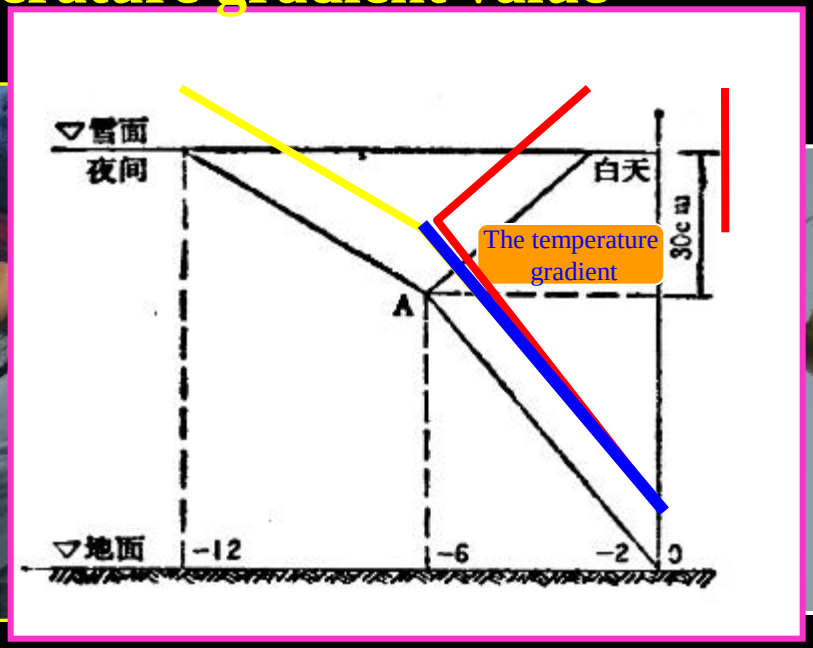
From the site investigation and happened in the past 520 avalanche slope data through data regression, after finishing, get highway avalanche stable snow cover the calculating formula of the critical thickness (hk) :

$$h_k = \frac{C}{r\sin\alpha - F \cdot \cos\alpha}$$



2. Causes and mechanism of an avalanche

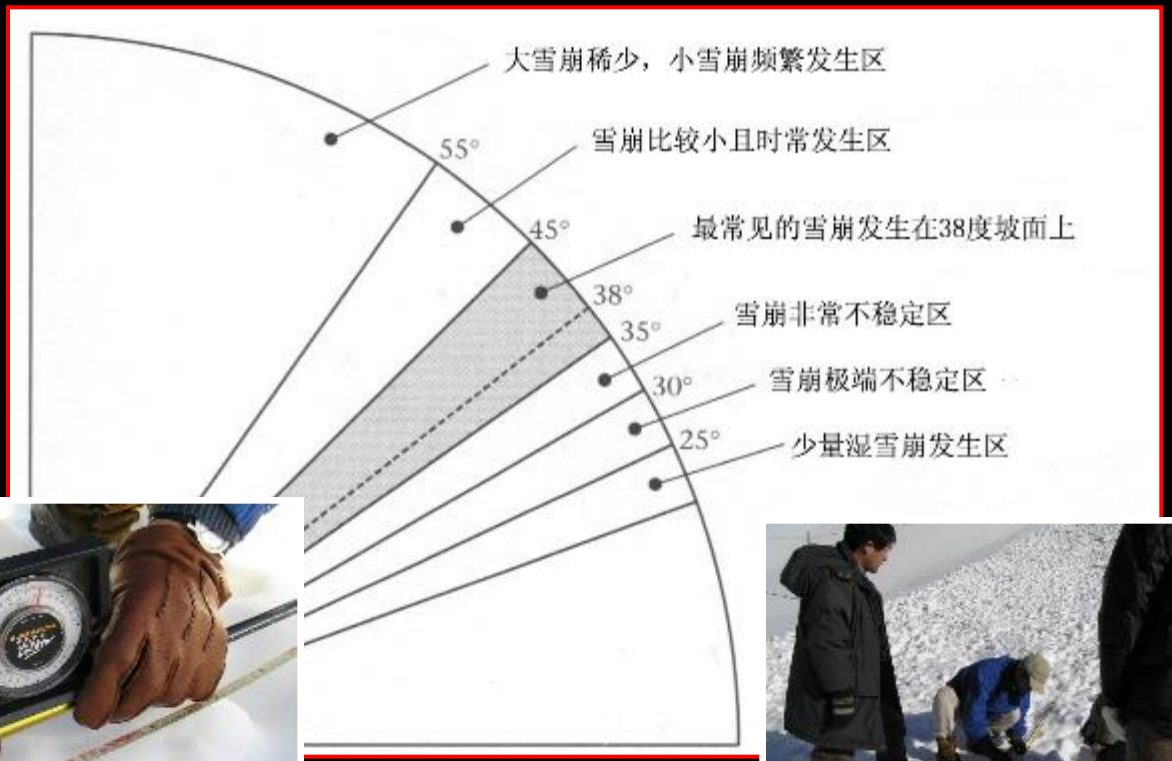
Falling snow temperature gradient value



From the field detection of 60 section analysis, in the snow cover internal temperature is lower than or equal to 0 ℃, the temperature with the height from the linear change, until about 30 cm from the surface of the snow, because of the upper air and the influence of solar radiation and the diurnal variation is different. Slash OA said snow layer temperature gradient. We concluded that temperature gradient is the main factor that an avalanche of snow crystals changes cause fracture, the gradient value is larger, the more prone to avalanches.

2. Causes and mechanism of an avalanche

Ⅳ Prone to avalanche slope gradient value



According to our field survey measurements and collection of 520 avalanche data analysis, it is concluded that highway avalanche prone to slope gradient range of 35 ° to 45 ° .

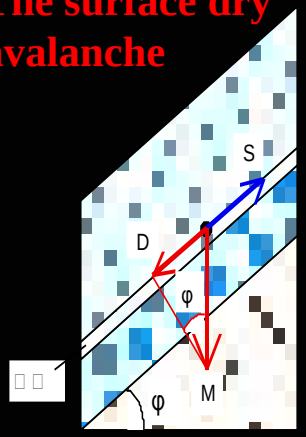
2. Causes and mechanism of an avalanche

Ⅴ Highway avalanche of classification and recognition method

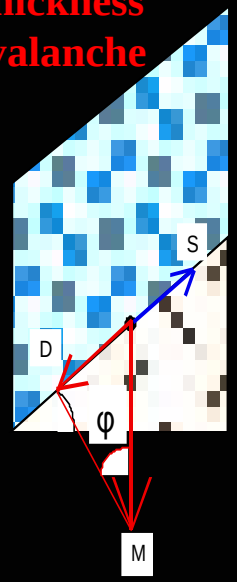
① Through the past experience and field investigation, put forward the highway should set basin, snow avalanche groove, an avalanche avalanche stacking cones, plant characteristics of avalanche area, access to the masses and so on five aspects to identify.

② Mainly based on the mechanism of avalanches occur, the nature of the sliding surface is divided into: January to December - surface dry avalanche, 2 to 3 months for full-thickness wet avalanche.

The surface dry avalanche



Full-thickness wet avalanche



③ Summarized on the basis of avalanche path morphology, density, humidity, the division of physical state highway avalanche types and properties.

2. Causes and mechanism of an avalanche

Ⅵ The avalanche danger degree of judgement and the comprehensive evaluation system

According to our experience and technical conditions, based on 61 snow observation data and satellite images to judge on the basis of the supplementary data and field measurement generalizations highway avalanche risk evaluation method system.

At all levels of the various factors evaluation score

因素	级　　别	评价得分
斜坡	1. 未满30	4
	2. 30～40	7
	3。40以上	10
植被	1. 裸露地，草地树高未满2m的灌木，树冠疏密度未满20%	10
	2. 低矮的树：疏密度未满20～100% 中高大的树：疏密度未满20～50%	9
	3. 中高大的树：疏密度50%以上 高大的树：疏密度20～50%	7
	4. 高大的树：疏密度50%以上	4
积雪深度	1. 未满50cm	0
	2. 50～100cm	6
	100～200cm	7
	200cm以上	9

Risk classification benchmarks

危险度	得　分	评　　价	备　　注
A	27以上	很容易发生雪崩	处于具有一定的积雪厚度的斜面，就很容易的发生雪崩（发生率30～50%以上）
B	23～26	引发雪崩的起因一般	处于具有一定的积雪厚度的斜面，就很容易的发生雪崩（发生率10～30%以上）
C	20～22	引发雪崩的可能性小	处于具有一定的积雪厚度的斜面引发雪崩的可能性小（发生率未满10%）

4. The main research results--Avalanche mechanical properties and the motion law of research

Ⅰ Avalanche impact test results

Impact is also called an avalanche avalanche and avalanche stress momentum, is one of the important parameters of avalanche dynamics, at the same time and the avalanche region of the highway project construction, prevention engineering is directly related to the design of an avalanche, the problem of avalanche impact becomes the core issue of avalanche dynamics research and observation.

3. Avalanche mechanics and motion

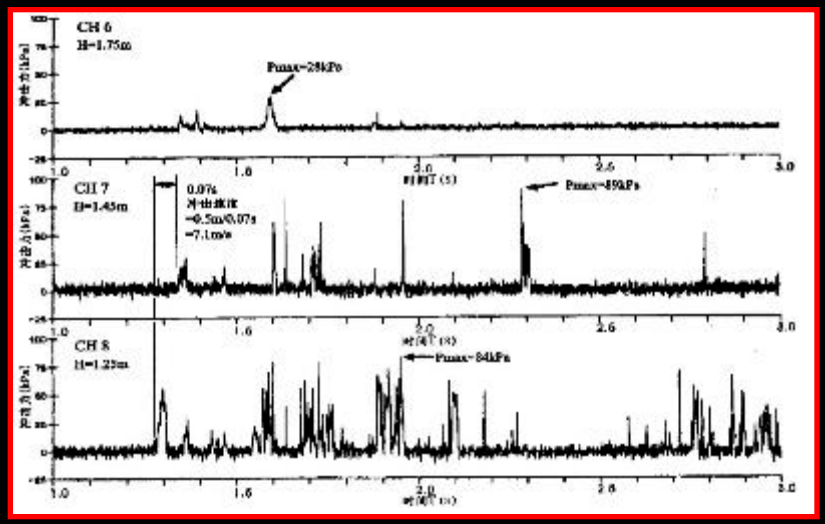
Impact test arrangement

When the beta in 20 ~ 25 ° , the calculated value of P is bigger than the measured values.

When the beta is less than 25 ° , the calculated value of P is smaller than the measured values.

Avalanche impact changes over the avalanche body height, the size of the largest impact appears near the 1.45 m height.

Avalanche impact time data records



Through the experiment, on the basis of empirical data analysis for simplified formula for computing the highway avalanche impact P:

$$P = 2.5 \rho V \sin\beta \cdot g \cdot 10^{-3}$$

In the formula: ρ : An avalanche of snow density;

V: Avalanche speed;

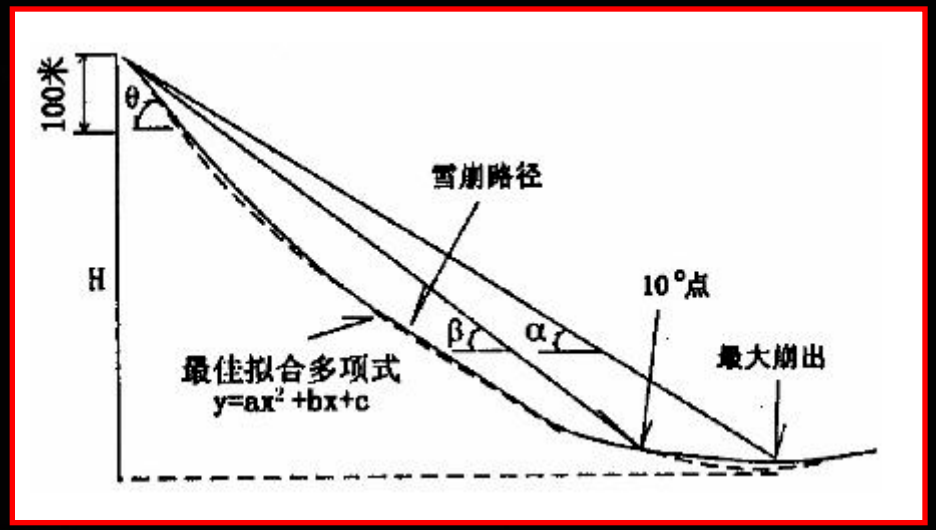
β : The Angle between the avalanche direction and obstacles;

g: Acceleration of gravity。

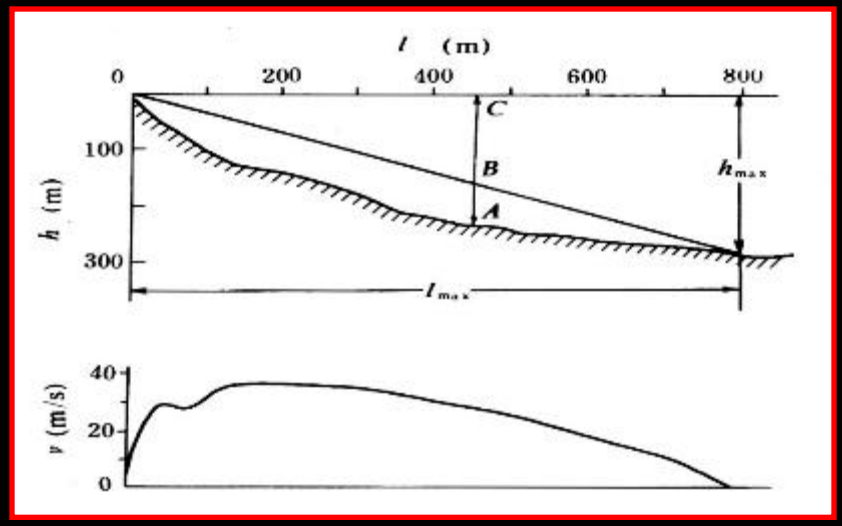
3. Avalanche mechanics and motion

II Largest avalanche movement history

Used to calculate an avalanche of terrain parameters



Graphical method modified avalanche maximum range



Use of statistical methods, based on the multiple regression terrain parameters, through the xinjiang tianshan highway 206 avalanche related parameters of the path analysis, draw the following regression equation:

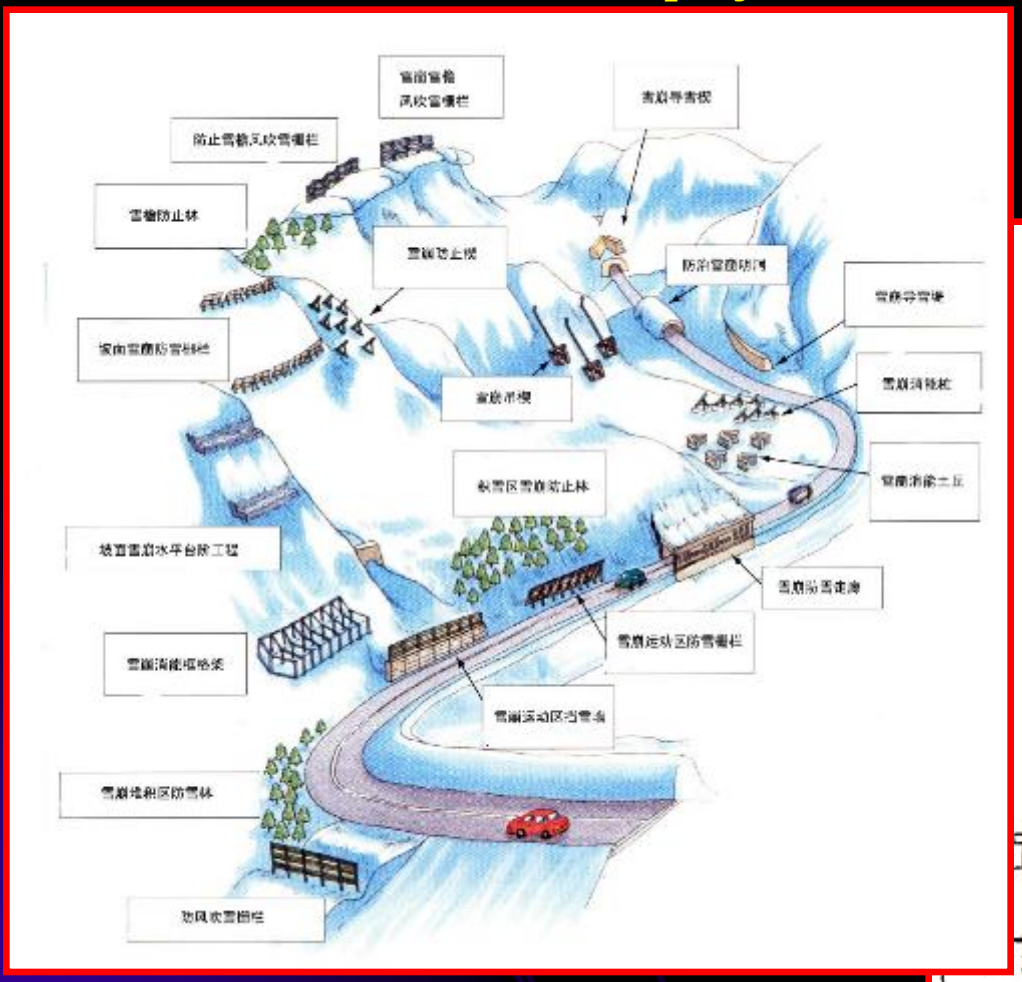
$$L = 0.928 - 7.9 \times 10^{-4} H + 1.4 \times 10^{-2} H y'' \theta + 0.04$$

Based on avalanche process simulation test the analysis of the field data, and the largest avalanche cast process calculation formula of the calculation results are identical with each other.

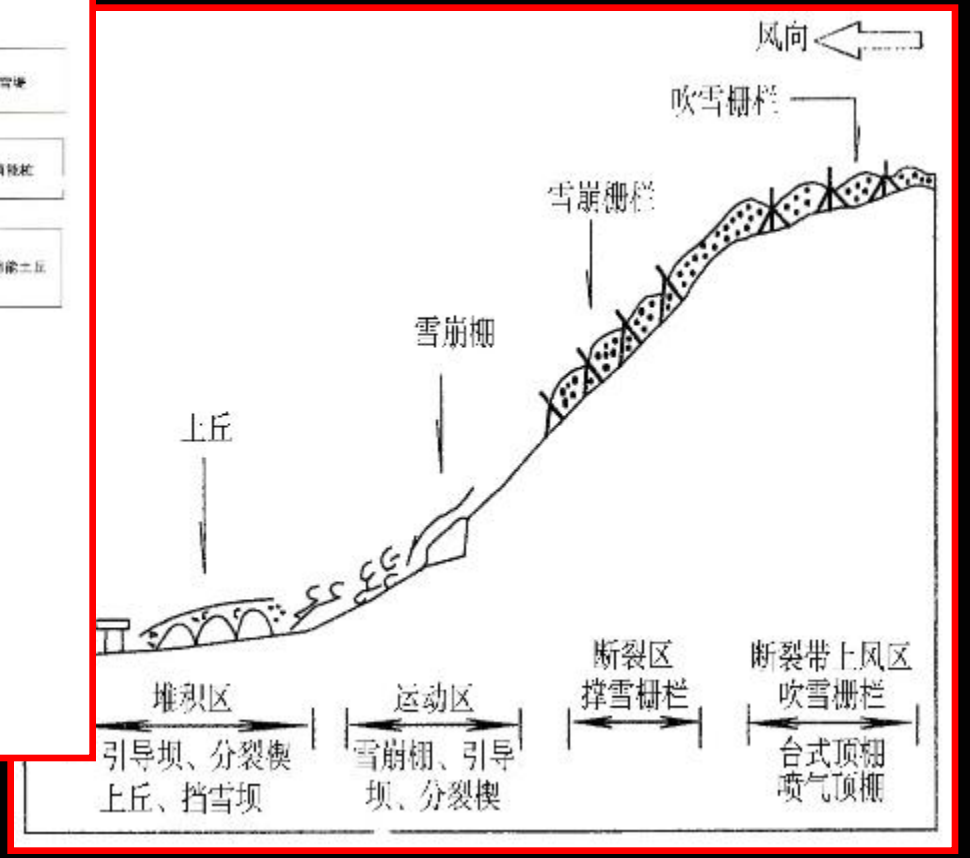
Largest avalanche behind cheng calculation results can also use the graphical method for correction.

4. An avalanche of prevention and control measures and principles

Highway comprehensive type diagram the avalanche control project



Highway avalanche control measures configuration principle



5. The engineering application cases

Ⅰ Relying on the selection of engineering and construction

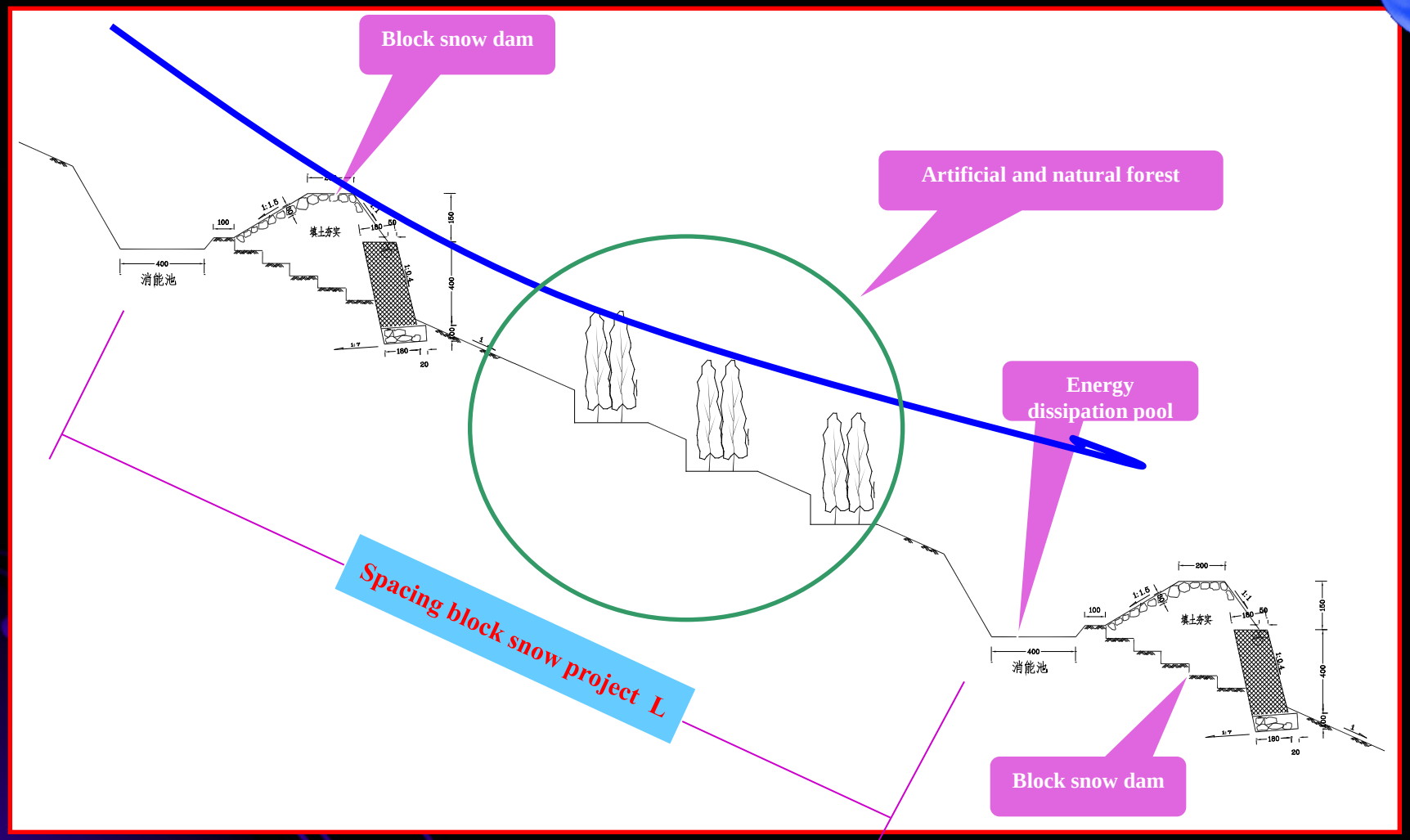
Guozigou avalanche size 107 national highway 312, test engineering in K4750 + 700 ~ + 200 and K4769 K4752 + 200 avalanches governance, around the four avalanches occur every year, for highway damage degree is the largest, we adopt snowbreak, snow fences, retaining dam, energy dissipation pool combined comprehensive control measures, etc.

位 置	雪崩类型	最大雪崩量(m^3)	高差/路径长度(m)	治 理 方 案	防治效果
K4769+560	沟槽雪崩	110000	1280/2390	分段在发生区、运动区设置防雪林、消能池、挡雪坝	最好
K4750+700	沟坡雪崩	61000	630/1360	发生区：钢板网稳雪栅栏 运动区：钢管挡雪栅栏	好
K4751+900	沟槽雪崩	75000	710/1650	发生区：钢管稳雪栅栏 运动区：消能池、挡雪坝	较好
K4752+200	坡面雪崩	56000	520/1230	发生区：钢管稳雪栅栏 运动区：钢板稳雪栅栏	好

5. The engineering application cases

K4769 + 560 belong to Yin slope avalanches, an avalanche avalanche source most of the funnel shaped, set the snow covers an area of about 2.3 Km2, groove is 2400 m long, winding valley and branch lander, scarp, average slope around 36 ° , trough cross section into "U" shape. Valley walls of an avalanche of snow sports and mark clearly and profile control corrosion mark clear, avalanche movement route is long, has obvious area, movement area and accumulation area, avalanche size is bigger.

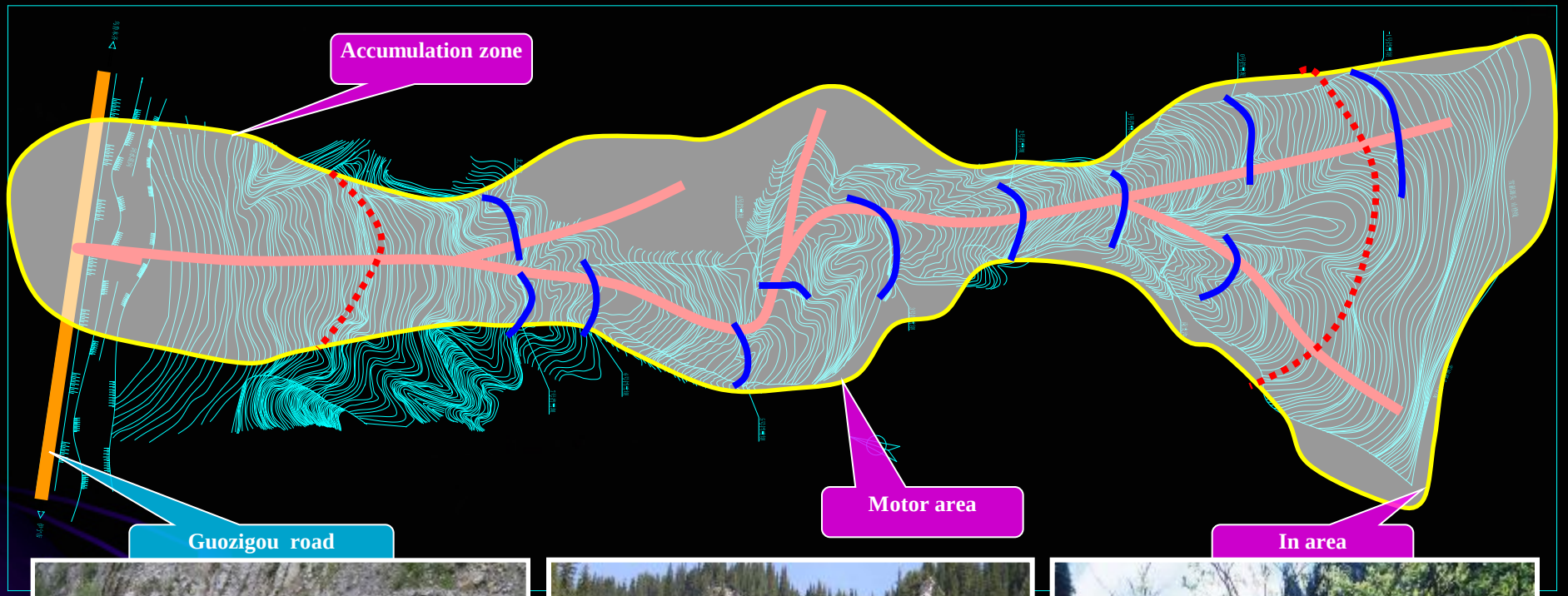
5. The engineering application cases



Highway avalanche control measures at home and abroad on the basis of investigation and cause analysis, first proposed and implemented a harm for change, dry shelter forest, energy dissipation pool, build by laying bricks or stones engineering with the combination of ecological environmental protection system for the prevention and control.

5. The engineering application cases

K4769+560 Avalanche paths engineering layout



5. The engineering application cases

Avalanches occur area of 500 ~ 1000 m away from the road, the terrain slope for the on wide below narrow sector average slope grade 36 ° ~ 39 ° , snow area is large. Slope soil fertile, thin under thick soil layer, side slope vegetation grew well, the average height of 30-100 cm, but only a few trees, area, movement area dividing line is not obvious, avalanche happened every year.

5. The engineering application cases

K4750+700 Ditch slope avalanches path engineering layout

5. The engineering application cases

Ⅱ Prevention and control engineering design basis

According to the investigation data and test engineering survey, regression avalanche movement region block snow dam project number and spacing of the formula：

$$L=2k\sqrt{R^2-(R-h)^2}$$

The type is a empirical formula, the formula of the sensitivity is strong, its value in the slope gradient, snow density, Angle of internal friction, cohesive force, the thickness of snow, snow slope coefficient of crude.

Using the avalanches governance experience data regression avalanches occur region stability snow fence engineering spacing calculation formula:

$$L=\frac{2tg\beta}{tg\beta-tg\varphi}H$$

L-Snow engineering spacing（）； -Slope Angle；

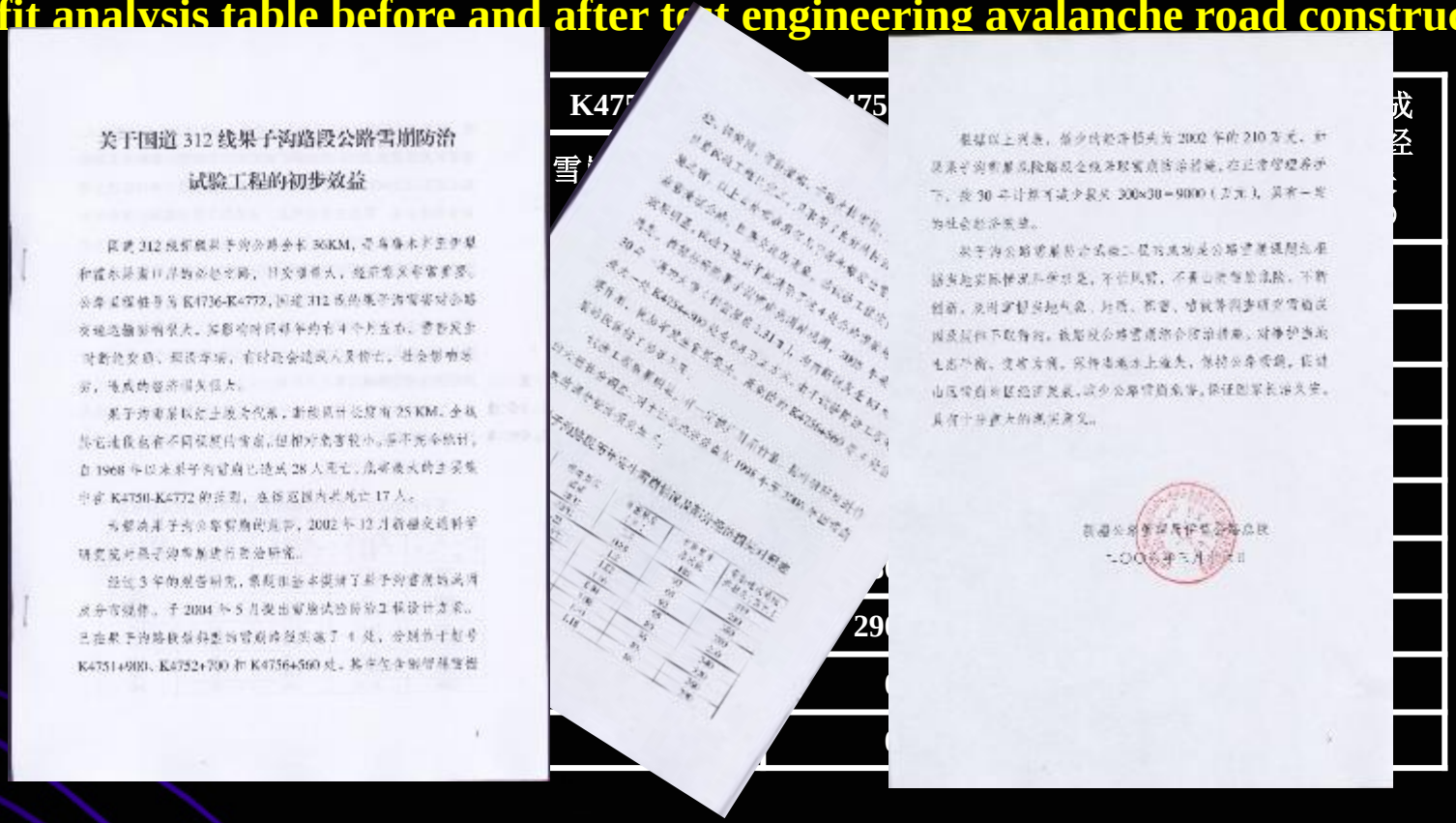
H-Stable snow cover thickness（m）； -Slopes and the friction coefficient of the snow，The values0.5-0.7。

6. Engineering benefit observation

Ⅰ The effect of governance of snow

6. Engineering benefit observation

Benefit analysis table before and after t engineering avalanche road construction


关于国道 312 线果子沟路段公路雪崩防治
试验工程的初步效益

Fruit valley avalanches occur each year nearly 107, often occur on a large scale avalanches, cause traffic jams, cut off traffic 172 hours per year on average, each block 11000 vehicles, four experiment project for the harm is the most serious sections of an avalanche, but from 2005 site investigation confirmed that the 4 avalanche hazard under control, not an avalanche, and other governance between highway avalanche 59. Seriously affect the transportation safety.

6. Engineering benefit observation

Ⅱ Ecological environmental benefits


Motor area no. 1 dam in snow


Motor area no. 2 dam in snow


Motor area no. 3 dam in snow

6. Engineering benefit observation

Ⅱ Ecological environmental benefits

Ecological benefit evaluation, we according to our country forestry industry standards, using biological community average high and the average coverage of two indicators:

Biological effect change within shelter forest in different periods

	The average coverage	The average high	Community dominance	uniformity	Diversity index
Before the construction	0.38	3.1	0.71	0.38	1.43
After a year of construction	0.67	6.5	0.82	0.51	0.7
After two years of construction	0.74	7.2	0.86	0.58	0.52

Ecological shelter forest vegetation coverage and biomass were higher than before construction, built of shelter forest system, improved the avalanche path small environment of moisture and light conditions, created a relatively good small environment, increase the species diversity of the region.

6. Engineering benefit observation

Ⅲ Water conservation of soil and water loss

K4769 + 560 an avalanche paths integrated protection system of the implementation of the test project, can solid snow of 100000 cubic meters a year, conversion into water is 38000 cubic meters of water, to keep the regional soil water, shelter forest and vegetation of pouring etc all have important role.

Warm congratulations on

The security and disaster relief coordination workshop

A complete successful!

Thank You

China xinjiang traffic science research institute

May 2016