

# Appendix

## Method Statement

### Installation of Culverts over a Defined Water Course

#### 1. Introduction

In road design and construction, culverts are used to :

- Transfer water from one side of the highway (or road) to the other;
- Equalize ponds and marshes on both sides of a road; and
- Permit cattle, wildlife or vehicles to pass beneath the road.

Depending on the hydraulic capacity required, and the characteristics of the water course, culverts made by made up of pre-cast units, or may be constructed in place. In general, the preferred material for culverts is concrete, although metal culverts are also utilised.

#### 2. Planning of culvert structures

In planning the construction of culverts over a perennial stream, attention is paid to the following:

- The possible impact on all, or any, matters related to water quality, navigation, wetlands, flooding, agricultural drainage, erosion, fish, other aquatic organisms, bird nesting, endangered species habitat, and natural scenic beauty.
- Appropriate storm water soil erosion control.
- Culvert size and placement, fish passage, and flow control during installation.
- For smaller culverts, pre-cast concrete or corrugated metal pipe structures are cost effective options.
- Constructing the natural water flow. It is preferable to provide sufficient culvert openings across the full width of the natural water course.
- Rainfall patterns. Culverts should be installed during seasons of low rainfall to reduce the risk of damage and erosion during construction.
- When considering a fish passage, corrugated metal culvert pipes are preferred over smooth bottom culverts in shallow water conditions and steep slopes. The corrugated surface slows down water velocity, making it more fish friendly. Nevertheless metal culverts are not recommended where significant load bearing and longevity are required. Neither are they recommended in corrosive environments.
- Pipe culverts may be circular, elliptical or even pipe arches. Circular is the most common shape. However, it may be necessary to use other shapes, or multiple smaller pipes, when roadway height is a constraint.
- Selection of culvert shape is based on water depth, roadway embankment height, hydraulic performance, and fish and wildlife concerns.

- When closed section pipes are used, the invert of at least one pipe per culvert should be buried 150mm to 300mm into the stream bed and aligned with the stream channel as close as possible, to cater for wildlife and low-flow periods.
- Where fish and wildlife migration is a major concern, open-bottom culverts are preferred. However, bottomless structures are generally 30% to 50% more expensive than circular or oval pipes and require concrete support footings. The creation of a bypass or similar arrangement must also be considered during installation.
- On certain high-value streams, bridges of suitable spans are the preferred option. A structure which spans the whole water course will minimise any impacts.

### **3. Possible causes of failure**

Culvert failure can be catastrophic, sometimes resulting in the collapse of a road and its subsequent closure. Attention must therefore be given to the following to mitigate against possible failure of installed culverts :

- Inadequate culvert capacity for the calculated stream flow.
- Structural failure due to excessive soil loading.
- Washout due to water overtopping the road.
- End scouring from poor end treatment and lack of erosion protection.
- Improper jointing resulting in water piping along the outside of the culvert.
- Erosion due to excessive water transport of sand and gravel, arising from the acceleration of flow through the culvert.
- Corrosion from acid or salt laden soils and water.
- Improper inlet and outlet structures, resulting in embankment failures.
- Improper alignment of the culvert relevant to the natural channel, resulting in scour of the embankment at the inlet.
- Poor installation and/or bedding condition resulting in settlement, joint separation, or structural failure of the culvert.

### **4. Installation of Culverts**

Culvert design and planning for installation is carried out in the following stages for successful construction :

- Competent site investigation, sampling and relevant testing to build up an informed picture of the task.
- Adequate design of all the stages of the construction.
- Channelization of the stream with the minimum possible alteration to the natural stream flow in order to enable construction work to proceed. This is only done where necessary and if there are no alternative solutions.
- Proper alignment of the culvert with the stream channel to prevent erosion and also to facilitate fish and wildlife migrations.
- All Environmental as well as Health and Safety requirements and good practice must strictly be adhered to.

Items needed for installation may include, *inter alia*, :

- Excavators.
- Crane of sufficient lifting capacity and reach.
- Compacting equipment.
- Culvert components.
- An on-site concrete batching plant.
- Concrete delivery vehicles for wet concrete.
- Formwork, reinforcing steel, and the necessary tools for assembly.
- Equipment for construction of foundations where required.
- Equipment for construction of inlet- and outlet end walls.

## **5. Construction Method for Pre-Cast Culverts**

- 5.1 Partially divert the stream flow to facilitate construction of the culvert in dry conditions within the defined watercourse where possible.
- 5.2 Set out crossing angle for culvert in relation to road alignment.
- 5.3 Trim the bed of the water course to the desired levels and to create a suitable platform for construction.  
For small culverts, it may be appropriate to trench through an already constructed fill embankment.
- 5.4 Construct foundations where required for bottomless structures.
- 5.5 Place and compact bedding in accordance with specifications and drawings.
- 5.6 Place culvert components, ie pipe sections, box sections or arch sections, to correct levels and falls and secure.
- 5.7 Ensure adequate anchorage of the culvert components against flood forces.
- 5.8 Backfill either side of the culvert (and also between barrels where required) in accordance with the specifications.
- 5.9 Backfill over the culvert in accordance with the specifications.
- 5.10 Construct inlet and outlet structures, as well as erosion protection measures.
- 5.11 Relocate channelization back to original stream channel.
- 5.12 Re-instate stream bed and embankments as well as possible.
- 5.13 Construct the road pavement layers and surfacing.
- 5.14 End of culvert construction.

## **6. Construction Method for Cast In-situ Culverts**

Cast in-situ culverts offer flexibility in the sizing of the culvert openings and in the alignment of the culvert barrel. The in-situ option is generally preferred for very large culverts due to the weight of such large pre-cast units. An in-situ culvert will have less joints than the pre-cast option, and reinforcing steel can pass through the construction joint, minimising the risk of movement at the joints.

Cast in-situ culverts are also more labour intensive than the pre-cast option, providing increased employment opportunities for local labour.

The construction methodology and sequence is essentially the same as for the pre-units described in 5 above. The only real difference is that step 5.6 would be broken down into sub items as follows :

- 5.6(a) Fix the reinforcement steel for the culvert floor and walls.
- 5.6(b) Erect appropriate formwork for the floor and cast the concrete.
- 5.6(c) Erect appropriate formwork for the walls and cast the concrete.
- 5.6(d) Erect soffit formwork and fix the reinforcement steel for the culvert roof / deck.
- 5.6(e) Cast the concrete for the roof / deck slab.
- 5.6(f) Strip the formwork when the concrete is suitable cured.

Resume from step 5.7.

## **7. Conclusion**

Every culvert is unique and requires thorough analysis. The design must be compatible with the stream type, stream flow, fish and wildlife requirements, construction equipment, construction methods, culvert structures and ground conditions.

As soon as reliable geotechnical information is available, comparable cost studies should be analysed to determine if the chosen culvert option is economically acceptable.

For streams crossing existing major roads, other methods of culvert installation such as jacking, boring or tunnelling may prove to be economical due to the cost of traffic control and disruption of services added to normal construction. The alternative methods such as jacking will often have a lesser impact on the existing water course and will reduce the risk of disturbance, erosion and sedimentation.

In summary, jacking, boring and tunnelling can provide more environmentally friendly solutions.

## **References:**

1. SANRAL : Drainage Manual – 6<sup>th</sup> Edition 2013
2. SANRAL : Geometric Design Guidelines
3. COLTO : Standard Specifications for Road and Bridge Works, specifically Section 6100.
4. SANRAL : Code of Procedures for the Planning and Design of Highway and Road Structures in South Africa – 1<sup>st</sup> Edition 2002, updated 2008.
5. SANRAL : Construction Monitoring Manual for Bridges and Structures – 1<sup>st</sup> Edition 2011 – Chapter 4.8.