# Soil stabilization of high fills as part of temporary shoring measures to accommodate phased construction above major culvert box structures

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## Abstract

This document details the practical use of geo-synthetics in order to aide phased half width construction methods of national and provincial roads with designed high fills over major cellular box culverts. This is completed by means of temporary shoring measures using geo-synthetics for soil reinforcement. The intention of this document is to highlight the practical applications, cost effectiveness, safety measures to the public and to mitigate stepped lifts in roadway construction over culverts. Mitigation of stepped lifts over major culverts with minor additional widening allows the process of road construction to be expedited to the designed final road level limiting the need for temporary surfaces and reducing construction duration.

***Keywords:*** *road upgrade, soil reinforcement, half width construction, major culverts.*

## 1 Introduction

During the design phase for the upgrading of national and provincial road infrastructure, existing major and minor river tributaries are evaluated to ensure that the existing and future proposed hydraulic structures have adequate capacity, to allow for anticipated flooding during its design life. This is done systematically for all tributaries adopting the South African National Roads Agency SOC Limited's (SANRAL) Drainage Manual, as the guideline for the hydrological and hydraulic design.

Major culverts that have proven to be hydraulically inadequate and unsafe either hydraulically, indicating future overtopping of the road prism or, structurally by a qualified Inspector and Engineer, are replaced with a new structure. The replacement is done by demolishing the existing structure and reconstructing a new structure in a similar location.

Numerous cases of replacement or reconstructed culverts occur throughout South Africa. This document will discuss the two varying construction methodologies of upgrading from a single carriageway to an undivided dual carriageway at major culvert locations. Firstly, by adopting

stepped phased construction and then by adopting geo-synthetic fabric as a soil reinforcement measure with minor additional widening.

## 2 Road Construction Methodologies over Major Culverts

The method of the construction is solely left as the Contractors responsibility to plan, implement and maintain with the end goal of producing a quality product based on the Engineers construction drawings and design philosophies. This document will look at two different approaches to highlight the use of geo-synthetics fabrics in the construction method.

The following practical example is adopted for discussion.

A replacement two-cell 3.0m x 3.0m cellular box culvert is to be placed under a proposed 14.0m new formation width from an existing 8.758m formation width. The vertical and horizontal alignment has been adjusted to suit design criteria. The example is illustrated by Figure1 and 2 below. Fill material obtained from residual sandstone borrow pit with no cohesion and a density averaging 18kN/m$^3$.

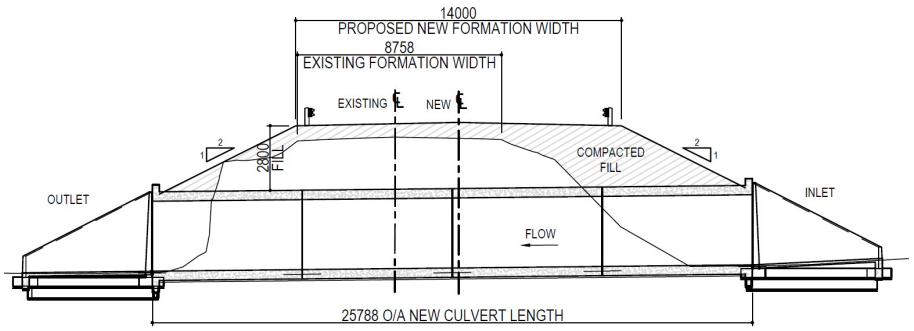


Figure 1. Longitudinal section through culvert centerline

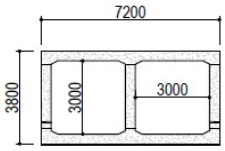


Figure 2. Cross section through culvert

A critical area of concern for road construction is limiting any adverse effect on the public commuting through the construction site by providing safe travelled lanes commonly done under the item traffic accommodation with additional safety protection measures dictated in the contract documentation and laws.

For both of the construction methods discussed, an initial single lane stop-go is adopted with a minimum 3.4m lane with an allowance for 1.0m wide new-jersey barriers to be placed on the existing road. This is done as a short term measure in order to provide sufficient working space to construct portions of the new culvert. Excavation is completed in layers and shot-creting with soil nails adopted to strengthen the existing travelled roadway as the supporting fill is removed. This is done to the designed founding levels of the new replacement structure.

## 2.1 Stepped Phased Half Width Construction

Following the example, this section looks at staged construction by adopting safe battered slopes over the new portion of the culvert. It was idealized that in order to mitigate the delays due to single lane stop go measures, dual traffic will be required over the new culvert portions. Geotechnical specialists indicated that with the existing fill material available for the construction site, safe battered slopes will be limited to 1:1 or 45°.

With this limitation and the requirement of dual traffic over the new structure portions, geometrically the roadway is limited to a lifting methodology as depicted in Figure 3 and 4 below.

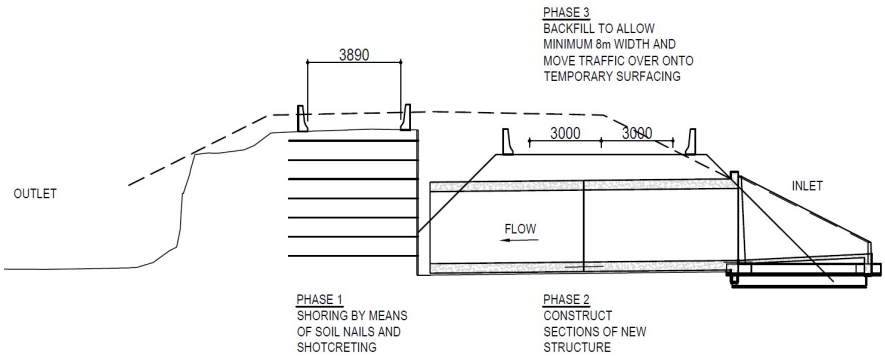


Figure 3. Construction Stage 1: Single Lane Stop-Go safety measures for existing road on left hand side. New culvert construction with dual traffic at first lift on right hand side.

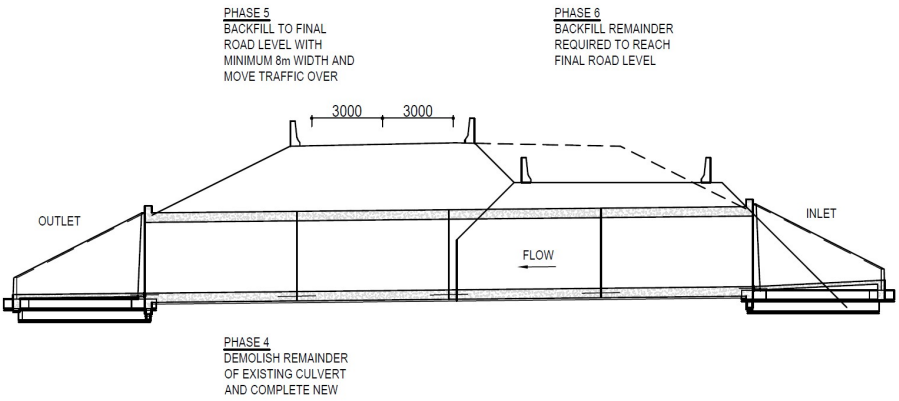


Figure 4. Construction Stage 2: Dual traffic is moved over to the newly constructed right hand side. Remainder of the culvert is constructed with road layers to final road level on the left. Construction Stage 3: Traffic is moved onto the left hand side and the road layers on the right hand side are then constructed to final road level.

This falls as the typical approach to road construction over major culverts with the first lift on the right hand side requiring a temporary surface to be constructed as depicted in Figure 3.

## 2.2 Soil Reinforced Half Width Construction

Similarly to that of the stepped phased half width construction, the criterion of accommodating dual traffic is required. Here however, a temporary vertical fill face is incorporated by means of geo-synthetic fabric wraps acting as a reinforced earth wall supporting the horizontal forces with the self-weight vertical force of the fill material. This is illustrated in Figure 5 below.

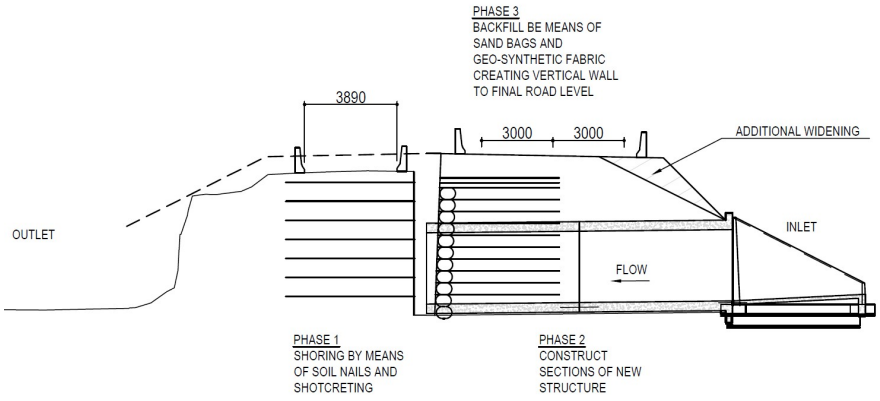


Figure 5. Construction Stage 1: Single Lane Stop-Go measures for existing road on left hand side indicating new culvert construction with dual traffic adopting geo-synthetic wrapping to final road level on the right hand side with minor additional widening.

This allows for the right hand side dual carriageway to be constructed to final road level avoiding the need for temporary surfacing, however requiring minor additional widening to accommodate the dual traffic criterion.

Figure 6. Illustration of shot-creting, new jersey barriers for existing road, new culvert and first layer of geo-synthetic fabric being placed. Captured by Author

Figure 6. Sand bags placed along edges of vertical face to provide additional stability during the compaction process. Captured by Author

The remainder of the existing road and culvert is excavated and demolished respectively and the final sections of the replacement culvert are constructed. The road layers on the left hand side are completed to final road level. With this process excluding the need to revert back to the right hand side to finish the road layers as per the stepped approach, this reduces the anticipated construction duration and in turn reduces the expected costs of construction.

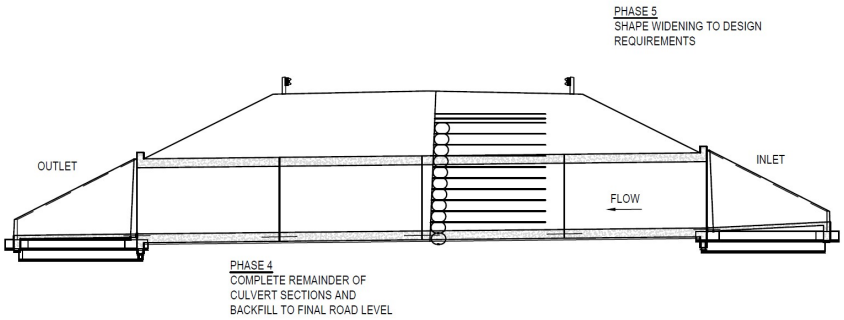


Figure 7. Construction Stage 2: Left hand side constructed to final road level

Figure 8. Left hand side new culvert under construction with right hand side at final road level. Captured by Author

## 3 Conclusions

With various service providers and products related to soil reinforcement readily available in South Africa and across the world, the use of geo-synthetic fabric in order to construct a temporary vertical soil reinforcement wall aides during road construction to accommodate dual traffic in restricted areas. The exclusion of a construction stage as well as the need for temporary surfacing comparing the step lift method to the soil reinforcement method expedites the construction process saving time and subsequent costs.

The choice of geo-synthetic to be adopted should be discussed with the relevant provider to determine the correct grade and product to be adopted for use. Technical literature and data sheets are readily available which is advantageous for planning and implementation.

The limitations to the soil reinforcement method will be site specific and at the culvert locations due to materials and design criteria.

Problems faced during the installation of the soil reinforcement wall were the exposed face of the geo-synthetic fabric being pushed out during the compaction procedure. Minor propping with shutter boards alleviated this. This was due to additional impact loading by roller compactors generating additional tensile forces of the fabric reaching maximum capacity and elongation.

## References

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