Analysis of Factors Affecting Flow in Panel Shaped Geocomposite Drains

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ABSTRACT: This study investigates the effects of adjacent soil structure, confining pressure and dynamic loading on the flow capacity of two panel shaped geocomposite drains (GCD).

Increased usage of panel shaped geocomposite drains has occured due to the panel shape aiding efficient interception of water along the full height of the panel, comparative flow rates with round, slotted pipes and ease of installation when compared to aggregate drains.

1 INTRODUCTION

The major reason for pavement failure is poor drainage (Koerner, 1990). A panel shaped GCD aids pavement consolidation by stabilising the base soil through the effective drainage of water. The long-term performance of the drainage system may be affected by horizontal, vertical and eccentric loading caused by vehicles encroaching onto the pavements edge and also by high soil confining presssure induced during installation and compaction.This leads to the need for high structural rigidity in the pavement edge drain.

The flow capacity of a panel shaped GCD is determined by four main factors.

1.1 Structural Rigidity

A GCD may deform when load is applied vertically, horizontally or eccentrically unless the structural rigidity is sufficient to resist these stresses.

1.2 Geotextile Intrusion

Dynamic loading and the properties of the base soil may induce geotextile intrusion (Hwu and Koerner, 1990) into the core of the GCD, unless the structure of the core or the tensile modulus of the geotextile are designed to resist intrusion.

1.3 Infiltration Rate

The infiltration rate of water through the side-wall of the panel shaped core is determined by the permeability of the base soil and the geotextile wrapping. The filtration performance of the geotextile must be defined to ensure there is not a decrease in water flow into the core, thus decreasing the flow capacity of the geocomposite drain.

1.4 Design

The shape, dimensions and structure of the GCD determine the theoretical flow capacity. Turbulent flow is induced (and therefore, flow capacity decreased) by the inner core configuration and surface drag created along the walls of the flow path.

2 PROPERTIES OF GEOCOMPOSITE DRAINS

The properties of each GCD evaluated in this study are listed in Table 1.

Table 1. Panel shaped core

Type	A	B
Trademark	Megaflo	Stripdrain
Composition	HDPE	PE
Nom. height	300 mm	300 mm
Panel width	36mm	37mm
Core shape	corrugated slotted columns	cuspated repeated each 50mm

The properties of the geotextile encapsulating Type A and Type B GCD's are listed in Table 2.

Table 2. Geotextile wrap

Type	A	B
Trademark	bidim	Terram
Composition	PET	PP/PE
Mass	143.7g/m^2	141.4g/m^2
Pore size(0_{95})	230μm	120μm
Flowrate (l/m^2/s)	454	50
Structure	nonwoven needlepunch	nonwoven 'melded'

3 TEST APPARATUS

A constant head flow steel test box consisting of a supply reservoir, sample reservoir (two metres long) and outlet reservoir was constructed for this investigation, as shown in figure 1.

Two loading mechanisms (vertical and horizontal) were used to model field conditions as shown in figures 2 and 3. Vertical load was applied at 600 kPa to simulate an equivalent imprint of one fully laden, overweight truck tyre in accordance with the Austroads Bridge Design Manual (1992). This loading mechanism effectively simulates eccentric loading on the GCD and stress caused by compaction of the adjacent drainage aggregate during installation. The GCD was placed adjacent to timber planks, with a 50 mm soil layer to simulate installation near a trench wall.

Horizontal load was applied to the GCD, located centrally in the sample reservoir, via two airbags producing confining pressures (range 0-150 kPa) from both sides of the test box.

Three types of soil were selected to simulate both normal drainage medium and a common base soil. These were a medium gravel (max. particle size 7mm), well graded sand and cohesive clay.

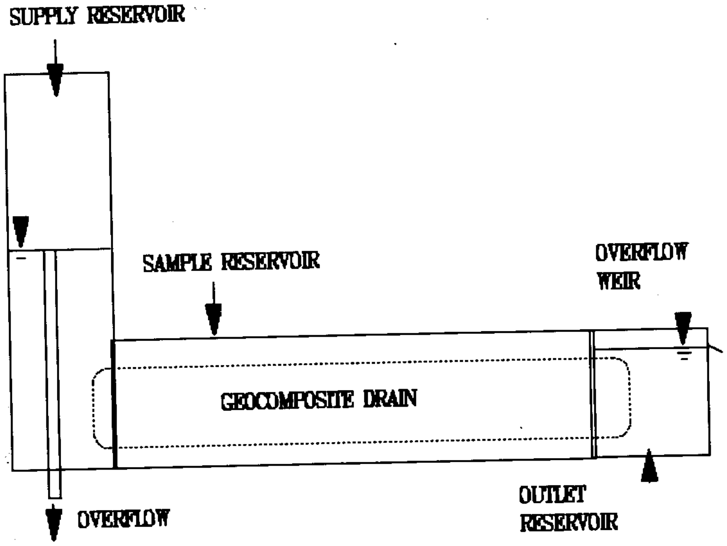

Fig.1 Flow apparatus

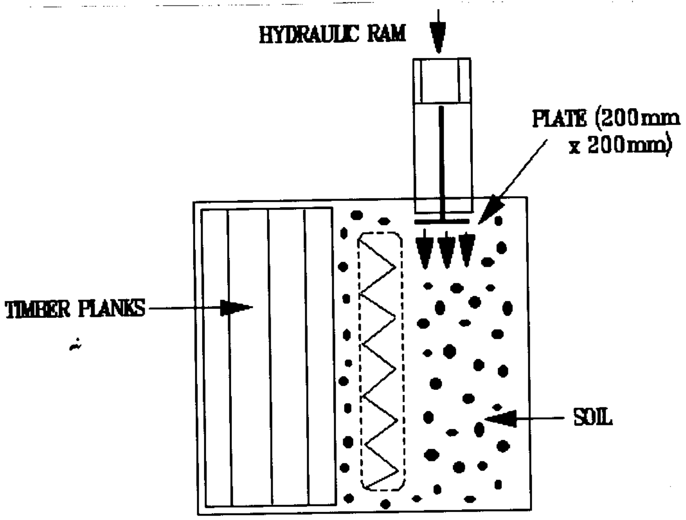

Fig.2 Vertical loading mechanism

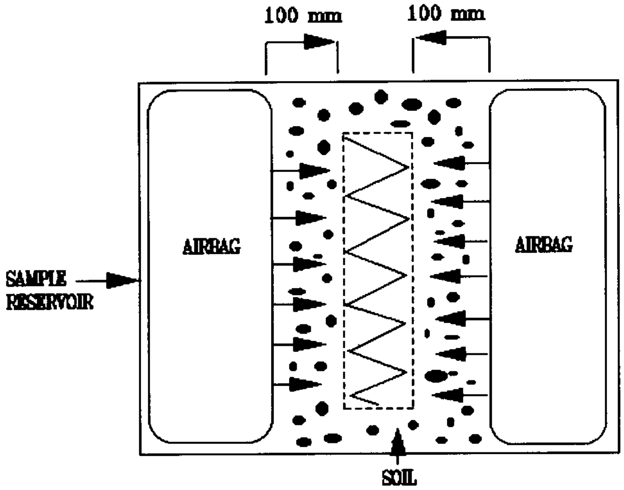

Fig.3 Horizontal loading mechanism

4 TEST PROCEDURES

4.1 Vertical loading - full channel flow

Each GCD was tested in each of the three soils. Water flow was introduced at a hydraulic gradient (i) of 0.01. Flow rates were recorded at zero pressure, vertical load applied to 600 kPa, then released and the system reloaded to 600 kPa. Flow rates were recorded to evaluate the short-term effect of dynamic loading on the flow capacity of the drain. The results are presented graphically in figure 4.

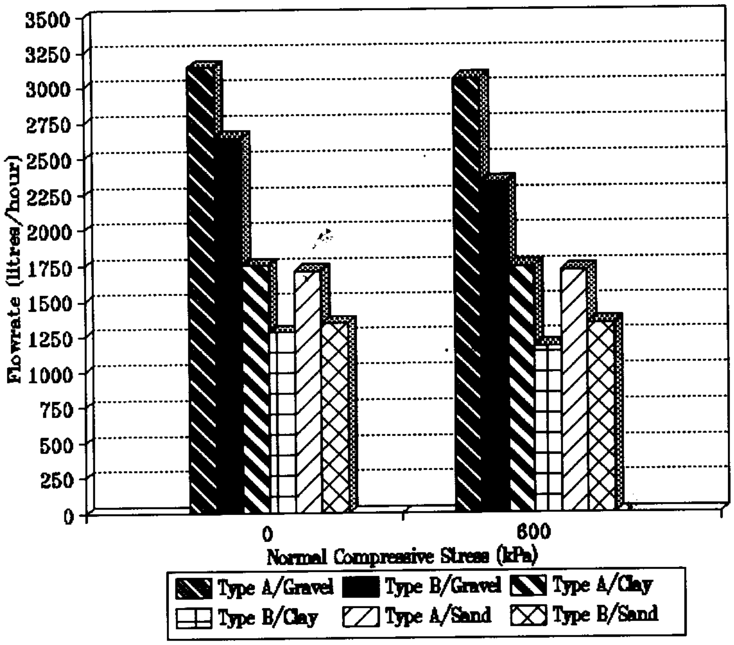

Fig.4 Flowrate vs compressive stress under vertical loading

4.2 Horizontal loading - full channel flow

Horizontal pressure was applied to the GCD encapsulated in a 100mm thick layer of gravel to identify the maximum flow capacity of each GCD under hydraulic gradients (i) equal to 0.01 and 0.1. Normal compressive stress was varied from 0 to 150 kPa and flow rates recorded at 50 kPa increments. The results are presented graphically in figure 5.

4.3 Horizontal loading - open channel flow

The effects of open flow conditions in clay were investigated by imposing a 50mm head on the system. Normal compressive stress was varied from 0 to 150 kPa and flow rates recorded at 50 kPa increments.The open flow tests were conducted via an outlet pipe at the base of the outlet reservoir.The results are presented graphically in figure 6.

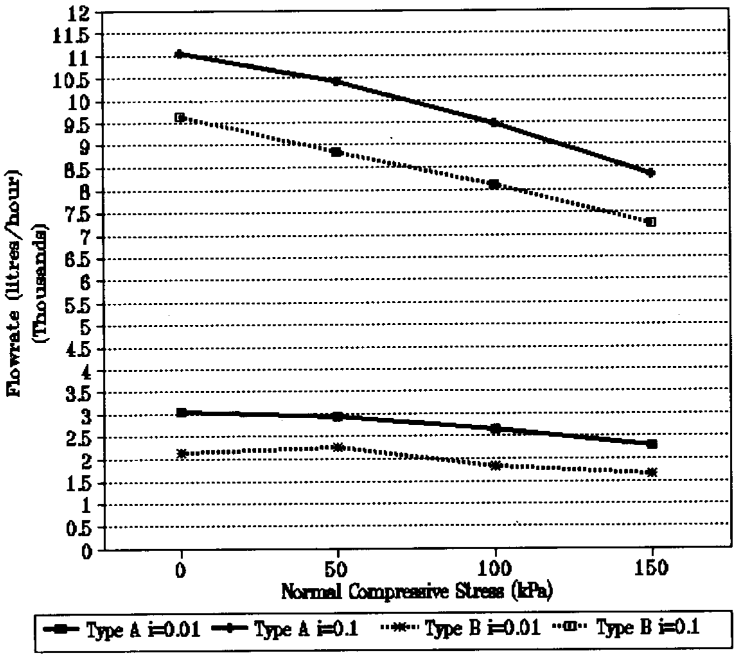

Fig.5 Flowrate vs compressive stress under horizontal loading

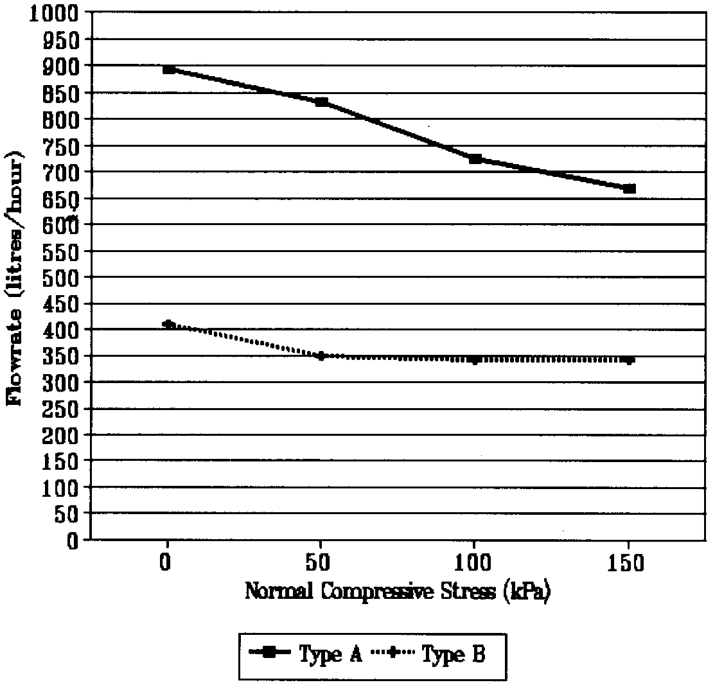

Fig.6 Flowrate vs compressive stress - open channel flow

5 DISCUSSION OF RESULTS

At the completion of each test the GCD was exhumed and inspected for signs of core deformation and geotextile intrusion. A new sample was used for each seperate test.

There was no evidence of core collapse of either GCD in the pressure range tested, ie. 0 to 150 kPa. This was as expected, as the specified parallel plate crush strength (according to ASTM D1621) for each GCD was well above the max. pressure used in these trials. Decreasing flow rate at increasing confining stress was attributed to a combination of elastic deformation of the inner core and geotextile intrusion.

The surrounding soil structure also effected the flow capacity of the GCD, with clay having the most detrimental effect.

The results of flow rates under vertical loading for the three soil types comparing flow rate at zero pressure and flow rate at 600 kPa are summarised in table 3.

Table 3.Percentage decrease in flow rate under vertical loading

Type	Soil		
	Gravel	Sand	Clay
A	-2.6%	0%	-0.8%
B	-12.0%	-0.6%	-8.5%

From these results it can be concluded that either core deformation or geotextile intrusion was the cause for a decrease in flow capacity for Type B, in each of the three soil types. It has been established that the application of vertical load more realistically simulates in-situ stress imposed upon a GCD (Fleckenstein and Allen, 1993). The results of this research therefore indicate that Type A would be more resistant to vertical and eccentric loading than Type B.

It was found that flow rates recorded in the vertical loading test were stable after the first load cycle. Type B flow rates did not decrease until the second load cycle. Therefore, it cannot be assumed that flow rates would remain unaffected by dynamic loading , eg. compaction or heavy vehicle tyre.

Under zero loading, Type A recorded higher flowrates than Type B in all tests performed. Due to the design of Type B, it is assumed that greater surface drag was induced between the core and the geotextile wrapping, causing lower flow rates. Type A continued to have higher flow rates than Type B after the application of load.

6. CONCLUSION

The effect of both vertical and horizontal loading on the flow capacity of two panel shaped geocomposite drains was investigated. The investigation will continue to study the long-term effects of dynamic loading on GCD's in different soil structures. This investigation found that the soil structure, degree of geotextile intrusion, and structural rigidity of the core decreased the theoretical flow capacity of panel shaped geocomposite drains when installed in a vertical position.

It was found that a corrugated core has a higher structural rigidity than a cuspated core and would therefore maintain higher flow rates under load in all directions.

7. REFERENCES

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