Measuring the Discharge Capacity of Band Drains by a New Drain Tester

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ABSTRACT: Prefabricated vertical band drains are commonly used in Singapore for land reclamation to reduce the time required for the consolidation of soft clay and of clay slurry. Very often the quality of drains needs to be checked by measuring the discharge capacity of the drains. To provide a simple method to measure the discharge capacity, a new drain tester has been developed. In this new tester, a short section of the drain is embedded horizontally in a clay layer and is loaded vertically using the loading frame for standard oedometer test. Since the new tester permits flow perpendicular to the drain, it can also be used to evaluate the effect of long-term clogging on the discharge capacity of drains.

1 INTRODUCTION

Prefabricated vertical band drains are extensively used for land reclamation or for the stabilisation of soft ground in Singapore and in the region. The band drains accelerate the consolidation process by reducing the time required for the dissipation of the excess pore water pressure. The efficiency of the drains is partly controlled by the discharge capacity. Therefore, the measurement of the discharge capacity of band drain is important in order to check the short and long term performance of the drain.

A number of methods have been developed to determine the discharge capacity of drains. However, cells or chambers with relatively large dimensions or special loading devices are usually required in these methods. Due to these reasons, a new testing device, the drain tester, has been developed at Nanyang Technological University, Singapore. This new drain tester measure the discharge capacity of drain when embedded in soil. It is simple and easy to use, thus can be used for routine quality control tests. The new drain tester can also be used to check the effect of long term clogging of the drains.

2 THE NEW DRAIN TESTER

A cross-section of the new drain tester is shown in Fig. 1. It can accommodate a 100 mm (or 300 mm) long and a 100 mm wide drain specimen. The new tester consists of a base and a loading plates. The base plate contains a thin layer of soil and the drain specimen to be tested. It also provides channels for water to flow in and out of the drain. The top plate contains soil and the loading platen. The disassemble of the new drain tester is shown in Fig. 2.

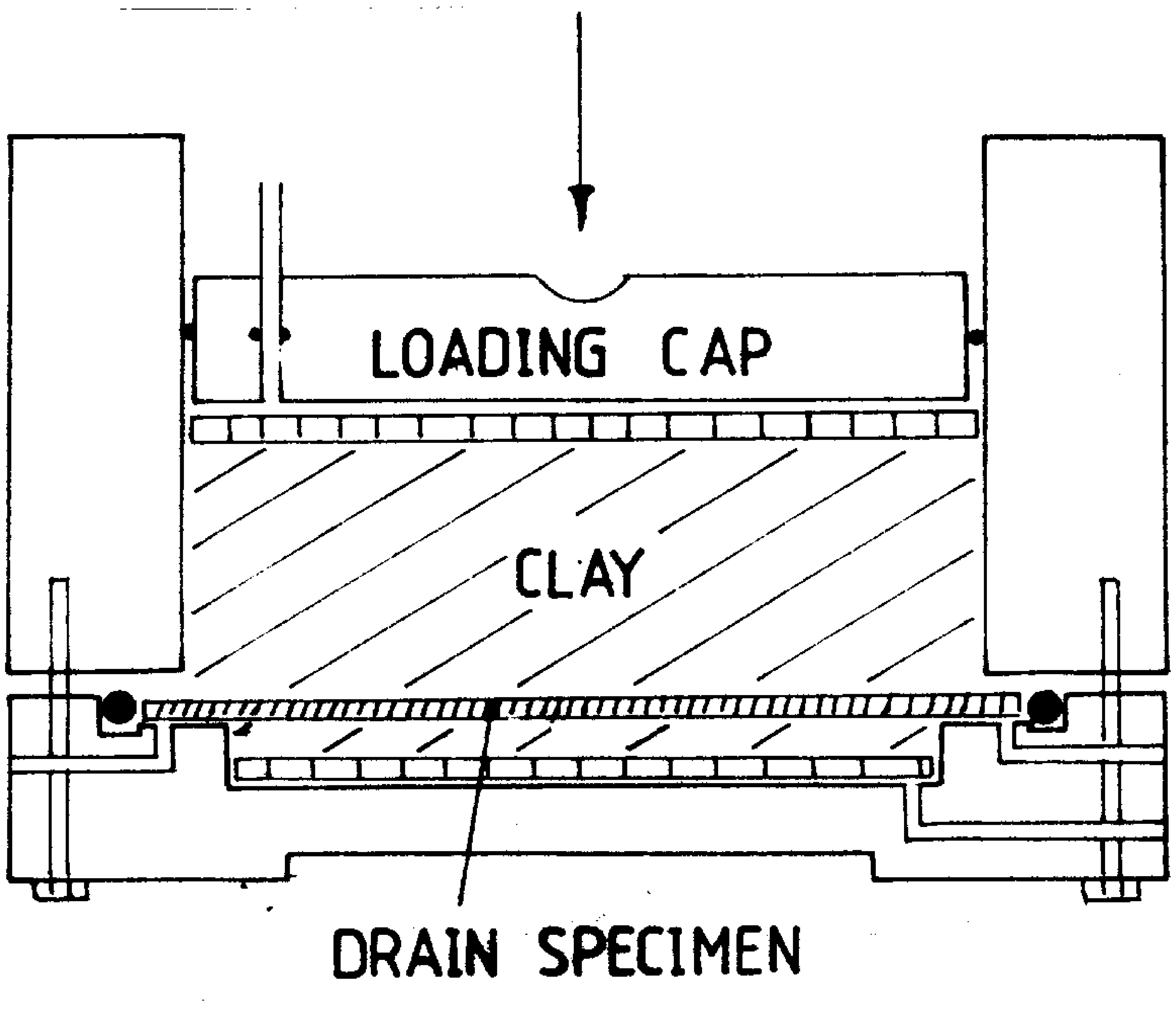

Figure 1 Cross-section of the new drain tester

Grooves have been cut in the base plate at the two ends of the drain to improve the flow along the drain and to facilitate the measurement of head loss. The water head at the inlet and outlet is measured by standpipes. There are also valves to control the flow in the vertical direction whenever necessary (Fig. 1).

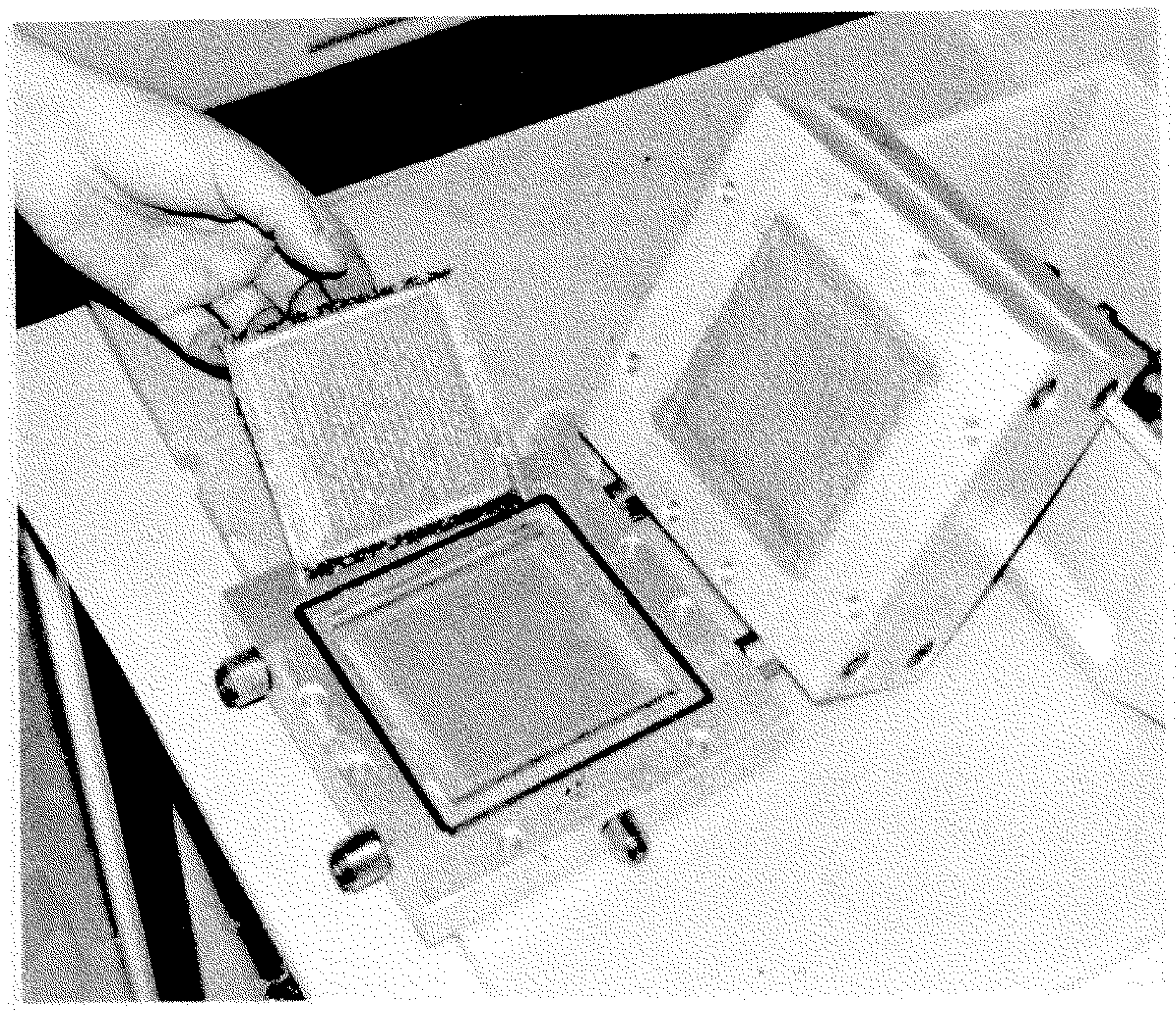

Figure 2 Drain tester disassembled after a test

The dimensions of the tester have been chosen to fit the loading frame for standard oedometer test so that the tester can be used in any soil laboratory for routine quality control tests of the drains.

3 TESTING PROCEDURES

The discharge capacity of drain has been determined by the constant head method, i.e., by measuring the discharge rate at a certain constant hydraulic gradient. It should be noted that the discharge capacity of drain can be affected by the hydraulic gradient used. Therefore, the discharge capacity of drain should be measured at a hydraulic gradient similar to that in-situ, which is normally between 0 and 1. A hydraulic gradient of 0.5 has been taken as reference in our measurement. The discharge capacity is calculated based on Dacy's law. Therefore it is important to maintain a steady flow during the tests and to deair the system properly.

As the discharge capacity of drain changes with the applied vertical load, the discharge capacity has been measured at different vertical loads. Vertical loads of 50, 100, 200, and 350 kPa have been used in the tests.

4 TEST RESULTS

The following different types of drains have been investigated to establish the relationship between the discharge capacity and the applied pressure:

- Type A: which has a polyester/polyamide core (wire type) and non woven polyester as filter.
- Type B: the polypropylene core has a ⌐⌐ cross-section and four different types of non woven fabric filters which are labelled as 75, 105, 120, and 130.
- Type C: which has a polypropylene core (similar to that of Type B) and non woven polypropylene fabric as filter.

The discharge capacity of the three types of drains is presented in Fig. 3 for different pressures. The values presented in Fig. 3 were measured half a day after the application of the load and at a room temperature of 26°C.

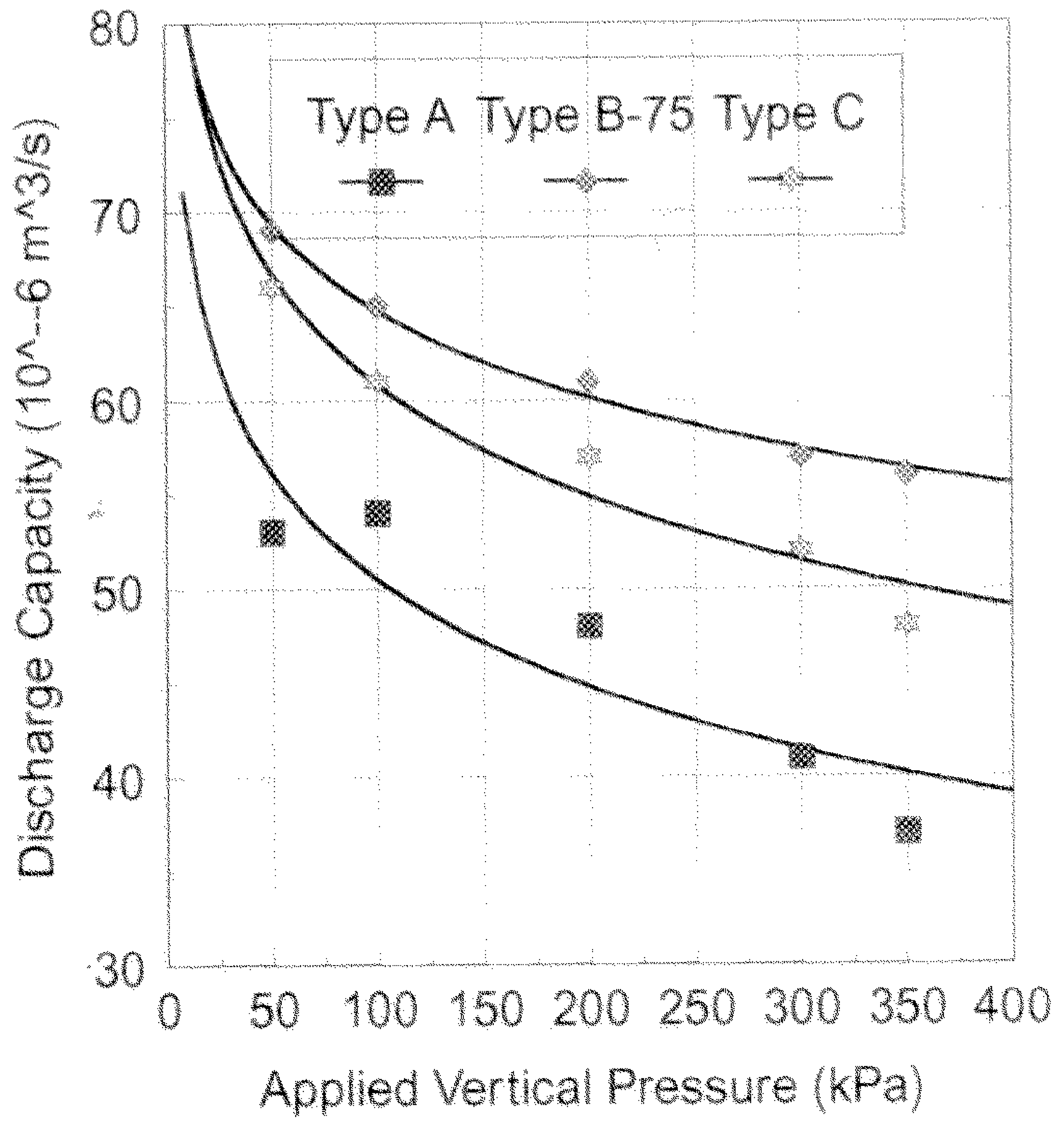

Figure 3 Discharge capacity versus pressure curves for three different types of drains

5 FACTORS AFFECTING THE DISCHARGE CAPACITY MEASUREMENT

The discharge capacity of drains is affected by the applied pressure and by the hydraulic gradient as discussed in the preceding sections. The effect of several other factors have also been investigated using the new testers. These include, the length of the specimen, the stiffness of the filter, and the duration of loading.

5.1 Length of the specimen

To investigate how the length of the specimen affect the discharge capacity measurement, a 300 mm and a 100 mm long Type A drain specimens were tested. The test results are shown in Fig. 4. A comparison of the two results indicates that the discharge capacity measured for the 100 mm long specimen is generally higher than that for the 300 mm specimen. One reason for this difference is that the errors involved in the hydraulic gradient measurement is smaller for a longer specimen. The difference, however, becomes very small when the applied pressure exceeds 300 kPa.

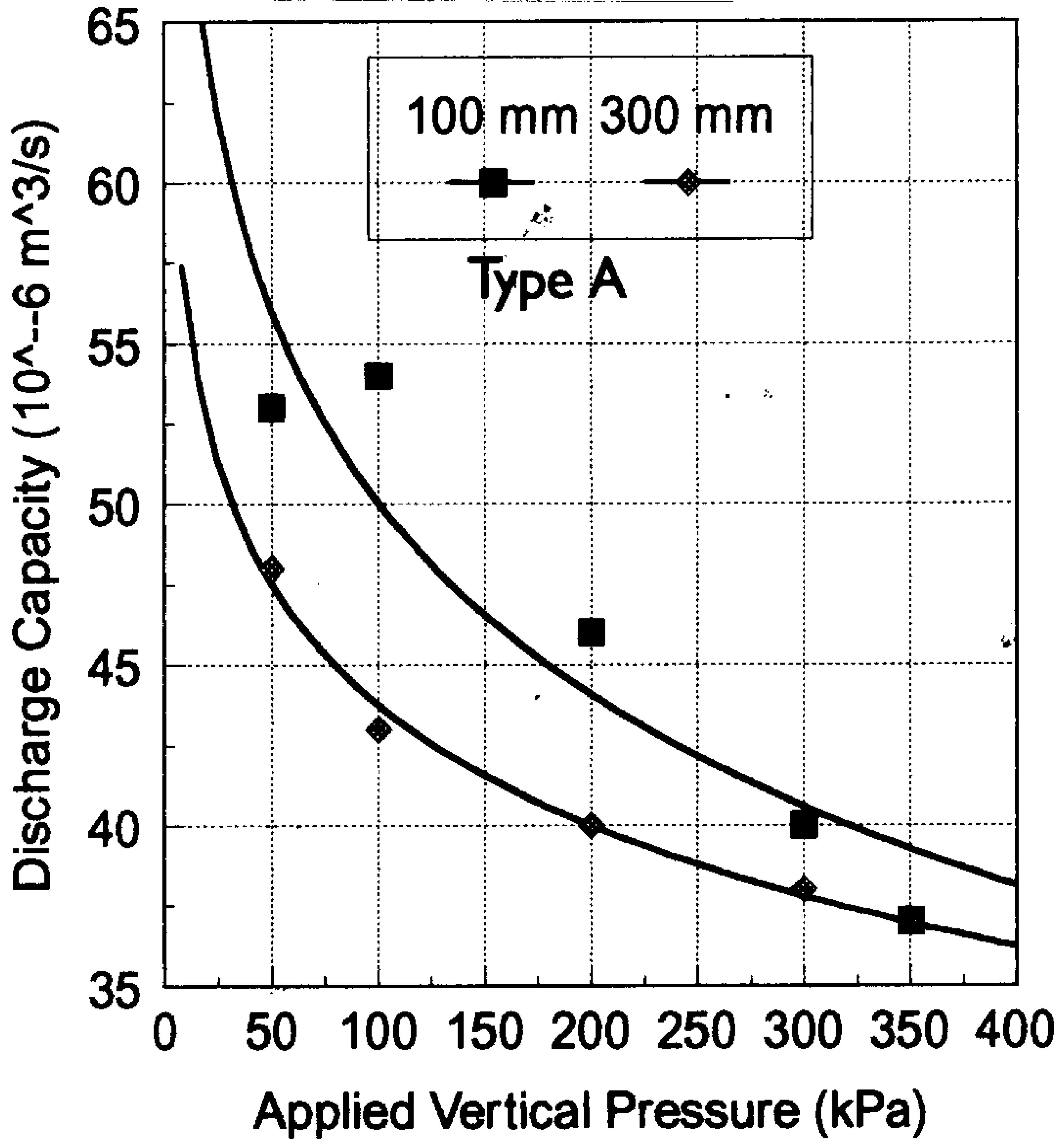

Figure 4 Comparison of discharge capacity measured for 300 mm and 100 mm specimens

5.2 The stiffness of filter

The stiffness of the filter affects the discharge capacity of the drains. The cores of the four Type B drains are the same but the filters are different. Among the four drains, 75, 105, 120, and 130, the filters for drains 105 and 130 are the same material, but the thickness is different. The ductility of the filters for these two filters was less than that for the other two drains. The filter for drain 120 is the most deductible among the four. The measured discharge capacity for the four drains is shown in Fig. 5 for different pressures. It can be seen from Fig. 5 that the discharge capacity of the drain decreases with decreasing stiffness of the filter.

It can be concluded that the discharge capacity of drain is influenced by the stiffness of the filter even when the cores of the drains are the same.

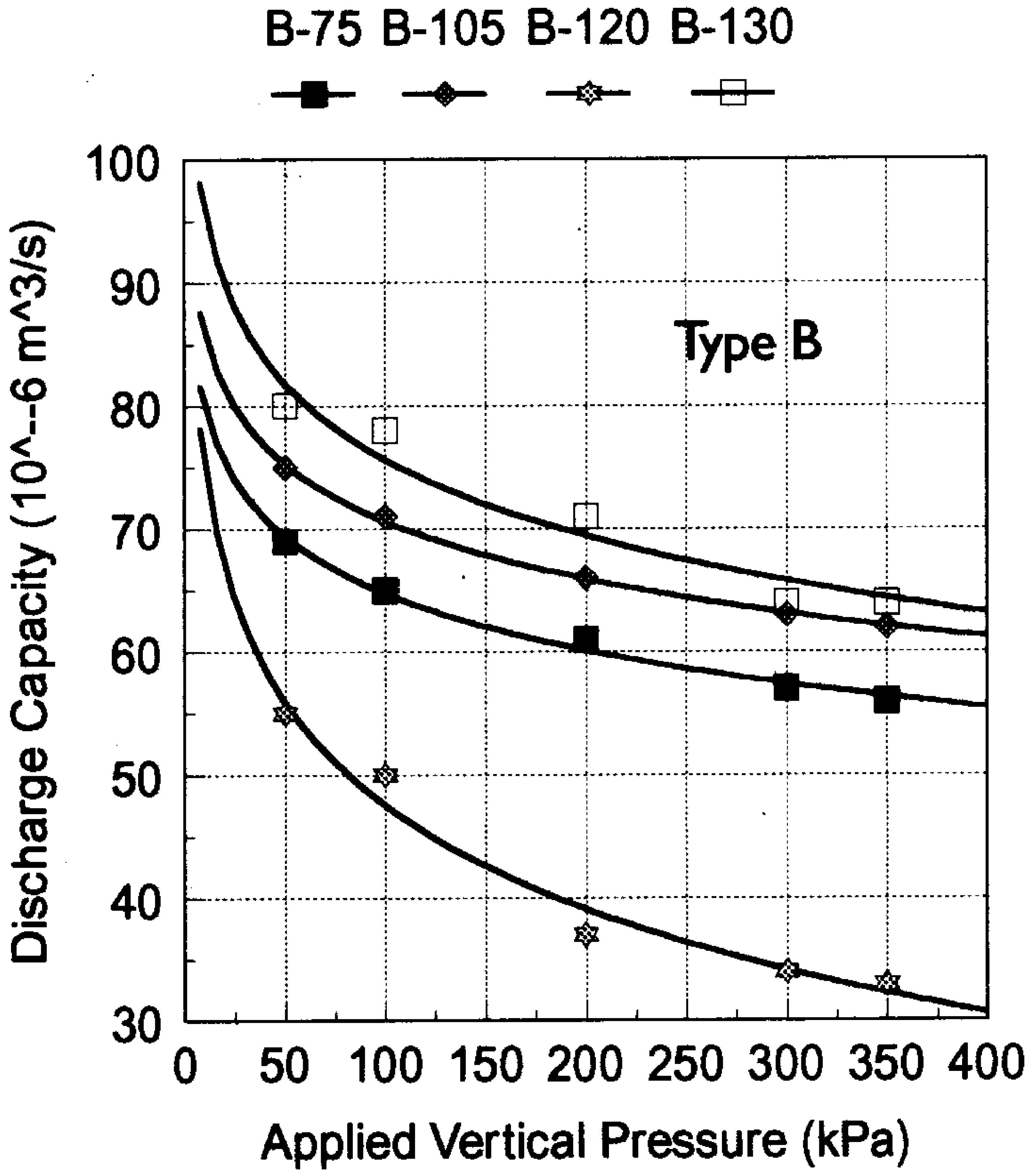

Figure 5 Influence of stiffness of filter on the discharge capacity of drain

The influence of the stiffness of filter of drain on the discharge capacity is illustrated in Fig. 6. The filter under pressure will be squeesed into the channels of the core. Consequently, the cross-sectional area of the drain will be reduced. The smaller the stiffness of the filter, the larger the reduction of the cross-sectional area and the smaller of the flow channels.

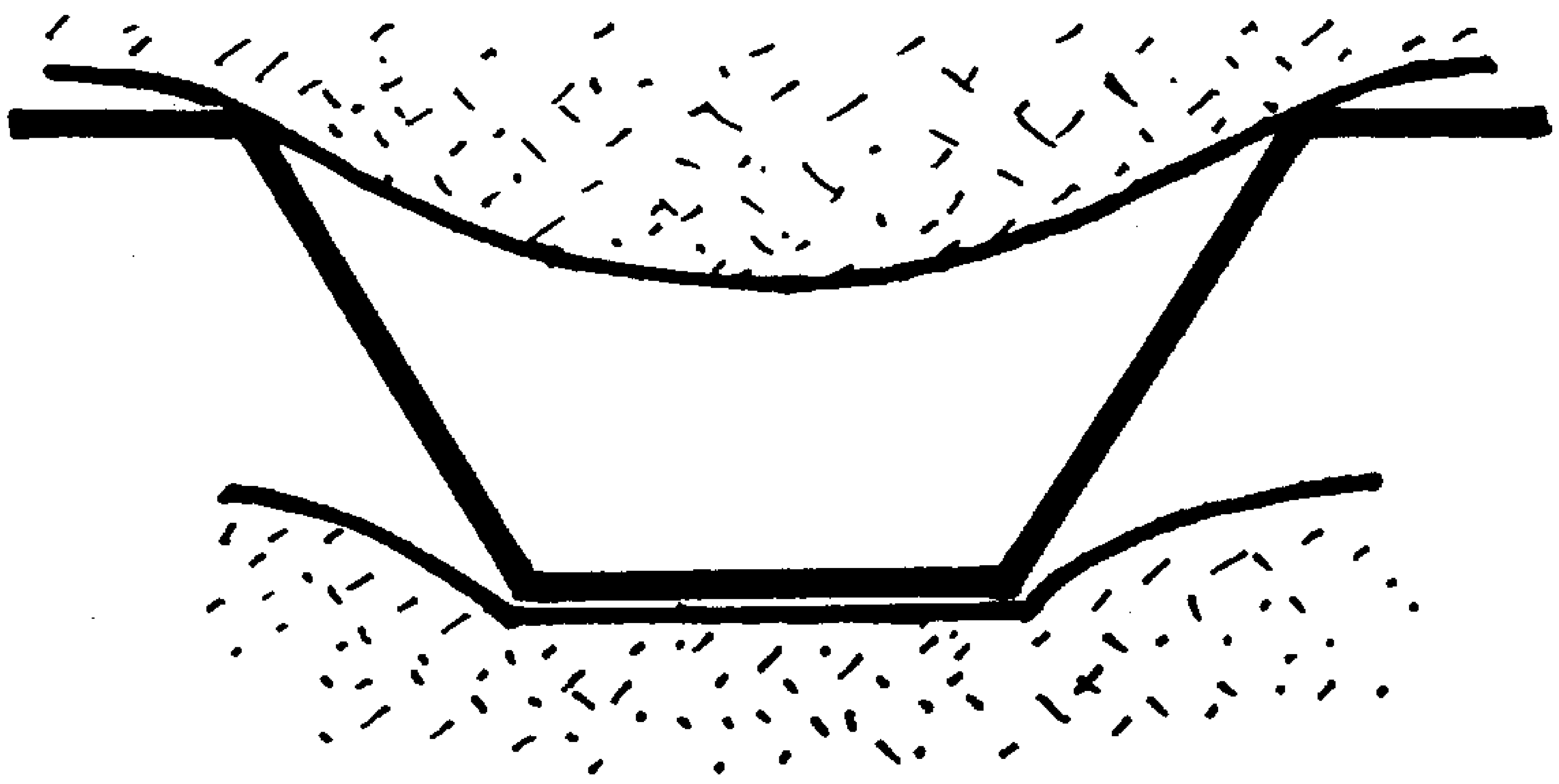

Figure 6 Reduction of flow area caused by the deformation of filter

5.2 Duration of loading

A Type C drain was tested at a pressure of 350 kPa for four weeks to investigate whether the discharge capacity of drain will change with the duration of the applied load. The discharge capacity measured at 1, 7, 14, 21, and 24 days after the application of the vertical pressure is shown in Fig. 7. It can be seen that the discharge capacity was reduced with time, although the reduction was small.

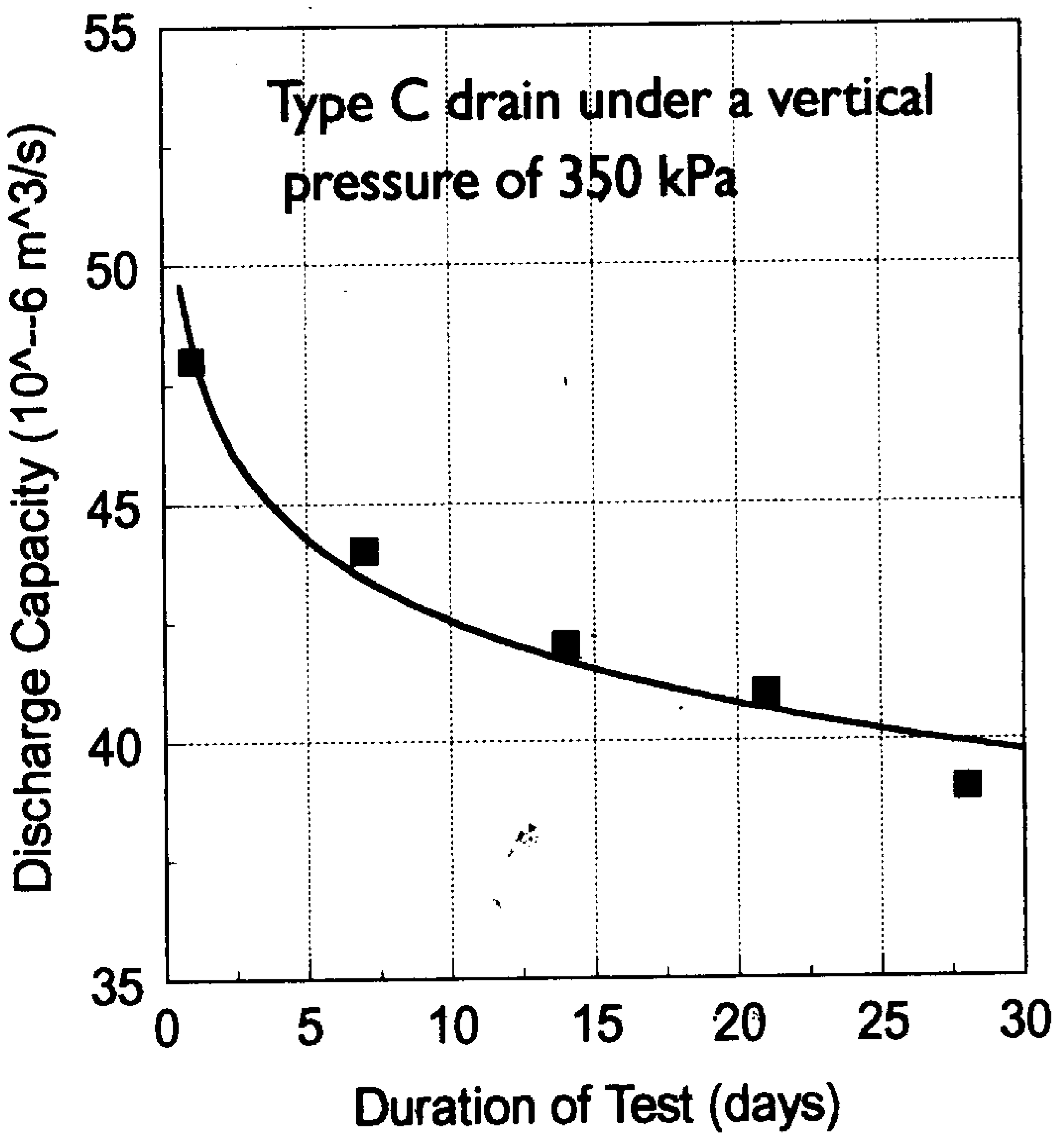

Figure 7 Effect of the duration of loading on the discharge capacity measurement

6 MEASUREMENT OF CLOGGING EFFECT

The pore size of the filter of drain is another important factor which affects the discharge capacity of the drains. If the pore size is too big, clay particles could pass through the filter and block the drainage channels. However, if the pore size is too small, the clay particles may clog the filter. The clogging is a very slow process. When clogging occurs, the permeability of the filter, and thus the efficiency of drain will be reduced. Therefore, it is necessary to measure the effect of clogging by long-term tests.

To measure the clogging effect with the new tester, the thickness of the top soil layer should be prepared to be the same as the bottom layer (Fig. 1). The soil is firstly consolidated under an applied pressure. An hydraulic gradient is then applied to allow water to flow vertically through the clay layer to the drain. The permeability of the soil-drain system can be measured, say, one, three, and six months after the application of the pressure. Any reduction in the permeability with time is the result of clogging.

7 CONCLUSIONS

A simple new drain tester has been developed to determine the discharge capacity of drains. The drains tested in the new tester is embedded in the soil and can be loaded by the loading frame for standard oedometer test. By such an arrangement, the new drain tester can be used in any soil laboratory. Different types of drains have been tested by using the new drain tester. A number of factors which affect the discharge capacity measurement have been investigated using the new drain tester. These investigations show that the effect of the length of the drains and the duration of loading on the discharge capacity of drain is small. However, the stiffness of the filter of drain can have a considerable effect on the discharge capacity of drains.

8. ACKNOWLEDGEMENT

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