Geocomposite Edge Drain Evaluation on Ontario Highway 402 at Strathroy

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ABSTRACT: Presented are results from excavations made to evaluate the performance of Geocomposite Edge Drains (GED). The highway of the areas investigated was built in 1981 over a stiff (c_u=50 to 100 kPa) clay subgrade (LL=40; PL=20; PI=20) as part of Ontario's freeway system (i.e. limited access divided highway). The GED was placed in 1990 and consisted of a plastic core 300 mm wide with 25 mm high cusps all wrapped in a nonwoven geotextile. The excavations clearly showed differences between the installation concept and actual construction. First, the GED was unable to prevent the underlying clay from pumping. Second, the GED installed was not square ended. Third, permeability tests on the backfill showed that the granular backfill was nearly 1000 times less permeable than the geotextile of the GED. These and other factors resulted in several valuable and practical conclusions.

1 INTRODUCTION

As one of a number of drainage systems investigated under contract "Performance of Geotextile-Based Hydraulic Pavement Systems" between Queen's University and the Ministry of Transportation, Ontario (MTO) excavations at various locations on Ontario Highway 402 just east of interchange 81 (near Strathroy) were made on 91/08/21.

Highway 402, at the locations of the investigation, was built in 1981 as part of the freeway system in Ontario (i.e. limited access divided highway with at least two lanes in each direction). At the site selected the original construction was built over a stiff (c_u = 50 to 100 kPa) silty clay subgrade. Typical Atterberg limits were LL = 40; PL = 20; PI = 20. Placed over the subgrade was 125 mm of lean concrete base, 175 mm of structural concrete and 40 mm Ontario designated HL4 asphalt binder plus 40 mm HL1 asphalt wearing surface. Adjacent to the pavement edge was a 3 metre wide partial paved shoulder. The partial paving was an 80 mm thick asphalt 610 mm wide.

In 1990 several sections of the highway were repaired/rehabilitated. The contract consisted of two phases. Phase 1 (removal/replacement) was done on about 10% of the contract chainage in the right lane and consisted of the removal of the load bearing structure down to subgrade and its replacement by a 100 mm thick geotextile-wrapped open graded unbound drainage layer (OGDL),

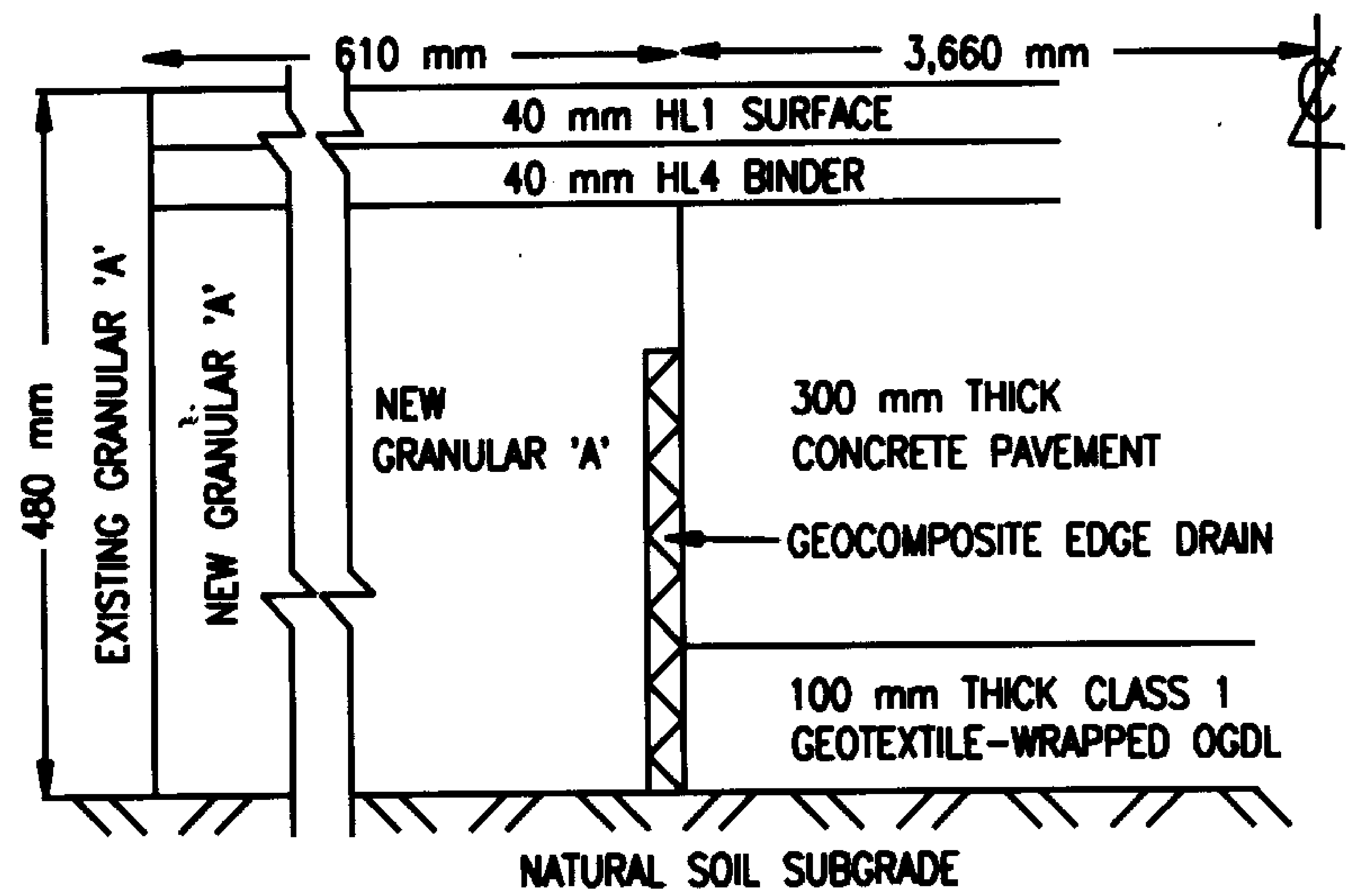

Figure 1. Cross section of Geocomposite Edge Drain installation as required from construction drawing.

300 mm of structural concrete and an asphalt overlay of 40 mm HL4 plus 40 mm HL1. The main cross section for the rebuilt portions is shown in Figure 1. Phase 2 consisted of placing a Geocomposite Edge Drain (GED) along and adjacent to the pavement edge (i.e. structural concrete). The GED was placed along the entire length of the contract chainage.

2 GEOCOMPOSITE EDGE DRAIN (GED)

The GED consisted of a high density polyethylene plastic core 300 mm wide with 25 mm high cusps having a

Table 1. Excavation and outlet locations (chainage in metres).				
Trial Pit	**West Outlet**	**Excavation**	**East outlet**	**Remarks**
TP1	23+685	23+710	23+785	Outlets working
TP2A	24+250	24+270	24+350	Outlets working
TP2B	24+250	24+266	24+350	Outlets working
TP3	25+526	25+575	25+626	Outlets not working
TP4	25+426	25+523	25+526	Outlets working
TP5	26+023	26+120	26+126	Poor outlet discharges
TP6	26+023	26+023	26+126	Poor outlet discharges

crushing strength of 380 kPa (ASTM D1621) all wrapped in a nonwoven polyester geotextile having a Filtration Opening Size (FOS) (CGSB 10.2-M) between 212 μm maximum and 75 μm minimum. The geotextiles grab strength (ASTM D4632) was 400 N and its mass/unit area 135 g/m^2. It was installed manually in a 600 mm wide trench. Outlets to the ditch were to be provided at all low spots and every 100 metres. The trench was backfilled with the excavated material. After compaction of the backfill, the partially paved shoulder was replaced.

3 OBJECTIVE

The objective of the investigation was to determine the effectiveness of the Geocomposite Edge Drain (GED) installed one year earlier (1990). In particular, it had been noted that frost heave and subsequent thaw settlements above the GED had occurred at some chainages along the partially paved shoulders of Highway 402.

4 WEATHER/DITCH CONDITIONS

The weather the night before the excavations were made was heavy rainfall. The ditches on flat sections of the highway had standing water which was, in all cases, at a lower elevation than the outlet pipes. The ditch centre lines were 6.4 to 7.7 metres from the pavement edge.

5 POSITION OF EXCAVATIONS AND OUTLETS

All excavations were made on the south side of the east bound lane. The chainage of the seven excavations and the nearest outlets are given in Table 1. It was noted that all outlets had discharged considerable sediment although the outlet pipes were clean.

6 EXCAVATION TP1

At the first excavation the pavement had intermittent centre line cracks; intermittent severe to moderate mid-lane cracks; multiple transverse cracks; transverse 'rout and seal' cracks that were starting to result in further alligator cracks. The paved shoulder area had considerable shoulder edge cracks running parallel to the structural pavement edge and the paved shoulder area dropped transversely towards the outer edge. The pavement shoulders were subject to about 50 mm of frost heave during the winter.

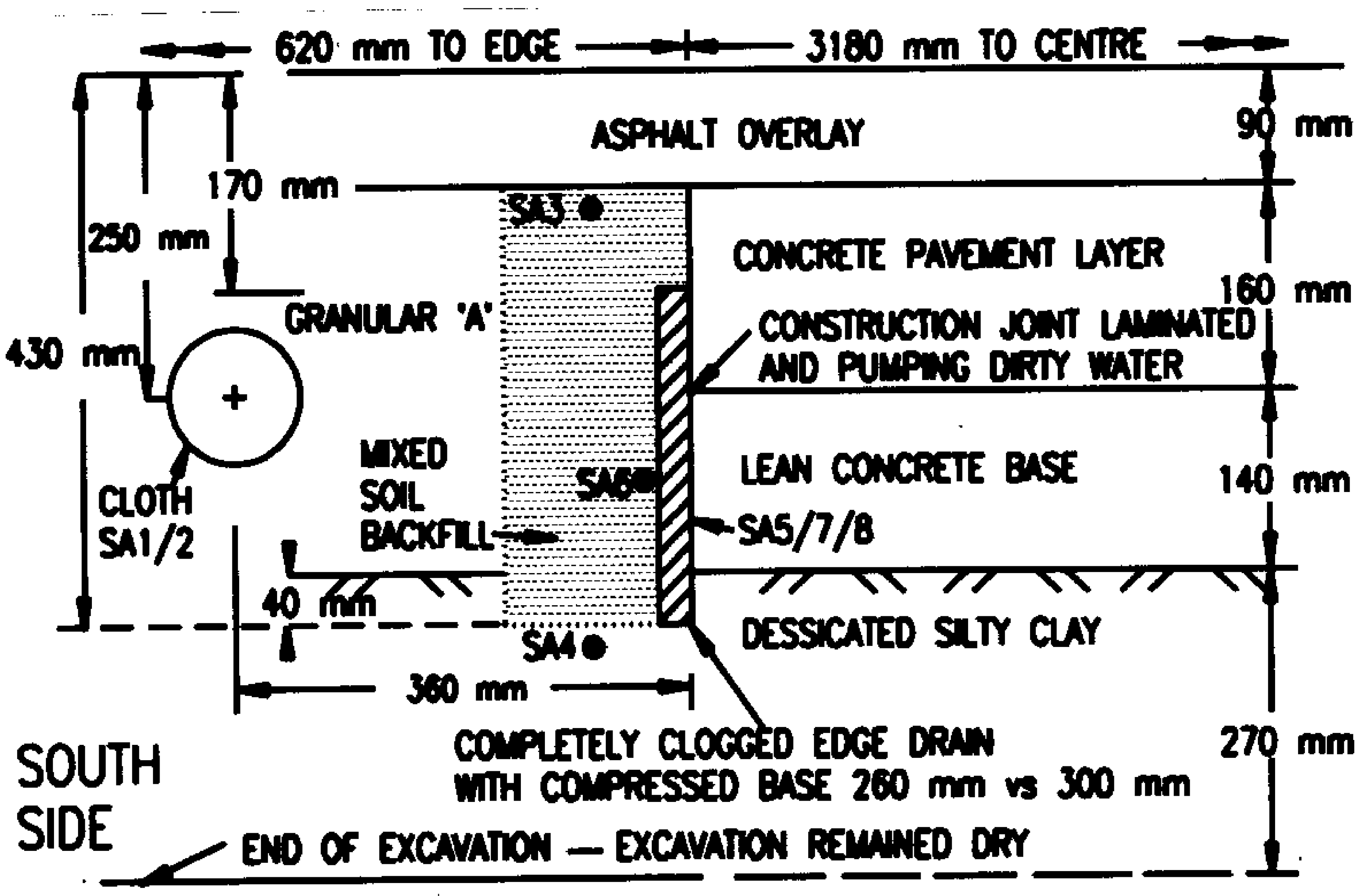

Figure 2. Cross section at Excavation TP1.

This first excavation was made in a Phase 2 only area (i.e. GED only installed with no rebuild). The pavement edge dimension, GED dimensions and locations of samples taken are given in Figure 2. The GED was completely plugged with clay. A grain size analysis on the subgrade gave 100% passing the 75 μm sieve which is the minimum FOS limit specified by MTO for GED geotextiles. Examination of the concrete slab edge wall indicated that clay was pumping between the structural concrete and lean concrete layers and there was infiltration of water through the pavement surface crack. The GED, was installed into the subgrade as seen in Figure 2. The subgrade soil appeared to be part of the GED trench backfill soil. A grain size analysis of the backfill (sample SA6 on Figure 2) is presented in Figure 3 and shows some 14% of the sample passing the 75 μm sieve. Such a high percentage of fines would not be conducive to good drainage. This was confirmed by doing a permeability test on the material passing the 4 mm sieve, washing the fines from the tested sample and repeating the test. The resulting values gave a

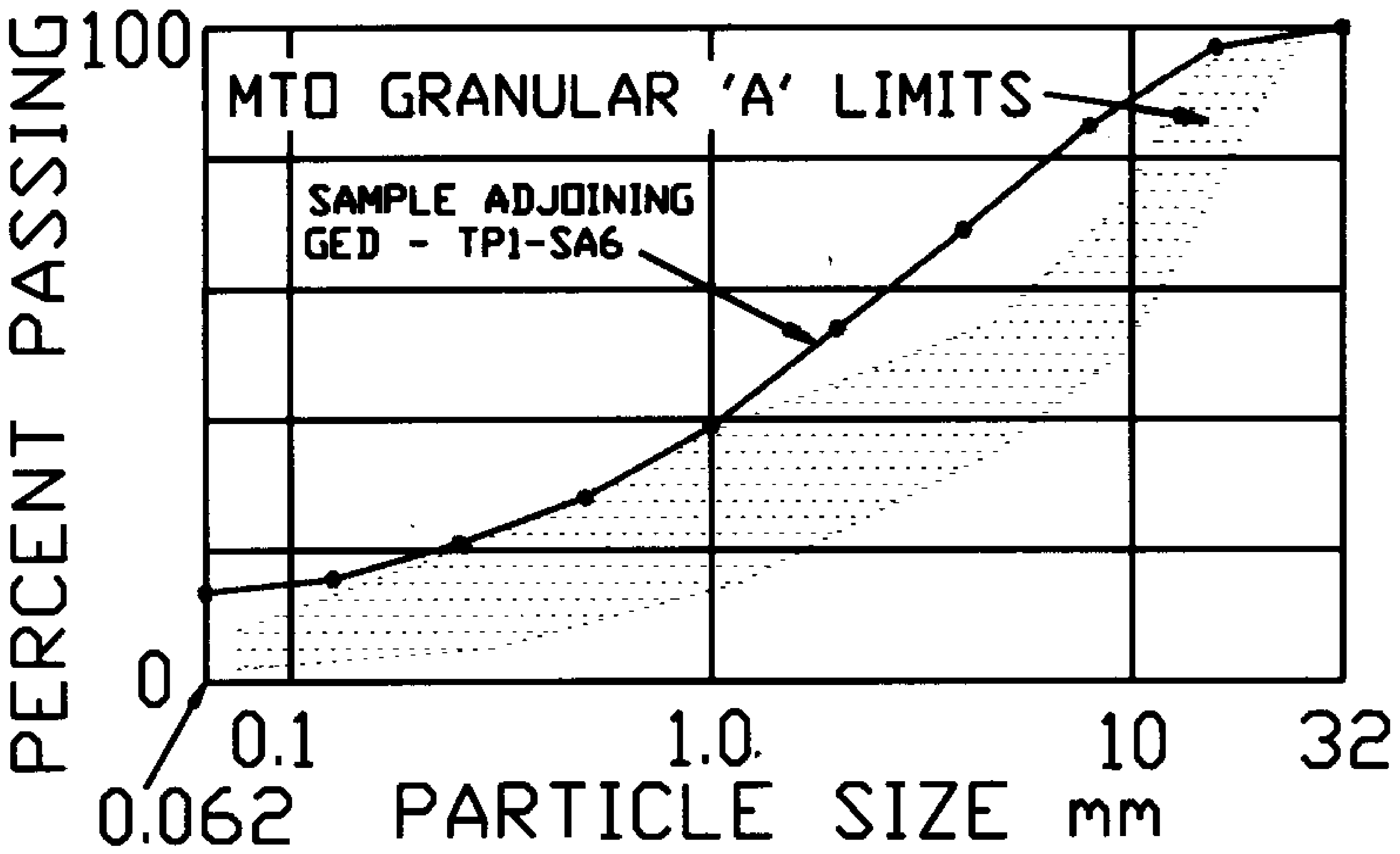

Figure 3. Grain size distribution of sample adjoining Geocomposite Edge Drain at Excavation TP1.

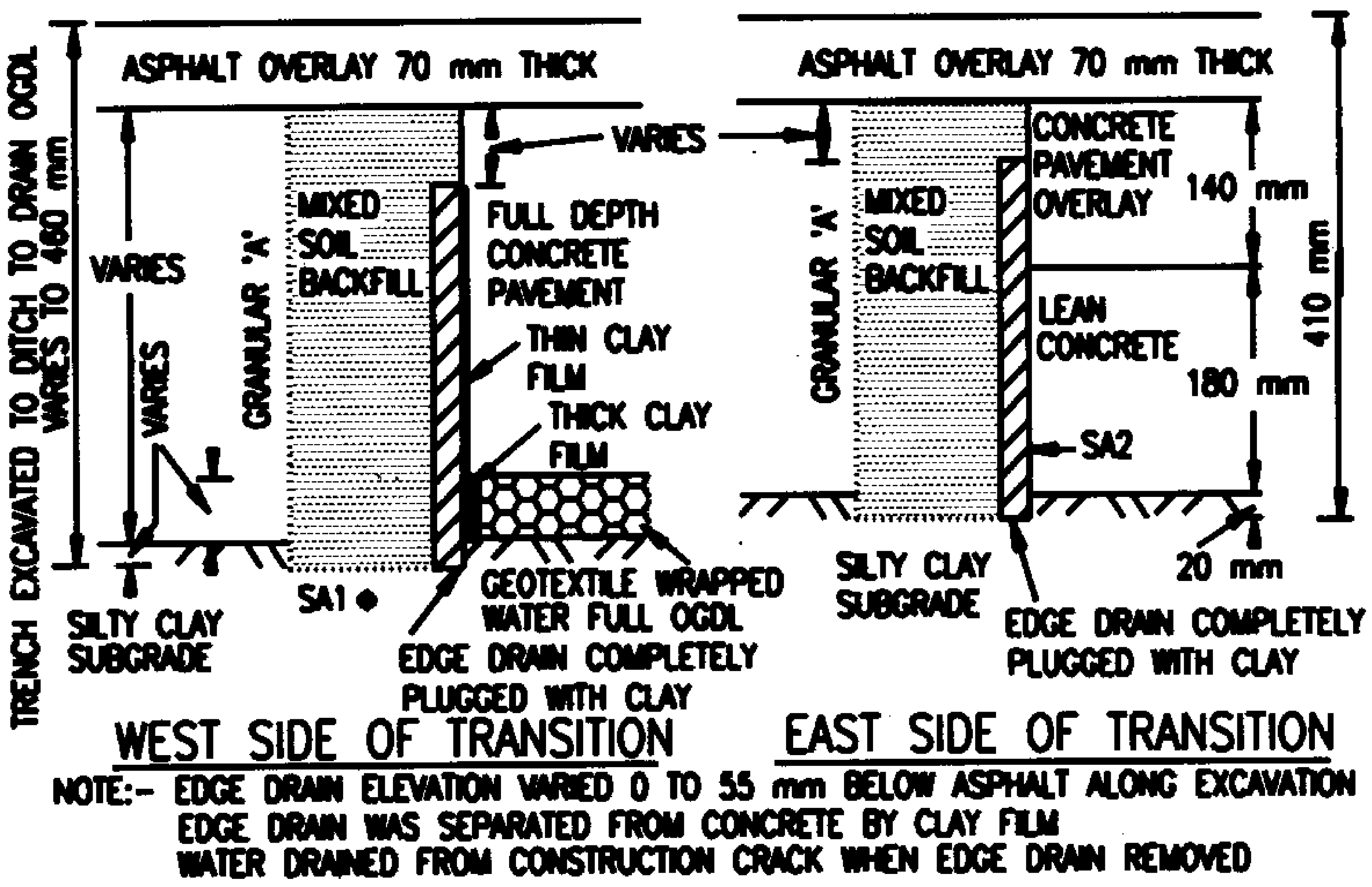

Figure 4. Cross section at Excavation TP3.

permeability of 0.532 μm/s for the dirty sample, 99 μm/s for the washed sample and a loss of weight from washing of 8%. These values may be compared with an in-plane permeability of about 400 μm/s for the geotextile. Clearly the use of a clean washed granular backfill would be most beneficial in helping the internal drainage of the pavement. A thin layer of such material should also be laid prior to placing the lean concrete. The GED systems cannot prevent pumping where pumping might have existed before installation of the GED. While 10% of the section which exibited severe pumping was reconstructed under Phase 1, the less distressed areas were only retrofitted with the GED under Phase 2 without increasing the structural capacity of the pavement.

Atterberg limits on the clay subgrade gave LL = 37, PL = 19, PI = 18 and on the material from within the GED LL = 42, PL = 25, PI = 17. For both samples, 100% of the material washed through a 75 μm sieve.

Elevations taken on the pavement edge at its surface at 10 metre intervals to distances of 20 metres on each side of the position of the excavation showed that the road surface was essentially flat. Starting at a location 20 metres to the west of the excavation the road rises 13 mm then drops to 0 mm at the excavation, it then rises 8 mm over the next 10 metres and then has the same elevation at 20 metres east. If, as expected, the GED was installed at a constant depth below the pavement edge then the GED base (invert) is also level (flat) and there is no hydraulic gradient from a position midway between the outlets to the outlet locations. This is clearly not good hydraulics for drainage. It should be noted that the current MTO specifications require at least a 0.1% slope for the longitudinal drainage.

7 EXCAVATION TP2A AND TP2B

At the second location the pavement surface was very similar to that at the first location except that there was only one crack at the shoulder and the paved shoulder area did not drop away towards its outer edge. The shoulder conditions would suggest much less frost heave during the winter 1990/91 at this site than at the first location. Some evidence of pumping was observed at the centre line of the two eastbound lanes although the GED only had a little sediment in its base.

At the base of the excavation a Torvane was used to determine the strength of the silty clay. On the subgrade surface a value of c_u = 33 kPa was measured and 13 mm below this level the value measured was 70 kPa. Clearly the subgrade was showing signs of softening and, once fully softened, pumping can be expected to occur and to plug the GED. The Atterberg limits and permeability test results on the backfill were similar to the values at TP1.

8 EXCAVATION TP3

Excavation TP3 was made at a transition zone between the rebuilt structural pavement westerly portion of the outer driving lane and a non-rebuilt pavement easterly portion. Both, of course, were retrofitted with GED. A centre lane crack started at the unrepaired section of the highway between the passing and driving lanes. The crack included a large pothole, partially filled with water, starting at the junction of the transition zone and extending into the unrepaired portion. The dimensions of the two pavement profiles are shown in Figure 4. A GED taped joint, connecting two lengths of GED, was found on the rebuilt pavement side of the transition zone.

There was considerable variation in the GED base (i.e. invert) along the length of this excavation. There was a full head of dirty water in the geotextile-wrapped OGDL. A slime buildup existed on the inside geotextile surface. In addition, the OGDL was horizontally separated from the GED by about a 60 mm thick layer of pumped clay sediment mixed with backfill aggregate. Exposure of the geotextile resulted in only a very slow drainage of the OGDL. This was due to the clay particles on the surface of the geotextile and suspended within the water trapped in the OGDL. It was not until the geotextile was punctured

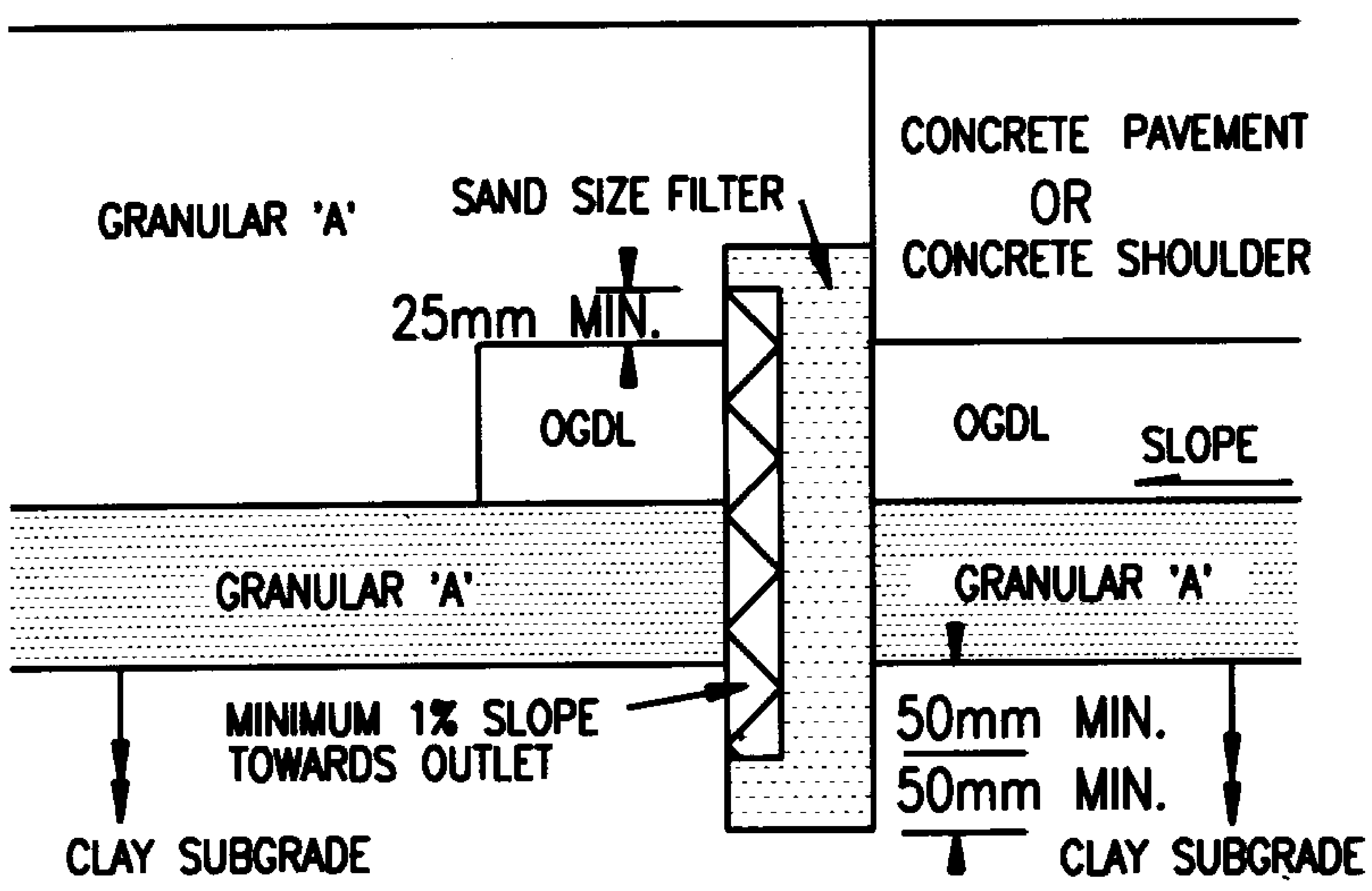

Figure 5. Recommended installation cross section.

that considerable quantities of water exited the OGDL and the water in the pothole dropped. Note that the measured dimension of the OGDL at the pavement edge was much less than the value shown on Figure 1 and was variable. The maximum depth was 60 mm. This may be due to the loss of clay on the subgrade and movement towards the edge of the slab or due to a less than required construction depth. It is unknown what the depth is, or its variation laterally across the highway. If thicker under the highway then water is probably trapped under the slab.

As might be expected the GED was completely clogged. In addition there was a thin clay film between the edge of the pavement slab wall and the GED. Here again is evidence that the GED's geotextile should be protected from clogging by a clean granular filter.

Additional excavations between other outlet pipes of the same highway edge confirmed the general findings.

9 DISCUSSION

The excavations have shown clear differences between the installation concept given on Figure 1 and actual construction. First the geotextile wrap for the OGDL was unable to retain the underlying clay from pumping. This is not too surprising since presently (1993) geotextiles do not have FOS values much less that 100 μm while clay subgrade samples taken at this site washed through a 75 μm sieve. Granular materials which have pore sizes about one fifth their smallest particle sizes are recommended to prevent pumping. In this case a good specification would be a grading similar to the sand portion of ASTM-C33 with the addition of the limits of 0-2% passing the 75 μm sieve.

The second point worth noting is that the GED installed was not square ended as shown on the construction drawing (see Figure 1). The outer face was longer than the inner face, thus there were bevels at both ends leaving a probable gap of 15 mm at the bottom of the inner face. To ensure contact with the base elevation of the OGDL the base of the GED would have had to be installed at least 15 mm below the OGDL base level. A further design shortcoming is that the present MTO GED specification (499F01) does not require any vertical compressive strength for the core. In all the excavations the lower cusp of the core of the GED was bent and in some cases even crushed vertically. In some cases the distorted core resulted in the GED base being at an elevation above the OGDL. Since the GED was placed in a 600 mm wide excavated trench it would appear that the crushing and bending resulted from the frost action.

Permeability tests on the minus 4 mm sizes of the backfill have shown that the backfill is in the range of nearly 1000 times less permeable than the geotextile of the GED. The backfill permeability should be improved by using a clean granular backfill. A recommended cross section is shown in Figure 5.

10 CONCLUSIONS AND RECOMMENDATIONS

Open graded draining systems and drainage collection systems must be protected from the intrusion of fines by an appropriate granular filter layer. Recommended is a layer of the sand portion of ASTM-C33 with the addition of the limits of 0-2% passing the 75 μm sieve.

Backfill used for Geocomposite Edge Drains (GED) should have a permeability similar to the above clean sand.

The base elevation of GED must be located below that of the base elevations of the layers they are intended to drain, plus any damage that may result from frost or installation damage. A minimum 100 mm is recommended.

Retrofit GED may not be an appropriate rehabilitation technique when the pavement already exhibits pumping and faulting unless accompanied by increased structural capacity of the pavement.

The GED Specification should state a minimum vertical compression and buckling resistance for the core.

In areas of long flat sections of highway, GED should be installed with minimum gradients dropping from mid-outlet locations to outlet locations. A suggested minimum hydraulic gradient of 1.0% (i=0.01) is recommended.

The installation of the GED should be carefully monitored during construction to ensure compliance with specifications.

11 ACKNOWLEDGEMENT

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