Vetiver System for Xinchang Railway Embankment Stabilization
The First Vetiver Application for Railway in China

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There has been a great progress in vetiver system (VS) applications for highway constructions since the conference titled Vetiver Bio-Engineering Technology for Erosion and Sediment Control and Civil Construction Stabilization which was held in Nanchang and organized by China Vetiver Network (CNVN) in 1999. Large demonstrations were established in several provinces in southern China, many vetiver companies were established by soil conservation institutions, highway bureaus, and private sectors. In some provinces the application of VS has became official regular activities adopted for highway embankment protection. For example, the Fujian Provincial Highway Bureau released an official document requesting all highway institutions to use VS, while the Zhejiang Provincial Highway Association established an Official Vetiver Company to extend VS. The national Highway Research Institute enclosed VS into national highway greening regulation to be finally approved by the Communication Ministry.

There was difference of using VS on highway and railway in China. Each highway section institution no matter highway level (national, provincial, county, or township) is entitled to use VS so long as he or she accept vetiver technology. However, no any railway institution can start vetiver planting until they got permission from the top railway organization via railway Survey and Design Academies. It means that if somebody wants to use VS he or she has to pass through various doors for permission. With efforts from Xinchang Railway Company located at Nanjing the capital of Jiangsu Province, the first railway vetiver company was launched in 2001and started to use VS at the same time.

1. Background of Xinchang railway

The Xinchang Railway Company has been responsible in constructing the Xinchang Railway totaling 638 km that was stared in 1998 is to be completed in 2001 with total budget of 6230 Million Yuan RMB. The railway is located in east China, from Xinyi of Jiangsu Province to Changxing of Zhejiang Province. Most of the land the railway passed is plain or low land. The embankment was constructed with pure silts of alluvial materials.

To introduce VS to the whole Xinchang Railway and to other railways, the first large demonstration was arranged in Huangqiao section (around N32°20', E 120°30') where the road materials came from the deep soil derived from Yangtze River with north sub-tropical climate (Table 1).The absolute maximum temperature was 38.8°C and the lowest temperature

Table 1. Air and soil temperature

Depth (cm)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
0	2.9	4.9	10.1	17.2	23.3	28.1	31.9	32.0	25.8	19.3	11.7	5.1	17.7
5	3.2	4.7	9.0	15.5	21.1	25.7	29.8	29.9	24.6	18.5	11.6	5.5	16.6
10	3.6	5.0	9.0	15.0	20.4	25.0	29.1	29.4	24.5	18.6	12.0	6.0	16.5
15	4.0	5.1	8.9	14.8	20.1	24.6	28.6	19.1	24.6	18.8	12.5	6.4	16.5
Air	1.9	3.8	8.0	14.9	19.2	23.9	27.7	77.5	22.5	16.8	10.6	4.4	15.0

Table 2. Soil mechanical analysis of the field

Depth (cm)	Particle size (mm, %)			
	>0.05	0.01-0.05	<0.01	<0.001
0-12	29	43	28	15
12-49	31	45	24	13
49-71	31	47	22	13
71-100	26	45	29	17

was –12.5C°. The annual rainfall was 1021.9 mm of which 55.8% was distributed from June to September. It mainly contains fine sand that is very easy to be eroded off by either water or wind (Table 2). When the embankment was constructed the Railway institution had to use plastic sheets to cover the whole slope against erosion. To protect the embankment the railway company had to use rocks to make wall and skeleton and then to spray grass seeds on the place between the skeletons. The seed spray usually costs 9 Yuan/M^2 and needs to be maintained for one year and to spray water every 3 days in the first month since seeding, if there is not enough rainfall, while the rocks cost around 60 Yuan/M^3. To save money and promote a quick vegetation cover a section for over 5000 m^2 was designed to use vetiver.

2. Vetiver planting and management

On 20 April 2001 vetiver planting materials for 120 000 tillers were transported from Dabie Mountain where farmers produced planting materials and contracted vetiver projects since 1998 in order to alleviate poverty and to protection environment.

When transported to the railway construction site the stems of planting materials were about 50 cm long plus 15cm roots. There were 15 – 100 tillers per clump. The tillers were adhered together with loam soil. To increase survival rate and reduce water loss the tillers were cut at 20 cm and then separated into small clumps which contains 3-6 tillers. Unfortunately some tillers were still around 40 cm long because the local farmers wished to save force and cut the seedlings as less as possible.

As the soil contains much silt particle and very little clay it lacks of water storage capacity. To moisten the roots and keep moisture for a longer time the roots were dipped with loamy-clay paste very thoroughly just before planting. At the same time ditches with 20 cm depth were prepared along straight contour lines. To avoid disturbing the slope too much the width of the ditches was limited to around 10 cm with a special designed digger. Vetiver was planted spacing around 10 cm x 140 cm (Fig.1). Because the soil was short of nutrients (Table 2), a little of compound chemical fertilizer (N 15%, P_2O_5 15%, K_2O 15%) was applied with an amount of 25 g/per 10 m ditch. After the application of fertilizer 3cm soil was buried to cover the fertilizer avoiding direct contact to roots.

Since there was a little rainfall before planting the soil contained little moisture, irrigation was provided just when the planting was finished on 22 April. The whole planting process lasted 2 days. There followed a rainfall the next day and then two days cloudy.

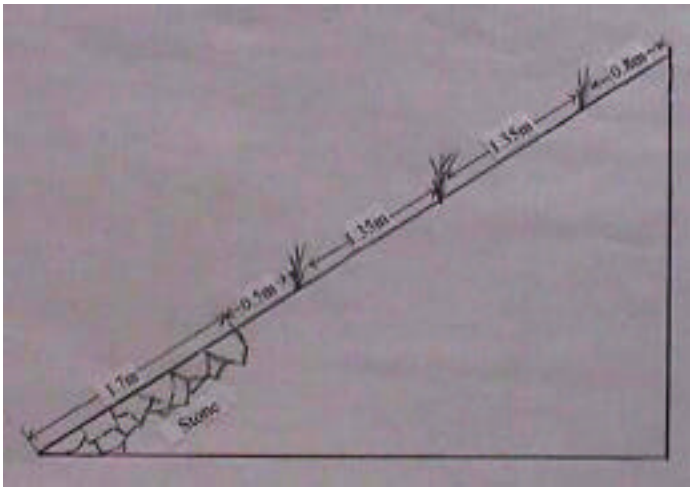

Fig.1 The planting pattern

Table 3. Soil nutrient analysis of nearby farm field

Depth (cm)	O.M. (g/kg)	T-N (g/kg)	T-P_2O_5 (g/kg)	S-N (mg/kg)	S-P_2O_5 (mg/kg)	S-K_2O (mg/kg)	$CaCO_3$ (g/kg)	CEC (Me/100 g soil)	pH (water)
0 - 12	10.0	0.87	1.66	100	7	97	6.9	9.4	8.1
12 - 49	8.3	0.67	1.51	79	1	51	9.2	9.3	7.7
49 - 71	4.5	0.38	1.57	70	1	73	16.3	10.3	7.8
71 - 100	2.0	0.25	1.25	57	2	61	58.8	6.1	8.1

O.M. = organic matter, T- = total, S- = soluble

Investigation on 25 May 2001 one month later, only 40% of the planting materials were survived. On 30 May, about 30 000 tillers were transported from Shuzhou to the demonstration site and planted as the second time. The re-planting was carried on 31 May 2001. The weather was cloudy. Watering was followed the same day just after the planting.

For the second planting, the tillers were come from the nursery with clay soil. As it was quite difficult to separate tillers even if the clumps were soaked under water. So at last the tillers combined with clay were cut parallel aside the tillers with knives. The stems of tillers were cut strictly limited to 20 cm long. Watering was also provided once the planting was finished. Later, the third planting was implemented on 26-27 June 2001 to insure vetiver hedges could be formed smoothly. The planting materials were come also from the Dabie Mountains.

In addition to irrigation for three times just after planting and re-planing, further two times irrigation was provided. Besides, diluted pig manure was applied on 28-29 July. Carbamide for 15 kg was applied on 17 August. It is worth to indicate that once vetiver grew up weeds also grew when investigated on 21 June, two months after planting since vetiver improved micro-ecological condition. To avoid effect of weeds, weeding was provided on 26 July. But the roots of weeds remained in soil to control erosion.

3. Survival rate and growth behavior

3.1 Survival rate

The survival rate of the first planting was not high when investigated on 25 May 2001 possibly caused by:

1) It was required that the chemical fertilizer should be buried by 3 cm thick of soil before planting to avoid the direct contact of roots with the fertilizer. However during practice the roots might touch the fertilizer, as the railway manager deemed it not important.

2) The tillers had long stems and leaves that increased evaporation. Although the stems of tillers was required to be 20 cm at most, some of them were 30 or even 40 cm because farmers wanted to reduce their pruning work and wished to cut as less as possible.

3) Since the tillers were too long and some of them were planted too deep. For some tillers about 20 cm stems were buried. It may also influence the survival.

4) It is showed that the survival rate was higher when planting 6 tillers/clump than 3 tillers/clump. Therefore it is recommended that more tillers should be used for engineering protections.

Regarding to the planting materials planted on 31 May, the survival rated was around 40% when checked on 21 June, about 20 days later since planting. However it increased to 70% and to 85% when checked on 26 June (just 5 days later) and 2 July respectively. It was because the soil and air moisture turned high during the plum-raining season at that moment. Furthermore, there was large area of rice field along the railway. At that time the field was irrigated for planting rice seedling and the air moisture became high. The new leaves appeared very late because most of the roots were cut out and destroyed during separating clumps and only few roots were left and adhered tightly by clay. It would take longer time for the very few adhered roots recover to new environment and to grow.

3.2 Growth differentiation

General speaking, the demonstration section of the road had a direction of east-west. Vetiver grass on the southern slope was not as good as that on the northern slope, possibly because the soil of southern slope had less moisture. However, even on the same slope vetiver growth was different especially in the first 2 months. In addition, tillering differentiated from 5 to 45 tillers/per clump. Analysis showed that soil nutrients differed from place to place (Table 4). It is because the soil materials come from farmland derived from Yangtze River sediments of which different layer contained different contents of nutrients. Besides, the surface soil of farm land should have higher nutrients which promoted vetiver growth. From table 4 we can find high nitrogen content may promote vetiver growth even at the early stage.

Table 4. Soil nutrient analysis of surface soil from different section of road embankment

NO	Descriptions	O.M. (g/kg)	T-N (g/kg)	T-P (g/kg)	T-K (g/kg)	S-N (mg/k)	S-P (mg/kg)	S-K (mg/kg)	pH (water)
1	Vetiver grew very well, south slope	5.9	0.33	1.70	19.8	78.16	3.7	34	8.70
2	Vetiver died after first planting, south slope	4.7	0.29	1.72	20.8	63.95	39.3	90	8.51
3	Vetiver grew well, north slope	5.5	0.32	1.22	21.8	71.05	2.4	32	8.86
4	Slide place, north slope	7.1	0.37	1.87	19.6	93.79	4.1	37	8.79

O.M. = organic matter, T- = total, S- = soluble, NO = soil sample numbers

3.3 Insect control

In the beginning of August, rice borer was found on some of the grasses. The insect was at the end of first generation and the beginning of the second generation. To control the insect Tamaron was used on 6 August, 28 September, and 15 October.

4. Function on erosion control

Generally, the grass that was firstly planted on 20 April reached around 80 cm high two months after planting and formed a preliminary hedge and started to exert the protection function. Investigation at the end of July, 3 months after planting, the whole embankment was fully protected with vetiver grass reached over 2 m high. The roots reached 80 cm – 110 cm. The embankments were well protected and past a raining season safely, because vetiver has dense and massive root system underground and offers better shear strength per unit fiber concentration. According farmers' experience, the slope must be protected by rocks otherwise the embankments would collapse and bury near by rice field. The railway engineers had to use huge plastic sheets to cover the whole embankments against erosion. The present demonstration showed that vetiver hedges acted as concrete wall or rock skeleton to protect the road.

However, according to investigation on 27 June a small slide with about 4 m^3 found and then repair and replanting were provided. Soil sampling and analysis showed that although the particle size distribution looked no great change, the NO.4 sample had a texture of sand and loamy sand because it had a little less clay particles, which explained why this section of the slope had a small slide (Table 4). However, the slide happen at a time two months later since planting when vetiver hedges were not fully formed caused by continuously rainfall during plum-raining season. Once the season passed and the vetiver grew up, the embankment no longer colapsed.

Table 5. Mechanical analysis of surface soil from different section of road embankment

NO.	Description	Particle size (mm, %)				Texture
		2 - 0.2	0.2 – 0.02	**0.02– 0.002**	< 0.002	
1	Vetiver grew very well, south slope	0.8	74.8	16.0	8.4	Sandy loam
2	Vetiver died after first planting, south slope	0.5	84.0	9.8	5.7	Sandy loam
3	Vetiver grew well, north slope	0.5	69.5	20.5	9.5	Sandy loam
4	Slide place, north slope	0.5	84.8	9.5	5.2	**Sand & loamy sand**

5. Conclusion

The first application of vetiver for railway embankment protection was quite successful, which indicated that vetiver could be used to protect slope formed by sand particles that was quite different from other numerous applications on highways in the mountainous area in China where usually contained rock fragments, some clay particles and mixed with forest soil containing certain organic matters. Although the best planting season in this area was March in

vetiver started to grow.

To ensure planting to be successful, followings should be seriously considered:

- Before planting people may consider it to an absolutely technical issue. However, once seeing the planting procedure, he or she may look down upon the technology and therefore led to the planting failure. As a result, planting and management regulation should be prepared and be followed during the whole process.

- Planting materials should not come from the nursery with very clayey soil to avoid difficulty for separating.

- Organic manure is recommended to be used as basic manure. If chemical fertilizer is used calcium-magnesium-phosphate might be used to avoid possible root damage.

- Planting materials should be very carefully prepared (not longer that 20 cm).

- To select suitable planting season so that the planting could be most successful with less effort and to prevent possible collapse during raining season, especially for the embankment formed by sand or loamy sand texture. Besides, soil analysis should be conducted before planting in order to design different measure for different soil.