FILL HEIGHTS FOR PRECAST CULVERTS UNDER ROADS

SNA

Concrete Manufacturers Association

REVISED REQUIREMENTS AND SPECIFICATIONS FOR PRECAST CONCRETE PORTAL CULVERTS INSTALLED UNDER NATIONAL AND OTHER ROADS

BACKGROUND

For many years several Roads Authorities have been concerned that the precast culverts manufactured and tested according to SABS 986: 1994 may not meet the strength and durability requirements for culverts given in TMH7: Code of Practice for the Design of Highway Bridges and Culverts in South Africa. This prompted the Pipe and Infrastructural Products (P&IP) Division of the Concrete Manufacturers Association (CMA) to appoint an independent consulting engineer to investigate these concerns and to identify the measures needed to address these matters.

This report is the result of this investigation and is supported by the South African National Roads Agency Limited (SANRAL).

INVESTIGATION

Structural strength

The structural investigation was carried out by comparing the load effects on the culvert units subjected to the proof loading specified in SABS 986 with that of the load effects of the SNABC installed loading specified in TMH7. This showed that the load effect envelope produced with the existing SABS 986 test loadings was inadequate to model the moments on the inside of the culvert legs and the shear in the deck slabs. The investigation was extended to identify and propose the changes to SABS 986 that would ensure that the test loading adequately modelled the load effects of the TMH7 installed conditions.

Durability

The concrete cover to steel reinforcement of 20 mm specified in SABS 986 is less than that permitted in TMH7 and the COLTO Standard Specifications for Road and Bridge Works.

For inland areas (further than 1 km from the sea) the 20 mm is sufficient as the environment can be considered mild. To ensure that this minimum cover is achieved a nominal cover of 25 mm will be used for the manufacture of precast culverts.

For coastal areas (within 1 km from the sea) the durability of the culvert units used has to be improved by specifying increased concrete cover and/or the use of cement extenders.

- For concrete not in direct contact with seawater the minimum cover using a 50 MPa portland cement mix should be 50 mm. If a fly ash/slag extender is used this can be reduced to 40 mm.
- For concrete in direct contact with seawater the minimum cover using a 50 MPa portland cement mix should be 75 mm. If a fly ash/slag extender is used this can be reduced to 50 mm.

The specifying authority/engineer should also check whether the discharge through the culvert is aggressive to concrete. If this could occur special measures would be required.

PROPOSED REVISION OF SABS 986

The strengths of precast portal culverts manufactured in accordance with SABS 986 are defined in terms of their S-load, which is the value of the vertical proof load expressed in kN per metre of culvert length per metre of culvert span.

Proposed amendments and additions for incorporation in SABS 986 are:

- In addition to applying the proof load at midspan it will be mandatory to apply it at the critical shear section on the deck.
- An additional horizontal load will be applied to the outside of the leg at 0,2 times the leg height from the bottom for culverts where the height to span ratio exceeds 0,5.
- The culvert units will be checked using a calibrated electronic cover meter to ensure that the nominal concrete cover of 25 mm to the reinforcement is never less than 20 mm.
- When a minimum fill height of 300 mm over a culvert cannot be achieved a 100 mm concrete slab reinforced with SMF 395 steel mesh shall be cast on top of the culvert.
- Where applicable, the culvert legs shall be marked at the appropriate level for propping.

Figures 1 (a), (b), (c) show the proposed test loading configurations. This and the other proposed changes are supported by SANRAL.

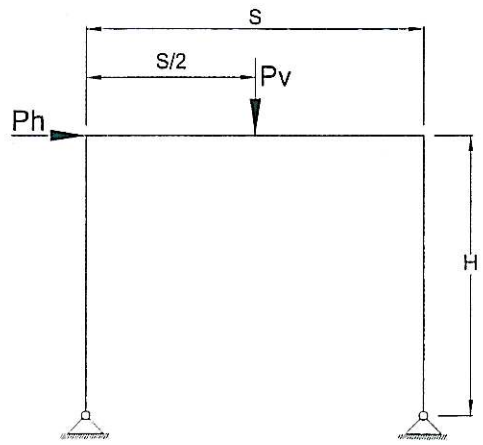


Fig.1 (a): VERTICAL & HORIZONTAL DECK LOADS

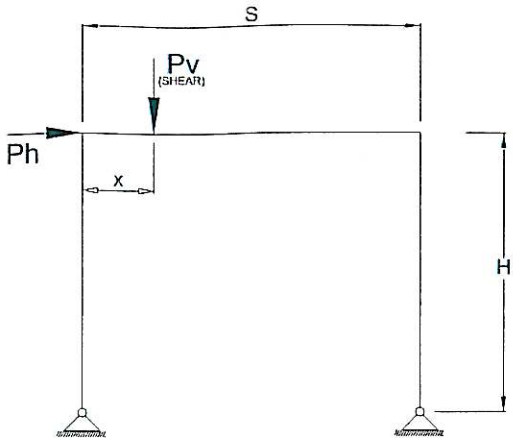


Fig.1 (b): DECK SHEAR LOAD

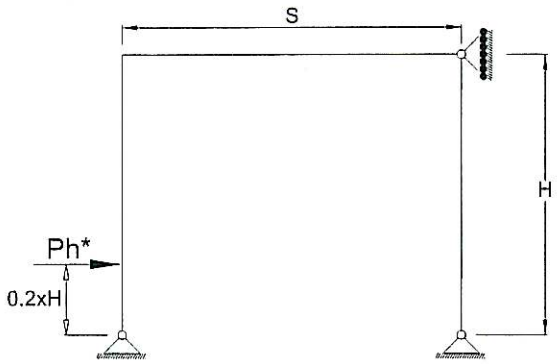


Fig.1 (c): HORIZONTAL LEG LOAD

Proposed revisions to Portal Culvert loading.

Pv = Vertical Load (can be applied at any point)
Ph = Horizontal Load
Ph* = Horizontal Load for Leg Test
x = Position of critical shear.
As defined in revised SABS 986.

INSTALLATION

It is important that the precast portal culverts are stored, handled and installed in accordance with the "Concrete Pipe and Portal Culvert Installation Manual" available from the CMA's P&IP Division or culvert manufacturers. Installation details are shown in figures 2, 3, 4 and 5. Two very important precautions are:

- When a culvert is 1,5 m or higher the legs are to be propped during installation at a point 0,4 times the leg height above the base. The propping level shall be marked on the culvert unit in the factory (refer to figure 5).
- When multiple barrels of culverts are installed a gap shall be left between the barrels and filled with a 15 MPa concrete (refer to figure 3).

PRECAST PORTAL CULVERT INSTALLATION DETAILS

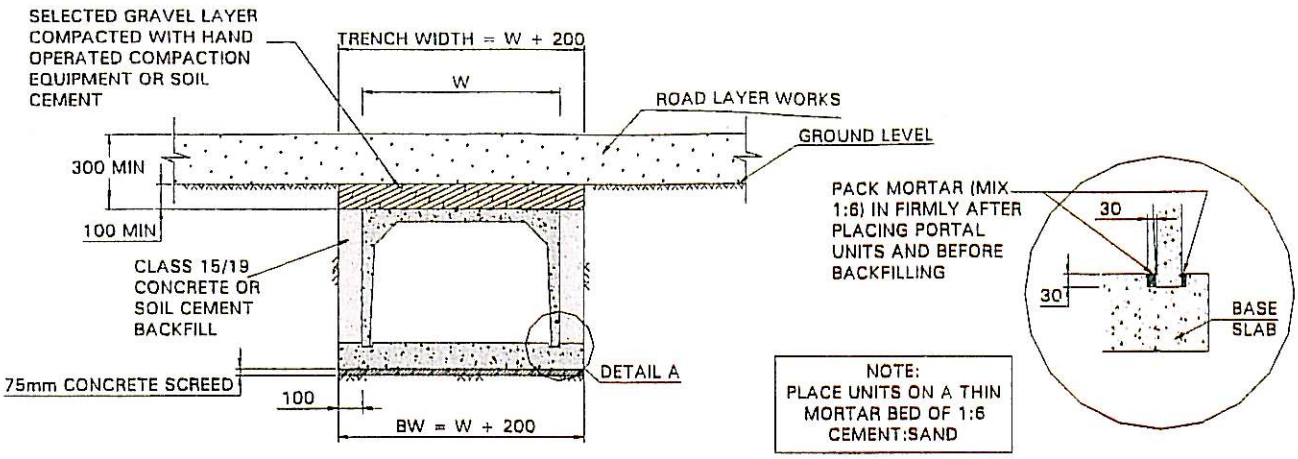


FIGURE 2: TRENCHED INSTALLATION

DETAIL A

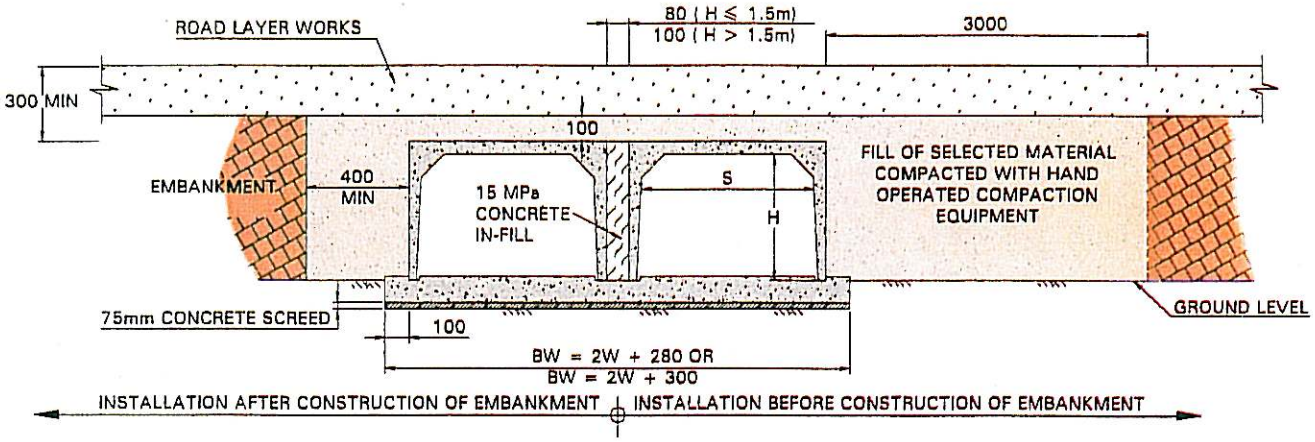


FIGURE 3: EMBANKMENT INSTALLATION

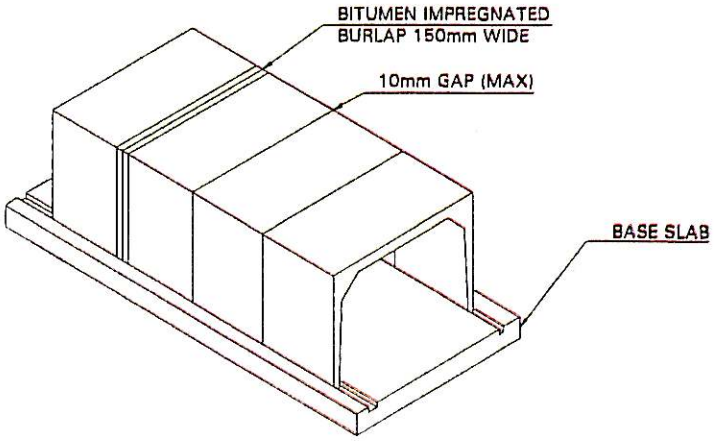
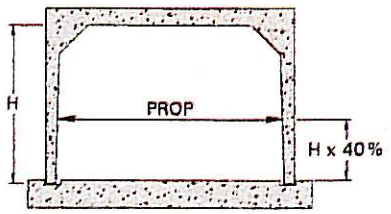


FIGURE 4: CULVERT AND BASE CONFIGURATION



NOTE :
FOR H≥1,5m PROVIDE HORIZONTAL PROPS AT 40% HEIGHT ABOVE BASE DURING BACKFILLING AND COMPACTION, ONE PROP PER PRECAST UNIT

FIGURE 5: TEMPORARY PROPPING ARRANGEMENT

CULVERT SIZE			FOUNDATION CONDITIONS			
			1 & 2		3 & 4	
SPAN		HEIGHT	CLASS	FILL	CLASS	FILL
(mm)	x	(mm)		(m)		(m)
600	x	300	200 S	10,2	200 S	5,6
600	x	450		11,0		6,0
600	x	600		12,0		6,4
750	x	300	175 S	8,7	175 S	4,9
750	x	450		9,2		5,2
750	x	600		10,0		5,5
750	x	750		10,5		5,8
900	x	300	175 S	8,6	175 S	4,8
900	x	450		9,0		5,1
900	x	600		9,5		5,3
900	x	750		10,0		5,6
900	x	900		10,2		5,8
1200	x	300	150 S	7,1	150 S	4,1
1200	x	450		7,4		4,3
1200	x	600		7,7		4,4
1200	x	900		8,2		4,7
1200	x	1200		8,8		5,0
1500	x	300	100 S	4,5	100 S	2,9
1500	x	450		4,7		3,0
1500	x	600		4,9		3,1
1500	x	900		5,3		3,3
1500	x	1200		5,6		3,5
1500	x	1500		6,0		3,7
1800	x	600	75 S	3,3	75 S	2,4
1800	x	900		3,6		2,5
1800	x	1200		3,8		2,7
1800	x	1500		4,0		2,8
1800	x	1800		4,3		2,9
2100	x	600	75 S	3,3	75 S	2,4
2100	x	900		3,5		2,6
2100	x	1200		3,7		2,7
2100	x	1500		3,9		2,8
2100	x	1800		4,1		2,9
2100	x	2100		4,3		3,0
2400	x	600	75 S	3,2	75 S	2,4
2400	x	900		3,4		2,5
2400	x	1200		3,5		2,1
2400	x	1500		3,7		2,9
2400	x	1800		3,8		2,8
2400	x	2400		4,0		3,0
3000	x	600	75 S	3,1	75 S	2,4
3000	x	900		3,2		2,5
3000	x	1200		3,3		2,6
3000	x	1500		3,4		2,7
3000	x	1800		3,5		2,7
3000	x	2400		3,7		2,9
3000	x	3000		3,1		2,7
3600	x	600	75 S	3,1	75 S	2,4
3600	x	900		3,1		2,5
3600	x	1200		3,2		2,6
3600	x	1500		3,3		2,6
3600	x	1800		3,3		2,7
3600	x	2400		3,5		2,8
3600	x	3000		3,5		2,7

TABLE 1. Maximum TMH7 fill heights on S-load culverts

PERMISSIBLE FILL HEIGHTS

The relationship between the proposed S-load culvert classes defined in SABS 986 and the corresponding maximum permissible fill heights to meet the TMH7 requirements was calculated and is given in table 1. If culverts are to be placed under higher fills than those given in this table then a higher S-load Class must be specified. The manufacturer may be consulted in this regard

Definitions

Yielding foundation conditions occur when the founding material and the fill material are expected to settle at equal rates (compressible material). The loading is calculated in accordance with TMH7 Part 2 clause 2.3.3.2 (2).

Unyielding foundation conditions occur when the founding material is incompressible (soft rock or other harder material). The loading is calculated in accordance with TMH7 Part 2 clause 2.3.3.2 (3) and (4).

Trench condition occurs when culverts are laid in a narrow excavation and backfilled to ground level.

Embankment (untrenched) condition occurs when culverts are laid at ground level and backfilled to final formation level.

The combinations of foundation and installation conditions used in TMH7 are defined as:

Condition 1: Culverts in trench on unyielding foundation with no projection.

Condition 2: Culverts untrenched on yielding foundation.

Condition 3: Culverts untrenched on unyielding foundation for $h>1,7b$.

Condition 4: Culverts untrenched on unyielding foundation for $h\leq1,7b$.

Where h = *fill height in metres*

b = *overall trench width or, if untrenched, overall culvert width, in metres.*

Assumptions

The following assumptions and clauses of TMH7 Parts 1 and 2 were used to compile Table 1.

- A minimum fill height of 300 mm over the culvert units. Where this cannot be achieved a 100 mm reinforced concrete slab must be used.
- Standard traffic loading (SNABC) as described in Clause 2.6.1.2.
- Fill material unit weight 20 kN/m^3 [Clause 2.3.1].
- Concrete unit weight 24 kN/m^3 [Clause 2.2.1].
- Horizontal earth pressure 7,8 kN/m^2 per metre depth [Clause 2.4.2].
- Ultimate Limit State load factors Table 7.

Culvert Producers:

CONCRETE UNITS

INFRASET

ROCLA (PTY) LTD.

SABS MARK HOLDERS

Pipe & Infrastructural Products Producer Members:

Concrete Units	Tel: (021) 386-1923
Infraset	Tel: (011) 827-3517
Rocla	Tel: (011) 670-7600
Salberg Concrete Products	Tel: (011) 316-3410
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