Culvert Crossings

Culverts are commonly used to provide road crossings over drains or small creeks, and there is a wide variety of culvert shapes and materials that can be selected to best suit a particular application. The correct design and installation of these culvert crossings will prevent blocked or eroded drainage channels as well as costly road repairs. There are a number of areas that need to be addressed.

Flow Capacity

The first and perhaps most obvious concern is to construct a culvert which is large enough to pass the design flow without overtopping the road or embankment. It is not practical to design culverts to take all possible flows; hence the designer must decide what risk level is acceptable for overtopping of the road and calculate a design flow of a suitable ARI (refer to Fact Sheet Nos 2 and 3). A culvert installation must then be sized to pass this flow. The hydraulics of culverts are surprisingly complex and rely greatly on the site conditions (ie. downstream flow depths, culvert sizes, shapes, lengths and slopes). It is not feasible to cover all possibilities in this handbook; however suppliers of culverts, State government roads departments, and many open channel hydraulics text books provide charts for determining the flow through various culverts. The basic controlling factors are as follows:

- **inlet/outlet control:** a culvert which is able to pass water at a greater rate than is being supplied is said to be flowing with *inlet control*. If the culvert inlet geometry, flow resistance or depth of water in the downstream channel result in water being supplied at a greater rate than it can flow through the culvert, it is said to be under *outlet control.* When using design charts it is important to examine both control cases and adopt the worst case value (ie. the highest headwater or least flow);
- **headwater:** the greater the level of water at the inlet to a culvert compared to the outlet, the greater flow it will pass. It is generally acceptable to design culverts to flow with water up to a level just below overtopping of the road (ie. 300 mm to 1.0 m), for the design peak flow;
- **downstream depth:** in contrast to the upstream depth, the normal depth of flow immediately downstream from the culvert should be kept as low as possible to maximise the efficiency of the culvert. To achieve this a deep or wide channel is advisable downstream of the culvert; and
- **inlet design:** the design of the inlet can greatly affect the flow capacity of a culvert flowing under inlet control. Greater flow can be achieved be shaping the approach to the culvert to funnel flow into the culvert. If the water entering the culvert has a high suspended solids load, it is important to keep this water moving through the culvert. Any ponding at the inlet will inevitably result in the culvert becoming blocked. To avoid this, drops or chutes can be utilised to accelerate flow into the culvert.

Inlet/Outlet Protection

Flows forced through culverts with a high head water will accelerate into the pipe and can discharge at a high velocity. High levels of turbulence will also result from water spreading out into basic channel flow again. To ensure that this high energy flow does not cause massive erosion at the inlet and outlet and under scour of the pipe it is important to provide erosion protection. This is usually achieved with headwalls and aprons of reinforced concrete, a concrete revetment mattress or grouted rock. At the downstream end, rock Rip Rap is also advisable for a further distance downstream from the apron. The level of protection required will depend on the outlet velocity, as described in Fact Sheet N0. 8.

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This will normally form part of the above hydraulic calculations.

Installation

Correct selection of culverts and supervised installation is vital to ensure that heavy vehicles passing over will not damage the culvert. Depending on the culvert material and shape selected, there will be varying requirements for cover (fill depth) over the culvert and compaction requirements around the culvert. Concrete culverts rely on their own strength and require good foundations and substantial cover, while corrugated steel culverts rely on the strength of the fill around them and hence require very good compaction in the side zones. Numerous Australian Standards, as well as material supplied by manufacturers, give excellent advice on correct installation. One important factor to note is that many mine vehicle axle loadings will exceed standard highway values and hence special care must be taken when selecting the class of culvert (ie. wall thickness) required.