

**INVESTIGATION OF SUITABLE  
METHODS TO PROTECT MAIN ROADS  
ADJACENT TO WATER BODIES**

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## **Declaration**

I hereby declare that the research thesis entitled “Investigation of suitable methods to protect main roads adjacent to water bodies” submitted by me in partial fulfillment of the requirements for MSc. (Research), is my original work and that it has not previously formed on the basis of any other academic qualification at any institution.

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## **Abstract**

Main roads adjacent to water bodies often face significant stability challenges due to erosion caused by, heavy rainfall, increased water flow along riverbanks, the sudden drawdown of water levels after flooding, sand mining and various other human activities within river catchments. These conditions can lead to failures in the river banks disrupting the functioning of the road.

This thesis presents four such problematic locations, identifying the root cause of the problem and presenting appropriate different rectification measures adopted. Common features and different aspects at the four locations are elaborated. The locations all in the Western Province are; Kelani River bank along the low-level road, the right side of the Halwathura Phalakotasa stream bank along the Ingiriya-Halwathura-Ekgaloya road, Halkotiyawatta stream bank on Seelarathana Mawatha, and Diyawanna Lake bank on Denzil Kobbekaduwa Mawatha.

A comprehensive literature review was done on various techniques involving both hard and flexible solutions, including reinforcing techniques and integrating natural vegetation developed in different parts of the world over the last decade. Novel approaches appropriate for Sri Lanka were proposed based on the findings of the literature review. At each location, different alternatives were closely evaluated considering cost, constructability and sustainability to decide on the best to be adopted. Stabilization techniques evaluated are; (1) Gabionwall with rock packing at the toe, (2) vegetated live bamboo crib wall construction with Gabion at the toe, and (3) vegetated flapped soil bag with live stake retaining structure with a Gabion at the toe. The proposals were implemented at three locations and the performance is being monitored. The satisfactory performance over few years serves as an encouragement to adopt sustainable techniques in infrastructure development in Sri Lanka.

*Keywords: Bamboo, Bio-slope engineering, Gabion wall, Slope stability, and Stream bank erosion*

## **Delegation**

I delegate this thesis to my beloved family members who are the pillar of my strength and existence.

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## LIST OF SYMBOLS & ABBREVIATIONS

|                        |                                                                     |
|------------------------|---------------------------------------------------------------------|
| $A$                    | Sectional area of sheet pile ( $\text{cm}^2/\text{m}$ )             |
| $B$                    | Gabion wall width of the base (m)                                   |
| $C$                    | Cohesion (kPa)                                                      |
| $C_w$                  | Design adhesion (kPa)                                               |
| $D$                    | Depth of embedment of sheet pile wall (m)                           |
| $e$                    | Eccentricity (m)                                                    |
| $e_0$                  | Initial Void ratio                                                  |
| $f_b$                  | Allowable bending stress in mild steel ( $\text{N}/\text{mm}^2$ )   |
| $f_y$                  | Ultimate stress of pre stress anchor bar ( $\text{N}/\text{mm}^2$ ) |
| $G_s$                  | Specific gravity of soil                                            |
| $H$                    | Retaining wall height (m)                                           |
| $I$                    | Moment of inertia ( $\text{cm}^4/\text{m}$ )                        |
| $K_a$                  | Active earth pressure coefficient                                   |
| $\lambda_{ah}$         | Coefficient of active lateral pressure                              |
| $M_{\max}$             | Maximum bending moment on sheet pile wall ( $\text{kNm}/\text{m}$ ) |
| $M_o$                  | Overturning moment on retaining wall ( $\text{kNm}/\text{m}$ )      |
| $M_r$                  | Resisting moment on retaining wall ( $\text{kNm}/\text{m}$ )        |
| $P_a$                  | Total active force on retaining wall ( $\text{kN}/\text{m}$ )       |
| $P_{AN}$               | Active horizontal earth pressure ( $\text{kN}/\text{m}$ )           |
| $P_o^1$                | Effective overburden pressure                                       |
| $q/p$                  | Surcharge load (kPa)                                                |
| $q_{\text{allowable}}$ | Allocable bearing capacity below the retaining wall (kPa)           |
| $q_{ult}$              | Ultimate bearing capacity below the retaining wall (kPa)            |
| $q_u$                  | Unconfined compression strength of soil                             |
| $T$                    | Anchor force ( $\text{kN}/\text{m}$ )                               |
| $V_{\max}$             | Allowable Shear force in steel sheet pile ( $\text{kN}/\text{m}$ )  |
| $W_g$                  | Weight of the retaining wall (kN)                                   |
| $W_s$                  | Weight of the soil (kN)                                             |
| $Z$                    | Section modulus of Steel sheet pile wall ( $\text{cm}^3/\text{m}$ ) |

|                 |                                                                  |
|-----------------|------------------------------------------------------------------|
| $\alpha$        | Wall inclination angle (degree)                                  |
| $\beta$         | Fill slope angle above wall (degree)                             |
| $\theta$        | Inclination angle to Vertical plane, (degree)                    |
| $\delta$        | Angle of wall friction (degree)                                  |
| $\delta_b$      | Angle of base friction (degree)                                  |
| $\phi$          | Angle of internal friction of soil (degree)                      |
| $P_A$           | Active soil earth pressure (kPa)                                 |
| $\sigma_v$      | Vertical soil stress (kPa)                                       |
| $\sigma'$       | Effective stress (kPa)                                           |
| $U$             | Pore water pressure                                              |
| $P_p$           | Passive soil Side resistance (kPa)                               |
| $\gamma_d$      | Dry unit weight of soil (kN/m <sup>3</sup> )                     |
| $\gamma_s$      | Saturated unit weight of soil (kN/m <sup>3</sup> )               |
| $\gamma_{bulk}$ | Bulk Density of Soil (kN/m <sup>3</sup> )                        |
| $bv_{max}$      | Maximum stress at bottom of the retaining wall (kPa)             |
| $\tau$          | Shear stress or mobilized shear stress (kPa)                     |
| $\tau_f$        | Average shear strength of soil (kPa)                             |
| $\zeta_{am}$    | Allowable stress of the retaining wall (kPa)                     |
| ASTM            | American Society for Testing and Materials                       |
| FOS             | Factor of safety                                                 |
| FEM             | Finite element method                                            |
| LEA             | limit equilibrium approach                                       |
| M               | Mobilization factor                                              |
| M-PM            | Morgenstern-Price method                                         |
| MSE             | Mechanically stabilized earth wall system                        |
| $N_{Field}$     | Field SPT blow counts                                            |
| $N'_{70}$       | Corrected SPT blow counts by energy method                       |
| RDA             | Road Development Authority                                       |
| SLOPE/W         | limit equilibrium approach software for slope stability analysis |
| SPT             | Standard penetration test                                        |
| ULS             | Ultimate Limit State                                             |

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