
Tran Tan Van* and Paul Truong**

*TVNI Associate Director
Director, Vietnam Institute of Geosciences and Mineral Resources
Ministry of Natural Resources and Environment
Thanh Xuan, Hanoi, Vietnam
Email: van@vignmr.vn; trantv@gmail.com

** TVNI Director for Asia and Oceania
Brisbane, Australia

Abstract.

The use of Vetiver System Technology (VST) for infrastructure protection in Vietnam has become very popular after more than a decade when it has, for the first time in 1999, been introduced by Paul Truong into Vietnam and met with considerable skepticism at the beginning. The grass is now known throughout the country and is in use practically in nearly 40 out of 63 provinces. It is planted in a very wide range of soil types and climatic conditions, from very cold winter in the North, very hot summer-cold winter, and pure sand in Central Vietnam to acid sulfate and saline soil in the Mekong Delta. The Ministry of Agriculture and Rural Development (MARD) and the Ministry of Transport (MOT) - the two most relevant ministries in terms of VST application - issued several guidances on the use of the grass for natural disaster mitigation and infrastructure protection. Tens of companies, NGOs, universities and institutions have been engaged in various pilot and mass applications of the VS and its promotion nation-wide.

Research results, successes and failures of numerous applications indicate that VS, having many advantages, is a very cost-effective, community-based and environment-friendly bio-engineering tool for natural disaster mitigation and infrastructure protection. However, to ensure successes and avoid failures, it is important that the VST be used with proper care. It is, therefore, the purpose of this paper to summarize some lessons learned from its applications on the Ho Chi Minh Highway to echo worldwide experience.

A Review was taken 15 years after this successful application of VST can be summarised as:

- On the whole there are no serious erosion occurs over the length of about 1000km of Sections 1 and 2 of the HCMHW and VST has successfully stabilized these sections of the highway
- Occasional eroded batters and small slips occurred, partly due to uncontrolled animal grazing and poor internal drainage
- Vetiver has accomplished its mission as a pioneer plant, providing effective erosion control on very steep and hostile slopes, trapping sediment and runoff water, producing a micro environment to facilitate the establishment of endemic plants
- Most importantly, in area where local species did not re-established, vetiver persisted and continue to provide protection
1. THE HO CHI MINH HIGHWAY (HCMHW) - A BRIEF INTRODUCTION

The master plan for the HCMHW was approved by Vietnam’s Government in 1997 and construction started in 2000 after the historic flood at the end of 1999 which disrupted for more than a month the North-South traffic on the National Route No.1 along Vietnam’s coastline.

The HCMHW, with cross-section width 40-100m, 2-8 lanes, is divided into several sections i.e.:

- Section 1 (Hanoi-Quang Binh): 500km in length;
- Section 2 (Quang Binh-Quang Nam) is divided into 2 branches i.e. East HCMHW, 364km in length; and West HCMHW, 514km in length;
- Section 3 (Quang Nam-HCM City): 825km in length;

According to the plan, the HCMHW will connect the border province of Cao Bang in the North with Ca Mau Cape of Kien Giang province in the South, totaling in length 3,200km (Fig.1). In addition, it will connect with National Route No.1 by a network of 20 traverses totaling in length nearly 1,700km.
Construction of the HCMHW, especially its west branch, faced unprecedented difficulties as the road alignment never existed before and it had to go through rugged terrains. In addition, under time pressure, at many locations the primary aim was to get the road operate first, leaving behind many other aspects e.g. safety of cut slopes, waste disposal, environmental impacts, nature conservation etc. (Fig.2-4).

2. VS APPLICATION FOR CUT SLOPE STABILIZATION

In early 2002, Pham Hong Duc Phuoc (Ho Chi Minh City Agro-Forestry University) and Thien Sinh Co. tried for the first time the use of VS for a cut slope on the newly constructed HCMHW (Fig.5-6). Following the initial success of this trial, the Ministry of Transport made a bold move in 2003, allowing the wide use of VS for slope stabilization along hundreds of km of the same highway and other national, provincial roads.
3. SOME LESSONS LEARNED AFTER THE FIRST FEW YEARS

The extensive use of VS for cut slope stabilization along the HCMHW brings in very good results e.g.:

- It helps increase the environmental friendliness of the road. Applied primarily for slope surface protection it greatly reduces surface erosion, which otherwise causes downstream hazards (Fig.7);
- By preventing shallow failures, it greatly stabilizes cut slopes and consequently helps reduce the number of deep slope failures. In some cases where the latter do occur, it still does a very good job in retarding the failures and reducing the failed mass. More on this follows in Section 4.
Successes and failures of VS application along the Ho Chi Minh Highway also showed some lessons:

- The slopes should first be internally stable, as the VS is not immediately effective (slopes can fail before roots have established) (Fig.8). Stabilization may take place earliest 3-4 months after planting; hence timing is also very important to avoid slope failure in the first rainy season;
- Appropriate slope angle should not exceed 45° (H:V = 1:1) to allow for successful establishment and visible effect of the grass on the slope stability;
- Good protection of the slope toe is a must even with Vetiver grass, be it alone or in combination with other structural measures (Fig.9); and
- Regular trimming is important to ensure further growth of the grass to achieve good, dense hedgerows etc.
4. LESSONS LEARNED A DECADE AFTER PLANTING

In a recent visit back to the Ho Chi Minh Highway in April 2001 by Tran Tan Van, the above mentioned lessons were once again confirmed. A few more remarks can be drawn out as follows:

- **Deep-seated failure.** A slope instability problem can exhibit itself in the following forms:
  
  a). Slow, gradual, either continuous or seasonal slope surface erosion;
  
  b). Shallow, small slide, having failure surface within 1-2 m below the slope surface; and
  
  c). Large, deep-seated slide, having failure surface sometimes exceeding a few m or even tens of m below the slope surface.

---

**Fig. 10.** Slope surface erosion, developing into gullies and small, shallow landslides before large, deep-seated ones take place and Vetiver grass cannot help.

Slope instability is usually progressive, starting just from invisible surface erosion, developing to gully and shallow, small slides long before deep slides take place. The latter can also happen suddenly but rarely, during extremely heavy meteorological events.

The HCMHW runs across several provinces of Vietnam which have the annual average rainfall intensity of 1,500-2,500mm. The rainy season accounts for up to 75% of the annual rainfall intensity. On the average there are 120-200 rainy days a year, 10-20 days a month during the rainy season and 5-15 during the dry season. Up to 130-170 days have more than 1mm rain but just only 6-8 days on the average have heavy (>50mm) rains. Extremely heavy rains (>100mm) happen even less, just 1-3 days a year. Observations confirm landslides and deep slope failures usually take place during these extreme events that follow prolonged (one week to ten days) smaller rains.

Vetiver grass can help prevent slope surface erosion, gully erosion or shallow, small slides and the slope can remain stable around the year, which may also result in false impression of the grass effectiveness. But it can hardly, even if well designed, established and maintained, prevent deep-
seated failures. So it is very important that the slope be internally stable first and measures against deep-seated failures be taken before deciding to plant the grass as a supplementary bio-engineering measure. In other words, one should try to stay within the capacity of the grass if it is not to be blamed in case of deep-seated failures (Fig.10).

- **Retarding failure:** Nevertheless, even in cases of large, deep-seated failures, Vetiver grass, when it establishes, can play a very useful role in retarding failure, which is well illustrated at many locations along the Ho Chi Minh Highway (Fig.11-14):

  ![Fig.11. Without Vetiver grass, the slope constructed out on strongly crushed rock/soil along a fault zone at Deo Da Deo Pass (Quang Binh province) continuously fails even though it has been very gently flattened down to the natural slope angle (photos taken 8/2004).](image1)

  ![Fig.12. Under the same condition, a combination of Vetiver grass and rock groins did a better job even though at the other end still couldn’t prevent a massive failure to occur (photos taken 1/2005).](image2)

- **Slope drainage and dissipation of excessive pore pressure:** In slope engineering it is well-known that water is number one enemy of the slope (Fig.15). Vetiver grass, with its unique characteristics and coupled with proper design, does a very good job in draining away surface run-off, dissipating excessive pore pressure and reducing infiltration (Fig.16). In so doing, Vetiver grass also help stabilizing the slope almost around the year. But in case of extreme meteorological events, sooner or later the slope will get soaked and saturated when the infiltration rate exceeds the grass’s evapotranspiration capacity. Also during prolonged rains the excessive pore pressure can eventually dissipate without needing the assistance of the grass extensive root system.
Fig. 13. (Same location). Planted just in 6/2004 (left photo taken 8/2004), the grass couldn’t help prevent a deep failure in 9/2004 during the rainy season (right photo taken 1/2005).

Fig. 14. But when established it helped restore the local vegetative cover and strongly retard the failure even though eventually a by-pass had to be made a few meters down (photos taken 4/2011).

Some other slopes can have such unfavorable condition that the water table is much deeper than the depth that the Vetiver roots can reach and such water table continuously drains out on the slope surface, saturating and weakening the slope rock/soil. Vetiver grass alone may not be fully effective also in this case.

It is, therefore, also very important that a slope is well designed and constructed in terms of water drainage before Vetiver grass can come in as a supplementary measure.
Understanding the geology, especially the weathering profile of cut slopes: Different parts of a cut slope may differ greatly in composition, due either to the weathering process or to the original bedrock lithology and structure. Understanding the regional and the slope geology and particularly its weathering profile is, therefore, a must if proper design and construction is desired. In any case, for a completely weathered cut slope, or at least its completely weathered part, it is advisable not to exceed 45° (H:V = 1:1). Moreover, although Vetiver grass appears versatile enough to grow on different soil types, this difference may also influence the growth of the grass on one and the same slope and may need to be taken into account. Even though some parts of the slope can be soft enough to allow digging a ditch, the mottled rock composition there would not allow further growth of the grass down beyond the soft and fertile soil that is provided during the planting (Fig. 17).

Vetiver grass vs. local species, or do we need long-term maintenance? At most locations the Vetiver rows are no longer maintained i.e. they are no longer watered, fertilized, trimmed or cut etc. As a result and because the grass is seasonal, it cannot compete with the local, perennial species (Fig. 18). Whether or not it is better or worse remains a question but to the authors of this paper, it is better to provide long term and regular maintenance to ensure as deep root penetration, and together with that, slope stability, as possible. Another reason for doing so is to maintain the environmental friendliness of the measure.

Vetiver grass and negative slope side/embankment protection: It is pity to admit that although planted extensively along the Ho Chi Minh Highway, a major drawback of the campaign remains i.e. the technology is not used at all for the stabilization of the negative side of cut slopes or both sides of filled embankments although these provide much more favorable conditions than cut
slopes for the VS to be applied. As shown above, the negative side of cut slopes can result in serious environmental concern. In addition, it too, can remain unstable and therefore, can threaten the road safety if it is not properly protected (Fig.19).

Fig. 17. Different parts of a cut slope may be of different composition due either to the weathering process (upper left and right) or to the original bedrock lithology and structure (middle left) and the grass may not grow equally well on them (lower left photo).

5. **A FEW MORE LESSONS LEARNED 15 YEARS AFTER PLANTING**

In February 2014 Paul Truong conducted a review over the distance of about 1 000km of Sections 1 and 2 of the HCMHW, stretching over a wide range of geology, topography, altitude and climate. It was very pleasing to report that the VST has successfully stabilized this highway in general. On the whole there are no serious erosion occurs over the length of about 1000km of Sections 1 and 2 of the HCMHW and Vetiver System has successfully stabilized these sections of the highway. Occasional eroded batters and small slips occurred, partly due to uncontrolled animal grazing and poor internal drainage. However in Section 3: from Quang Nam to HCM City where some shallow (small slips 1-
2m deep) and more serious large (deep-seated slides 5-10m) occurred due to inadequate internal drainage and weeds

VST has accomplished its mission as a pioneer plant, providing effective erosion control on very steep and hostile slopes, trapping sediment and runoff water, producing a micro environment to facilitate the establishment of endemic plants. All these plants re-established naturally by themselves, mostly from endemic seeds from the surrounding areas. Some were blown in from further out.

In general, the original vetiver was shaded out by the spread of the local plants. It can be found only along the edges of the original planting. But most importantly, in area where local species did not re-established, vetiver persisted and continue to provide protection.

Based on long term experience in subtropical Australia, local trees will eventually come back to provide a permanent protection.

It can be concluded that Vetiver planting created favourable condition for local species to come back and faded away due to shading, but it persisted where local species could not come back.

Fig. 18: General view along the Highway in February 2014, 15 years later
Fig. 19: Vetiver plating in 2005 and 2014
6. **CONCLUSIONS**

From both the successes and failures of numerous applications presented above, it is clear that we now have enough evidence that VST, having many advantages and very few disadvantages, is a very cost-effective, community-based and environment-friendly bio-engineering tool for natural disaster mitigation and infrastructure protection. However it should be used with proper care, with lessons learned so as to achieve desirable results. Keeping the measure within its capacity and using it in combination with other proven measures, understanding geological and geotechnical conditions and providing long term maintenance etc. are probably the most important pre-requisite conditions.
Fig. 21. As Vetiver is seasonal and no longer maintained, local, perennial species strongly come back to compete, penetrating even the rock rip-rap and wire mesh (lowermost photo, taken 4/2011).

Fig. 22. Failure of the negative side of cut slopes and rigorous remedial measures.

7. REFERENCES


