VIP LINER

2-D INTERLOCKING CONCRETE BLOCK SYSTEM

User Manual For Installation

Kumpulan VITAL
Bahagian Rekabentuk dan Empangan

USAGE OF MANUAL

The information provided in this installation manual is indicative and provided as reference only. VIP LINER is a system invented and designed in the year 2011 by members of the VITAL Group based in the Division of Design and Dam, Department Irrigation and Drainage, Malaysia. Members of VITAL Group are as follows:-

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The registration for patent for this product is pending. Usage and application of VIP LINER in any form of waterway revetment works must be consented to and in consultation with the following representatives of the Vital Group's i.e.

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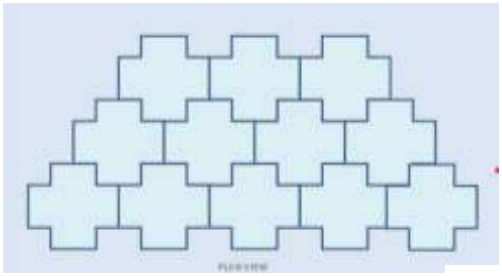
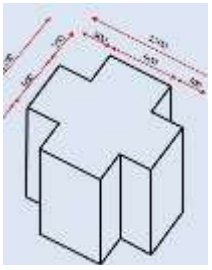
1. INTRODUCTION

The purpose of this manual is to provide a standardized basis for analysis, design and installation of VIP LINER, a 2-dimensional interlocking precast concrete block revetment system for erosion control applications on toe of open channel bank and bed. Toe and bed scour along revetments, is thought to be the most common cause of channel bank failure.

VIP LINER protective system is used to provide erosion protection to underlying soil at the toe of the channel bank and bed against hydraulic forces of moving water. The system is comprised of a matrix of individual blocks placed together to form an erosion-resistant layer with specific hydraulic performance characteristics. The term interlocking implies the ability of individual blocks to minor changes in the sub-grade while remaining interconnected with geometric interlock. *Figure 1* below show the various views of the VIP LINER.



(a) Plan View of Interlock Blocks



(b) Isometric View of Invidual Block

Figure 1: View of VIP LINER

VIP LINER is a system created and developed by the Group VITAL in the year 2011 which comprises of about 10 members as shown in *Appendix A* attached. This system had been applied and tested to be very effective in arresting the erosion problem at a pilot project at Taman Kayu Ara Indah, Sungai Kayu Ara, Damansara, Petaling Jaya in 2010. Further details of the project are briefly described in the paper in *Appendix B*.

2. GENERAL FEATURES

VIP LINER is an Industrialized Building System (IBS) comprises of a matrix of Interlocking precast concrete blocks to form a continuous, stable, durable and effective protective lining against erosion or scouring at the channel bank toe and bed. In this way, the bank can be protected against failures due to these destabilising factors as any bank failure would endanger the safety of inhabitants and causing damage to properties along the channel.

This product is designed for usage on the waterway or channel with or without bank revetment works to prevent and control scouring and erosion of the channel bed and toe of bank. In fact, a lot of failure of the slope or retaining structure on channel bank have

failed due to severe erosion and scouring at the toe and bed which destabilise and cause the bank failure.

The design of size of the VIP LINER allows you to adjust the thickness (i.e. its weight) in relation to the flow conditions such as degree of turbulence, curvature of the flow, depth of water and most of all, the velocity of flows.

The VIP LINER system can be used in a broad range of erosion control applications for the channel bed and bank toe with good success. It can be used in flow conditions of low turbulence to high velocities conditions such as outlet to control structures, culvert, spillways and grade control structures. The interlocking characteristic allows the systems to be placed effectively at bends and regions of vertical changes, such as sloping grade control structures.

VIP LINER block units are assembled into a continuous matrix with uneven top surfaces which provides protection against high velocity flows as well as for hydraulic energy dissipation. Also, VIP LINER can be installed with voids or open cells to provide habitats for aquatic lives.

The system should not be placed on slopes that are geotechnically unstable. VIP LINER are intended for erosion control, not slope stabilization. Geotechnical engineering and slope stabilisation references should be sought for problems in these areas.

Some the Basic features of the VIP LINER System are:-

i) Material : Mass Concrete, Garde C 20 minimum (no reinforcement except for lifting)

ii) Formworks: Steel or timber depending on economy of scale

iii) Casting: Off-site casting yards

iv) Installation: Easy and can be laid under water

v) Durability: Durable against milling erosion effect of sediment laden flowing water

vi) Interlock: 2-Dimesnsional lockage

vii) Thickness: 300 mm (minimum) to 2000mm

Some advantages of the system are summarized in *Figure 2* below.

Figure 2: Benefits and Advantages of VIP LINER

A typical VIP LINER protection system on the channel bank toe and bed consists of a continuous matrix of interlocking precast individual concrete blocks and underlies with a levelling and/or cushioning gravel layer 25 mm to 75mm diameter, about 100 mm thick. A filter layer of geotextile is laid above this cushion layer to prevent soil from being washed out from the subgrade and is design for pressure relief, particularly in highly turbulent flows. The system is illustrated in *Figure 3* below.

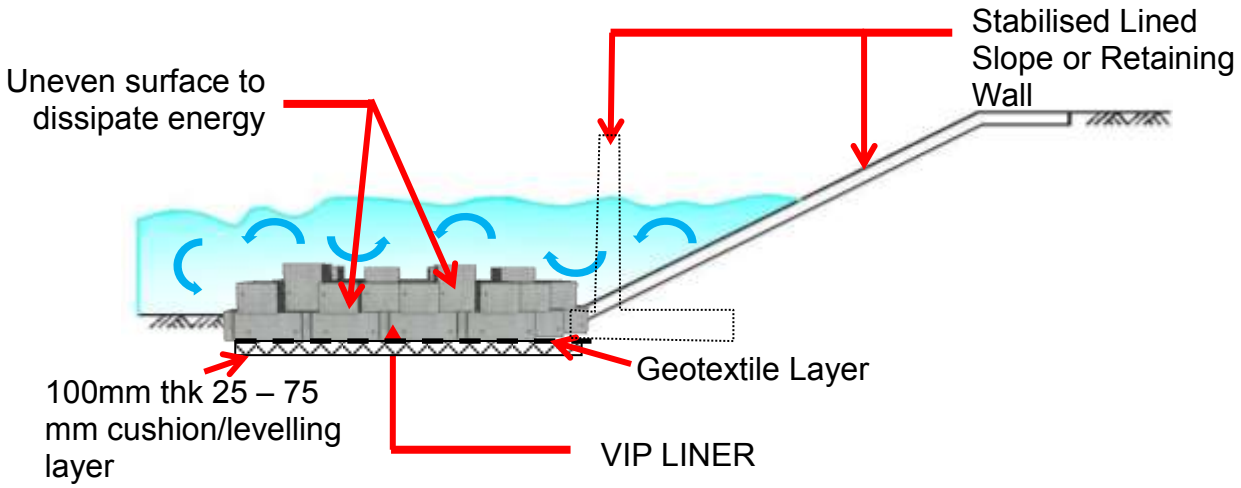


Figure 3: Illustaration of VIP LINER Protection system

3. APPLICATION

This VIP LINER system can be used in many erosion control application for channel bed and bank toe with good success. It can be used in flow conditions of low turbulence to high velocities conditions such as outlet to control structures, culvert, spillways and grade control structures. The interlocking characteristic allows the systems to be placed effectively at bends and regions of vertical changes, such as sloping grade control structures. It can be used effectively to protect the toe and bed of existing bank stabilisation works, or incorporated into the construction of new revetment works such as retaining wall or protective layer on sloping bank. Some illustrations of these applications are in *Figure 4* below.

The typical bank protection problems encountered include repair of existing embankments (often required the re-construction of the bank), extension of existing embankment to address erosion; erosion protection for natural banks to prevent damage to dikes or flood protection structures or to other resources and emergency erosion protection during floods.

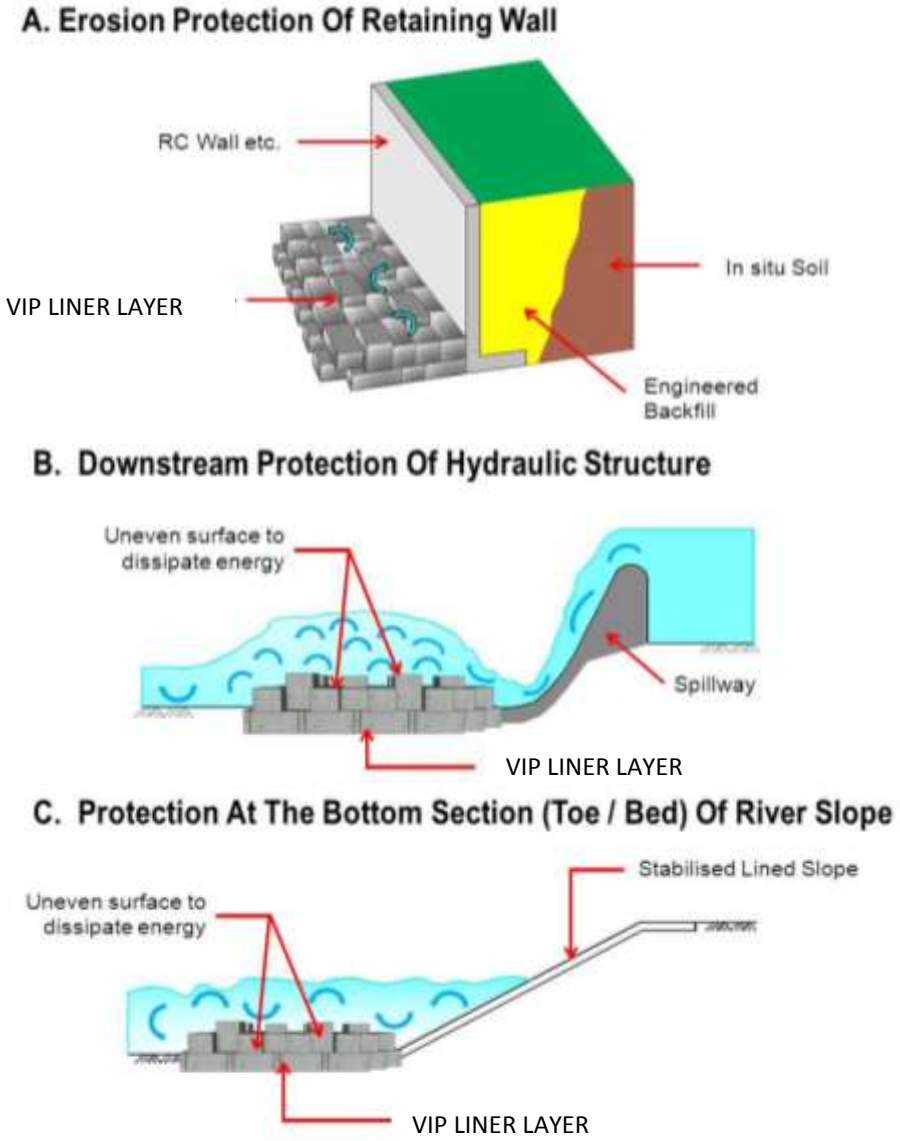


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Figure 4: Illustration of Typical Application of VIP

4. DESIGN CONSIDERATIONS

4.1 Extent of Protective System Coverage

a) Longitudinal Extent

The revetment should be continuous for a distance which extends upstream and downstream of the region which experiences hydraulic forces severe enough to cause dislodging and/or transport of bed and bank material. The minimum distances recommended are an upstream distance of 1.0 channel width and a downstream distance of 1.5 channel widths (see Figure 5 below). The channel reach which experiences severe hydraulic forces is usually identified by site inspection, examination of aerial photography, hydraulic modelling, or a combination of these methods.

In meandering reaches, the natural progression of bank erosion is in the downstream direction, the present limit of erosion may not necessarily define the ultimate downstream limit. The designer is encouraged to review other relevant references such as Lagassee et al. to provide guidance for the assessment of lateral migration.

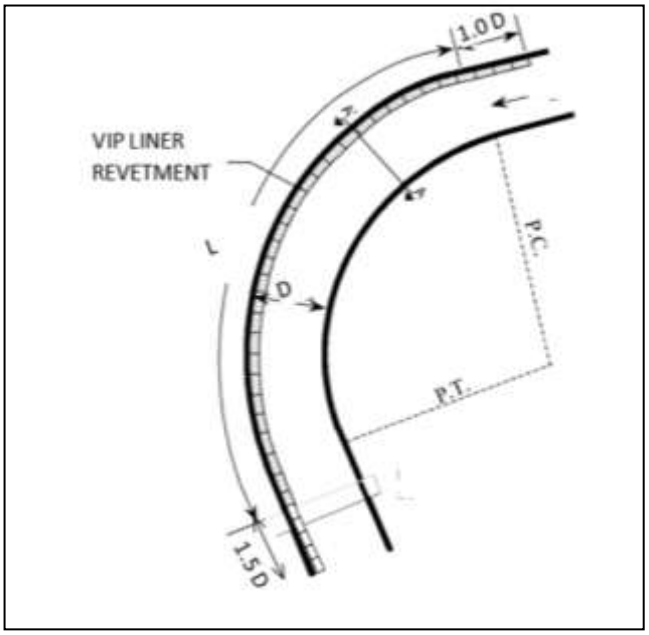

Figure 5: Longitudinal Extent of Protective Coverage

b) Lateral Extent

The VIP LINER revetment system should extend along the bed far enough so that the revetment is not undermined from local scour or degradation. Local scour often occurs at bends, changes in flow direction, obstructions, constrictions, sills, control structures, piers or abutments. In addition, general bed lowering may result from long-term degradation, perhaps downstream of a large dam. The general bed lowering is added to the local scour to predict design scour depth.

A variety of publications provide methods to predict scour depths (Hoffmans et al 1997; Breusers and Raudkivi 1991, Richardson et al). Users are advised to refer to relevant literatures for design of the scour depth and thus, to provide adequate and effective length (perpendicular to flow) of lining to protect he toe and channel bed. As a general guide, the length of revetment should be at least 1.25 times the estimated total scour depth**.** The intention is that when scour occurs, the apron will settle and cover the side of the scour hole on a natural slope.

c) Levelling/Cushion Layer Beneath VIP LINER

A filter and cushion layer is necessary to avoid loss of subgrade and bank materials through the void in the liner as well as levelling the surface for ease of placing the LINER. It also serves to backfill any over-excavation of the subgrade. The traditional material used is gravels or crushed rocks. For placement of VIP LINER, the level and cushion layer should be at least 100 mm thick comprises of 25 to 75 mm in diameter and overlaid on top with a layer of filtration geotextile as shown in *Figure 3* above

d) Sizing of VIP LINER

The design of VIP LINER revetment is based on the nature of the streambank and the hydraulic characteristics of the stream at the design flood. The interlocking of VIP LINER provides resistance to movement for the individual blocks in the revetment works. As a result, the following background information is usually required as part of design

- An inspection of the banks and river channel, the extent of recent erosion, potential hard points (inerodible materials along the bank), and the general behaviour of the river near the proposed bank protection site. For most projects, cross sections of the bank, stream channel and floodplain are required. If the stream has been previously surveyed for design of bank protection works or floodplain mapping, then these would be repeated

- Maps, air photographs, bed and bank material descriptions, channel surveys, design briefs for floodplain mapping and previous studies for bank protection all provide valuable information on channel characteristics and behaviour

- Hydrologic analyses, either of a local Water Survey of Canada gauge record on the stream, or a regional analysis, is often required to predict the design discharge for the stream.

- Hydraulic analyses, at the design or other discharges, are required to predict design water levels, and maximum average velocities and depths. A key aspect of the hydraulic analysis is to predict the maximum average velocity that occurs along the channel and, by extension, the bank where protective works are to be constructed. Local scour often occurs at bends, changes in flow direction,

obstructions, constrictions, sills, control structures, piers or abutments. In addition, general bed lowering may result from long-term degradation, perhaps downstream of a large dam, or from the effects of long-term gravel mining (Galay 1983). The general bed lowering is added to the local scour to predict design scour depth. A variety of publications provide methods to predict scour depths (Hoffmans et al 1997; Breusers and Raudkivi 1991).

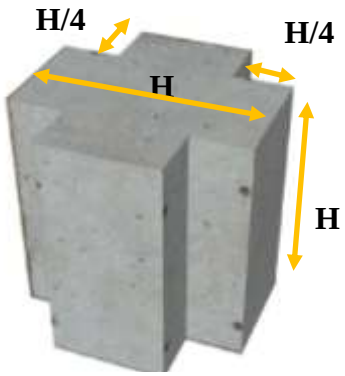

Figure 6: Dimensioning of VIP LINER

Figure 6 above indicated the typical dimensions of a VIP LINER individual block proposed by the inventor. However, the exact dimensions can be adjusted to suit the local condition. Users are advised to consult the inventor of this product to ensure this new system is designed by competent engineers and constructed correctly on the ground. Some relevant references are also listed at the end this manual for users to have a better understanding of the best engineering standard and practices in the application of blockmat such as VIP LINER in controlling the erosion of the channel toe and bed.

5. INSTALLATION OF VIP LINER

The proper installation of a VIP LINER protective system is essential to achieve suitable hydraulic performance and maintain stability against the erosive force of flowing water during the design hydrologic event. Quality workmanship is important to the ultimate performance of the system. The following sections address the subgrade preparation; cushion/levelling layer, geotextile placement, block system placement, and inspection.

5.1 Site Preparation

Preparation of the site including any backfilling or excavation works for bed and toe trench should be carried as required to meet the specifications shown on design drawings. Loose, soft or spongy material, and large rocks projecting through the slope are removed and the resulting minor potholes or hollows filled with selected non-cohesive materials and compacted as directed. Typically, any bank stabilisation works are carried first before the VIP LINER is installed. *Figure 7* illustrated a typical site preparation works in progress.

Figure 7: Exampe of site Preparation Prior to Placement of VIP LINER

5.2 Placing Cushion/levelling Layer

The materials for gravel or crushed rock cushion or levelling layer is inspected for quality (hardness and durability of rock and presence of fines) and compliance with gradation by the site engineer. The layer materials are spread evenly on the prepared bed and toe to the dimensions on the drawings. The layers are usually placed by techniques that do not result in segregation of the rock mass. Compaction is not required but the surface should be smooth and level to ease the laying of the VIP LINER blocks. Prior to that, a layer of geotextile should be laid before the placement of the cushion/levelling layer of gravels.

5.3 VIP LINER Placement

The VIP LINER blocks are transported and placed usually by crane or hydraulic excavator. Care should be taken to prevent cracking or breaking of concrete blocks by rough handling or inappropriate method of placement. The blocks are placed and arranged neatly with minimum void. If necessary, large stones are placed along the outer edge of the VIP LINER layer to further enhance the stability of the lining.

For above water work, VIP LINER blocks are placed from the toe of the bank or wall and extend to a certain length as required before extending in the direction toward the center of the channel. The VIP LINER concrete block system should be placed on the geotextile in such a manner as to produce a smooth plane surface in intimate contact with the geotextile. Individual VIP LINER blocks should be placed to ensure adequate block-to-block interlock is achieved. In channel curvature and grade change areas, alignment of the individual block and the orientation of the neighbouring adjacent block is to provide for adequate block-to-block interlock. Care shall be taken during block installation so as to avoid damage to the geotextile during the installation process.

For underwater placement, it important to monitor the blocks placed on the streambed or the toe of the bank are in accordance to the pattern and interlock adequately to prevent dislocation of the blocks especially when under high turbulence conditions. Quality control is often based on dive inspections.

It is important that the surface of the liner is left uneven (as the thickness of the VIP LINER blocks can be varied in height). However, in some circumstances, crushed rocks are used to fill any large voids in the revetment surface. See *Figure 8* for an example of VIP LINER placement at the pilot project carried out year 2010.

Figure 8: Example of Placement of VIP LINER (At Sg Kayu Ara, Damansara, P.J.)

APPENDIX A

APPENDIX A

Pilot Project at Taman Kayu Ara Indah, Sungai kayu Ara, Damansara, Petaling jaya, Selangor (2010)

PILOT PROJEK FOR THE INSTALATION OF VIP LINER AT TAMAN KAYU ARA INDAH, SUNGAI KAYU ARA, DAMANSARA, PETALING JAYA, SELANGOR

1.0 LATAR BELAKANG

Lapisan VIP telah digunapakai dalam projek perintis iaitu projek pembaikan tebing di Sungai Kayu Ara berdekatan Taman Kayu Ara Indah, Damansara, Selangor. Tembok penahan konkrit tetulang ini telah gagal pada hujung tahun 2009 di mana tembok penahan itu telah mendap dan anjak akibat dari hakisan pada *toe* dan dasar sungai yang disebabkan oleh aliran arus sungai yang deras dan berpusar. Pada asalnya, bahagian *toe* tebing dan dasar sungai tembok ini dilindungi dengan lapisan batu-batuan (*rip-rap*).

Kegagalan tebing ini telah menyebabkan tebing ini mendap dan tembok konkrit retak di beberapa tempat. Batu-batuan yang diletak di *toe* dan dasar sungai pun telah terhakis oleh arus sungai yang amat deras itu. Sebuah jalan serta beberapa deret rumah juga terletak di atas tebing kawasan runtuhan ini. Kejadian ini amat membimbangkan penduduk rumah berkenaan serta mengancam harta-benda dan keselamatan kemudahan awam (sila rujuk Rajah A).

Tapak kegagalan tembok penahan ini terletak di bahagian sungai yang berlimpah (*spillway drop*) serupa jeram setinggi 5 meter disebabkan oleh batu granite semula jadi yang terdedah di dasar sungai (sila rujuk Rajah B di bawah). Keadaan sedemikian telah menyebabkan arus sungai yang deras, bergelora dan berpusar ketika hujan lebat yang berimpak secara terus terhadap tembok penahan berkenaan. Keadaan ini juga telah menyebabkan batu-batuan yang bertindak sebagai pelindung tebing telah dibawa arus sungai.

Rajah A: Kegagalan Tembok Penahan di Sungai Kayu Ara, Petaling Pada Hujung Tahun 2009

Rajah B: Keadaan Tapak Projek Perintis Sebelum Inovasi

Foto 1: Keadaan tapak Projek

Foto 2: Keadaan aliran air semasa 'low flow' (jeram setinggi 5 m)

Foto 3: Keadaan arus air yang deras & bergelora semasa paras air tinggi

Foto 4: Keadaan arus air yang deras dan bergelora semasa paras air tinggi

Foto 5: Keadaan air yang deras, bergelora & berpusar menyebabkan hakisan yang serius di tebing

2. Proses Pembangunan Lapisan VIP

Penggunaan kaedah perlindungan jenis lain misalnya cerucuk kepingan keluli (*steel sheet pile*) dan papak (*slab*) konkrit adalah tidak sesuai kerana kawasan berbatu di dasar sungai dan kesukaran untuk melaksanakan kerja-kerja konkrit di dalam air. Di samping, Lapisan VIP merupakan produk jenis IBS yang mudah dan cepat dibina.

Untuk menyelesaikan masalah kegagalan ini, Kumpulan VITAL telah diberi tanggungjawab untuk mewujudkan satu kaedah perlindungan baru atau yang lebih berkesan. Selepas kajian yang mendalam, maka tercetuslah idea menggunakan sistem IBS jenis blok konkrit saling kunci mengunci (interlocking) yang kukuh dan tidak mudah dibawa oleh arus yang amat deras bergelora itu. Dengan kelulusan pihak JPS Selangor dan pihak pengurusan BRE, projek pemulihan tebing di Sungai Kayu Ara ini telah di jadikan sebagai projek perintis untuk menguji keberkesanan Lapisan VIP yang baru di reka cipta oleh Kumpulan VITAL.

3. Pemasangan VIP di Sungai Kayu Ara

Projek Perintis ini melibatkan kira-kira 80 unit blok konkrit Lapisan VIP dengan berat setiap blok 2.4 ton (isipadu $1m^3$). Kos keseluruhan pembaikan tebing ini adalah lebih kurang RM325,000, namun demikian, kos untuk membekal dan memasang lapisan VIP ini hanya lebihkurang RM 26,000.00 sahaja (sebahagian kos kontrak adalah untuk kerja lain seperti *grouting*, pembaikan retakan konkrit, pembinaan semula tebing dan pemulihan tebing di bahagian hiliran).

Projek perintis hanya bertumpu pada bahagian tembok penahan konkrit yang telah gagal iaitu lebihkurang 10 meter panjang sahaja. Lapisan VIP di bina dengan menyusun blok-blok di *toe* dan dasar sungai selebar 6 meter dari tembok penahan. Sebelum itu, blok-blok konkrit ini telah di pratuang di sebuah kilang di Rawang, Selangor dan diangkut ke tapak.

Pemasangan di tapak adalah mudah dan cepat dengan tenaga pekerja yang minimum. Masa yang diambil untuk menyiapkan kerja-kerja pemasangan adalah kurang dari 2 minggu bagi 80 unit blok. Kerja pemasangan ini telah disiapkan pada bulan November 2010. Proses pemasangan adalah seperti ditunjukkan di Rajah C.

4. Keberkesanan Lapisan VIP

Pemantauan setakat ini (iaitu lebihkurang 10 bulan selepas dipasang) telah menunjukkan bahawa tebing berkenaan masih kukuh dan stabil serta tiada tanda-tanda pergerakan blok konkrit dan tanah tebing. Ini membukti bahawa Lapisan VIP ini memang berkesan dan telah berjaya mengawal hakisan *toe* dan dasar sungai di bawah keadaan arus sungai yang begitu deras dan bergelora di tapak projek perintis ini. Malahan, kejayaan serta keberkesanan Lapisan VIP ini dapat pengiktirafan dari penduduk sendiri yang telah memberi satu sijil keyakinan dan penghargaan melalui JKKK Taman berkenaan serta surat pengesahan dari JPS Petaling.

Rajah C: Proses Pemasangan Lapisan VIP Di Sungai Kayu Ara

I. Casting of VIP LINER at Factory

II. Lifting & Placing at site

III. Placing and Arranging BLOK

IV. Completed VIP LINER

Completed Pilot Project (2010)

A. Before Project

B. After Project

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