LABORATORY MEASUREMENT OF THE COEFFICIENT OF PERMEABILITY FUNCTIONS OF SELECTED HONG KONG SOILS

GEO REPORT No. 193

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GEOTECHNICAL ENGINEERING OFFICE

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PREFACE

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R.K.S. Chan
Head, Geotechnical Engineering Office
November 2006

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1. INTRODUCTION

This project is part of a study on the application of permeability functions to the stability of slopes. The study is being sponsored by the Geotechnical Engineering Office (GEO) in Hong Kong.

The coefficient of permeability function is an important soil parameter in the study of problems related to potential slope instability. The coefficient of permeability directly affects the infiltration of water into a slope as well as the transmission of water through the soil comprising the slope. The coefficient of permeability decreases when the degree of saturation (or water content) of a soil decreases. In turn, the degree of saturation of a soil decreases in response to an increase in soil suction.

The coefficient of permeability can decrease by several orders of magnitude as the degree of saturation of a soil decreases (or as the suction in the soil is increased). The unsaturated coefficients of permeability corresponding to changes in soil suction, are difficult to measure because their variation can be over several orders of magnitude. The variation in the coefficient of permeability over several orders of magnitude makes it extremely difficult to design a single apparatus (i.e., permeameter) that can be used for testing all soils. In addition, the heterogeneous nature of the residual soils in Hong Kong adds further complications to the measurement of saturated coefficient of permeability.

Unsaturated coefficients of permeability (or the coefficient of permeability functions) can be measured in the laboratory or estimated using the soil-water characteristic curve together with the saturated coefficient of permeability. Either one of the two mentioned procedures has been used in most research studies. However, there are few research studies where both procedures have been applied to the same soil. The purpose of this study is to experimentally measure the coefficient of permeability function for several soils from Hong Kong and compare the measured results with values predicted using a soil-water characteristic curve and the saturated coefficient of permeability.

In this study, the coefficient of permeability functions for five selected soils from Hong Kong were measured in the laboratory. Initially, a method developed by Huang (1994) using a triaxial permeameter, was proposed for measuring the coefficient of permeability functions. Numerous attempts during the initial stages of testing showed that the method proposed by Huang (1994) would be difficult, if not impossible to use for the selected Hong Kong soils. In particular, the preparation (i.e., trimming) of suitable triaxial soil specimens for the Hong Kong soils was difficult.

A new method was therefore developed for measuring the coefficient of permeability of the Hong Kong soil specimens at various suction values. The methodology and test procedure for the new method are described in the following section.

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2. A NEW, DIRECT METHOD FOR THE MEASUREMENT OF THE UNSATURATED COEFFICIENT OF PERMEABILITY

Several methods are available for measuring unsaturated coefficients of permeability in the laboratory. A comparison of six methods for the determination of unsaturated coefficients of permeability was recently presented by Stolte et al (1994). Most of these methods, however, involve complex procedures and while appearing to be feasible, are very difficult to perform. As well, a method that is suitable for one particular soil may not be suitable for another soil type. The methodology presented in this study was developed with special attention given to the nature of the residual, saprolitic soils from Hong Kong.

The new methodology was developed to provide a direct measurement of unsaturated coefficients of permeability in the laboratory. The method makes use of the pressure plate concept for the direct control of the pore-air and pore-water pressures in the soil specimen. The pore-water pressure was controlled at both ends of the soil specimen with the assistance of high air-entry ceramic disks (or a low air-entry porous brass disks for the case of pore-water pressures greater than -2 kPa). The air pressure was controlled through an air inlet.

It was not possible to install small tensiometer tips (or piezometer tips) at two points in the soil specimen for the measurement of pore-water pressures. This was due to the coarse and fragile nature of the soils. Therefore, it became important to ensure that the coefficients of permeability of the soil were always lower than the adjacent ceramic porous disks.

The setup shown in Fig. 1 was used for determining the coefficient of permeability at suction values ranging from 10 kPa to 100 kPa. The air entry value for the soils being tested was fairly low, generally less than 10 kPa (Gan and Fredlund, 1998). Since the soils readily became unsaturated, their coefficients of permeability were anticipated to be low. Consequently, 1-bar high air-entry ceramic disks were used that had a saturated coefficient of permeability of approximately 1×10^{-7} m/s.

The pore-water pressure head at the inflow end of the soil specimen was maintained at a higher value than the head at the outflow end of the specimen in order to maintain a gradient across the specimen (Fig. 1). The water pressures at both ends of the specimen were used to compute the average water pressure within the specimen. The matric suction in the specimen was computed as the difference between the applied air pressure and the average water pressure in the specimen.

The setup in Fig. 2 was used for measuring the coefficient of permeability at low suction values (i.e., suctions less than 1.5 kPa). At low suctions, the soil has its highest coefficient of permeability and highly permeable porous disks were required in place of the 1-bar, high air-entry ceramic disks. Hydraulic conductivity tests were conducted on steel porous stones, brass porous stones and corundum stones (Table 1). Porous brass disks were selected for use in the new permeameter. The hydraulic conductivity test results for the porous brass disks are shown in Fig. 3. The porous brass disks have an air entry value of about 1.5 kPa and a coefficient of permeability of 4.5×10^{-5} m/s (Fig. 4). The head losses across the porous brass disks were a function of the flow rate. The results are presented in Fig. 5.

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In the setup in Fig. 2, the pore-water pressures were controlled at both ends of the specimen. The pore-water pressure heads were maintained at negative values using a column of water at each end. The intake end of the soil specimen was maintained at a matric suction of 1.10 kPa (i.e., -110 mm of water) and the outflow end of the soil specimen was maintained at a matric suction of 1.15kPa (i.e., -115 mm of water). The head loss across the specimen was 85 mm of water (or 0.85 kPa) (i.e., 90 mm + 110 mm – 115 mm = 85 mm, see Fig. 2).

The above test procedure utilizes essentially the same concepts as the "inflow equal to outflow" method. The inflow and outflow ends were maintained at constant heads, with the inflow head higher than the outflow head. The inflow to the specimen, however, was not measured during this testing program. Instead, the inflow to the specimen was assumed to be equal to the outflow from the specimen once the outflow rate was constant with respect to time. The outflow volumes were monitored with respect to time.

3. TEST PROCEDURE ASSOCIATED WITH THE NEW PERMEABILITY TEST-CELL

The soil specimen in the test-cell was first saturated by applying a positive head of water to both ends of the specimen. The air inlet to the test-cell was open to the atmosphere and water could rise into the air inlet line, driving out air from the specimen.

Upon saturation of the soil specimen, the water head at one end of the specimen was lowered to maintain a head difference across the specimen. In the tests conducted using the setup shown in Fig. 1, an air pressure was applied to the air inlet. The difference between the applied air pressure and the average water pressure in the soil specimen gave the average matric suction of the specimen once equilibrium was attained. The water movement (i.e., outflow) from the specimen, was monitored with respect to time. Initially, water would flow from the specimen in response to both the applied air pressure and the total pressure head gradient across the specimen.

Once the matric suction corresponding to the applied air pressure and the applied water pressures was established in the specimen, water would flow only under the influence of the total head difference across the specimen. Eventually, when the flow rate from the specimen was constant with respect to time, the inflow to the specimen was assumed to be equal to the outflow from the specimen. The coefficient of permeability corresponding to the applied matric suction value was then computed from the measured steady state outflow rate. Since the pore-water pressure at the ends of the specimen differed, the average value was taken to represent the matric suction value for the specimen. The air pressure was then increased to attain the next desired matric suction value. After the air pressure was applied, the monitoring process was repeated.

In the tests using the setup in Fig. 2, the air pressure inlet was left open to the atmosphere (i.e., u_a was maintained at zero pressure) once the soil specimen was saturated. Since the air pressure was zero, the matric suction at both ends of the specimen could be computed from the applied negative pore-water pressures.

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Tests with both negative and positive pore-water pressures were conducted for each specimen using the setup shown in Fig. 2. In the first tests with the positive pore-water pressures, the constant head tank was raised such that the water level at the top end of the specimen was higher than the opening in the hypodermic needle attached to the lower end of the specimen. In the tests with the pore-water pressures negative relative to the air pressure, (i.e., positive matric suctions), the test-cell was raised such that the top end of the specimen was 110 mm above the water level in the constant head tank. In this way, the water pressure at the top end of the specimen was maintained at a constant value of -1.10 kPa.

In order to induce water flow through the specimen in the tests with a positive matric suction, a water pressure head gradient was maintained across the specimen. This was achieved by lowering the opening of the hypodermic needle attached to the lower end of the specimen. The hypodermic needle was lowered a distance of 90 mm below the water level in the constant head tank. This provided a constant negative water pressure head of 115 mm (or -1.15 kPa) at the bottom end of the specimen and a constant head difference of 85 mm across the specimen (see Fig. 2).

4. SOILS TESTED

Soils from the following five sites were selected by the Geotechnical Engineering Office, GEO, Hong Kong, for the measurement of their coefficient of permeability functions.

1. Shau Kei Wan,
2. Nam Long Shan,
3. Chai Wan Fei Tsui,
4. Butterfly Valley, and
5. Castle Peak Road.

The soil specimens were trimmed directly into a *Lucite* specimen ring holder. The soil specimen ring had a height of 35 mm and a diameter of 69 mm.

Measurements of the soil-water characteristic curves for the above five soils were conducted as part of an earlier study ("Study of the Applications of Soil-Water Characteristic Curves and Permeability Functions to Slope Stability, Final Report on Part 1 – Permeability and Soil-Water Characteristic Curve Tests and Computation of Permeability Functions," Report for Geotechnical Engineering Office, Civil Engineering Department, Hong Kong, 1998). A description of these soils can be found in the above report.

The soil specimens used to measure the soil-water characteristic curves were from the same block samples as the specimens trimmed for the unsaturated permeability tests. However, the overall block samples were quite heterogeneous and susceptible to disturbance. As a result, there is no assurance that the soils used for the two sets of tests were identical.

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5. PRESENTATION OF THE LABORATORY TEST RESULTS

The coefficient of permeability measurements on the porous disks, as well as the permeability measurements on the soil specimens, are presented in the following section. Also presented is a summary of the soil-water characteristic curve data measured as part of the previous study for GEO, Hong Kong (1998).

5.1 Permeability Measurements on the Porous Disks

Measurements of the coefficient of permeability on the porous brass disks are presented in Figs. 3 to 5. The porous brass disks were used for the low matric suction tests where suction was less than 1.5 kPa. Figure 3 shows the cumulative flow with elapsed time for the porous brass disk corresponding to head differences of 50 mm and 100 mm. The coefficient of permeability of the porous brass stones was found to be a function of the flow rate. It would appear that the flow through the porous brass disks becomes increasingly turbulent as the gradient is increased.

The coefficient of permeability of the brass porous disk as a function of the flow rate is shown in Fig. 4. The coefficient of permeability of the brass porous disk extrapolated to a low gradient condition, gave a value, k_o, of approximately 4.5 x 10^{-5} m/s. Head losses across the porous brass disks were computed as a function of the flow rate and are presented in Fig. 5. The test results show that the head losses across the brass porous disk are negligible for flow rates below 1 x 10^{-1} cc/s.

The coefficient of permeability of the 1-bar, high air entry disks was not measured. However, the manufacturer's quoted coefficient of permeability for the ceramic is approximately 1 x 10^{-7} m/s. The ceramic disks were of the "high flow" type. Similar values for the coefficient of permeability of the ceramic disks have been measured at the University of Saskatchewan laboratory, in the past. There is some concern that the coefficient of permeability of the ceramic may be quite close to the coefficient of permeability of the soil when the suctions are low. If the coefficients of permeability of the soil and the ceramic become too similar, there is the possibility of impeded flow through the soil.

5.2 Saturated and Unsaturated Coefficients of Permeability for the Hong Kong Soils

The laboratory data obtained from the saturated and unsaturated coefficient of permeability tests for the five Hong Kong soils are presented in Tables 2 to 6.

The saturated and unsaturated coefficient of permeability test results are presented as plots of cumulative flow versus elapsed time for each applied matric suction value. The flow rates at steady state condition are determined for each test. The test results for the Shau Kei Wan soil are presented in Figs. 6 to 14. The test results for the Nam Long Shan soil are presented in Figs. 15 to 22. The test results for the Chai Wan Fei Tsui soil are presented in Figs. 23 to 31. The test results for the Butterfly Valley soil are presented in Figs. 32 to 40. The test results for the Castle Peak soil are presented in Figs. 41 to 47.

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The steady state flow rates for each test were used to compute the coefficients of permeability. The coefficients of permeability for each soil specimen corresponding to various matric suction values were used to plot the coefficient of permeability function for each of the five Hong Kong soils. The experimental coefficient of permeability functions for each of the soil specimens from Shau Kei Wan, Nam Long Shan, Chai Wan Fei Tsui, Butterfly Valley and Castle are presented in Figures 48, 49, 50, 51 and 52, respectively.

5.3 Previous Saturated Coefficient of Permeability Test Results

The saturated coefficients of permeability were also previously measured as part of the "Study of the Application of the Soil-Water Characteristic Curves and Permeability Functions to Slope Stability" for GEO (Gan and Fredlund, 1998). The specimens used for the previous saturated coefficient of permeability measurements were taken from the same block specimen as were the saturated and unsaturated soil permeability tests using the setup shown in Figs. 1 and 2. However, there could be some variation in the soil specimens due to the variability of the soil. The saturated coefficient of permeability tests from the earlier test program are also presented in Figs. 48 to 52, for comparison.

5.4 Soil-Water Characteristic Curve Measurements on Independent Soil Specimens

The soil-water characteristic curves for soils specimens from Shau Kei Wan, Nam Long Shan, Chai Wan Fei Tsui, Butterfly Valley and Castle Peak were also obtained from the earlier test program by Gan and Fredlund (1998). The results are presented in Figs. 53 to 57, respectively. The soil-water characteristic curves were used along with saturated coefficients of permeability to compute permeability functions and these are compared with the experimentally measured permeability functions presented in Figs. 58 to 62.

6. DISCUSSIONS AND CONCLUSIONS

The various independent laboratory measurements will first be discussed. This will be followed by a comparison of the measured and the predicted coefficient of permeability functions for the five Hong Kong soils. Finally, some suggestions are made regarding the feasibility of measuring and/or predicting the coefficient of permeability functions for unsaturated soils.

6.1 Saturated Coefficients of Permeability for the Five Hong Kong Soils

The saturated coefficients of permeability obtained from earlier tests by Gan and Fredlund (1998) on equivalent soils (i.e., from the same block sample) were all higher than the values measured in the present test program. The values from Gan and Fredlund (1998) were higher by 1 (Fig. 50) to 4 (Fig. 51) orders of magnitude. The higher values from the earlier test program and the wide variation in the saturated coefficients of permeability, can largely be attributed to side-wall leakage. Side-wall leakage in the saturated tests was also accentuated by the coarse and fragile nature of the soils leading to trimmed specimens that did not fit tightly in the specimen ring. The effects of side-wall leakage was also increased by the use of taller specimens (i.e., 88.8 mm in the tests by Gan and Fredlund, 1998) as compared to 35 mm specimens used in the present test

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program. On the other hand, side-wall leakage is not considered to be a serious problem in the permeability tests on specimens subjected to a small matric suction. In this case, the large voids along the soil-wall interface would drain first and prevent the flow of water. The results from the unsaturated permeability tests were considered to be more reliable.

Impedance due to the use of porous brass disks did not appear to be a problem in the tests conducted at low matric suction values. The flow rates across the soil specimens at matric suction below 1.5 kPa were sufficiently low that head losses across the porous brass disks were negligible. The highest flow rates of 1.24 x 10^{-2} cc/s (Fig. 33) and 2.02 x 10^{-4} cc/s (Fig. 34) were obtained for the soil specimen from Butterfly Valley. The flow rates through the other soil specimens from Shau Kei Wan (Figs. 6, 7 and 8), Nam Long Shan (Figs. 15 and 16), Chai Wan Fei Tsui (Figs. 23, 24 and 25) and Castle Peak (Fig. 41) were in the 10^{-3} cc/s to 10^{-4} cc/s range. Head losses across the porous brass disk were negligible for flow rates lower than 1.0 x 10^{-1} cc/s (Fig. 5).

6.2 Measured Unsaturated Coefficient of Permeability Functions

The experimental coefficient of permeability functions (or *k*-functions) for the five soil specimens presented in Figs. 48, 49, 50, 51 and 52 show how the coefficient of permeability decreases with matric suction. In Figs. 48 to 52, the gradients are shown at which the saturated coefficient of permeability values, k_{sat}, were obtained. In the present series of tests, (i.e., the tests performed using the new test-cell with either positive pore-water pressures or slightly negative pore-water pressures) lower saturated coefficient of permeability values, k_{sat}, were obtained for gradient values that were greater than 10. For future saturated permeability measurements, it may be preferable to conduct permeability tests at constant gradient values for consistent results. Since turbulent flow appears to be a problem, the lower gradients are preferable.

Permeability Function for the Shau Kei Wan Soil

The experimental permeability function in Fig. 48 shows that the coefficient of permeability for the soil specimen from Shau Kei Wan decreases from about 10^{-7} m/s at saturation to a value of 10^{-9} m/s at a matric suction of 100 kPa (i.e., a decrease of about 2 orders of magnitude). Over the same range of matric suction change, the soil-water characteristic curve shows a change in water content from 36 % to either 20% or 22 % (Fig. 53).

Permeability Function for the Nam Long Shan Soil

The experimental permeability functions in Fig. 49 shows that the coefficient of permeability for the soil specimen from Nam Long Shan decreases from about 5 x 10^{-8} m/s at saturation to a value of 2 x 10^{-10} m/s at a matric suction of 100 kPa (i.e., a decrease of about 2 orders of magnitude). Over the same range of matric suction change, the soil-water characteristic curve shows a change in water content from 35 % to 21 % (Fig. 54).

Permeability Function for the Chai Wan Fei Tsui Soil

The experimental permeability function in Fig. 50 shows that the coefficient of permeability for the soil specimen from Chai Wan Fei Tsui decreases from about 1 x 10^{-6} m/s at saturation to a

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value of 3 x 10^{-9} m/s at a matric suction of 100 kPa (i.e., a decrease of between 2 to 3 orders of magnitude). Over the same range of matric suction change, the soil-water characteristic curve shows a change in water content from a starting value in the range of 31 to 35 % to a final value of 24 % (Fig. 55).

Permeability Function for the Butterfly Valley Soil

The experimental permeability function in Fig. 51 shows that the coefficient of permeability for the soil specimen from Butterfly Valley decreases from about 10^{-4} m/s – 10^{-6} m/s at saturation to a value of 10^{-10} m/s at a matric suction of 100 kPa (i.e., a decrease of between 4 to 5 orders of magnitude). Over the same range of matric suction change, the soil-water characteristic curve for the BU-S1 specimen shows changes in water content from 31% to 16%; and the soil-water characteristic curve for the BU-S2 specimen, shows a change of water content from about 28% to about 13% (Fig. 56).

Permeability Function for the Castle Peak Soil

The experimental permeability function in Fig. 52 shows that the coefficient of permeability for the soil specimen from Castle Peak decreases from about 1x 10^{-8} m/s at saturation to a value of about 7 x 10^{-10} m/s at a matric suction of 100 kPa (i.e., a decrease of about one and a half orders of magnitude). Over the same range of matric suction change, the soil-water characteristic curve shows a change in water content from 36 % to 18 % (specimen C4-S3), from 28% to 15% (specimen C4-S1) and from 24% to 14% (specimen C4-S2) (Fig. 57).

6.3 Comparison of the Experimental Permeability Functions and the Permeability Functions Computed from the Soil-Water Characteristic Curves

A comparison of the experimental permeability function with the permeability functions computed from soil-water characteristic curves (and the saturated coefficient of permeability) are presented in Figs. 58 to 62.

The theory used for the prediction of the permeability functions has been presented by Fredlund, Xing and Huang (1994). The soil-water characteristic curve is first best-fit using a non-linear regression analysis. Then the procedure involves integrating along the soil-water characteristic curve, starting from saturated soil conditions. The end result is a series of computed points that can be joined to form the predicted permeability function. The theory has been programmed into the computer software package called SoilVision (Fredlund, 1996).

The shape of the permeability function is controlled by the shape (i.e., soil parameters) of the soil-water characteristic curve. The permeability function can be moved up or down in order to make the function pass through the saturated coefficient of permeability. In other words, the saturated coefficient of permeability controls the vertical location of the permeability function on a log-log plot while the shape of the function is controlled by the soil-water characteristic curve. Therefore, it can be seen that it is equally as important to have an accurate value for the saturated coefficient of permeability as it is to know the nature of the soil-water characteristic curve.

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Comparison of the Measured and Computed Permeability Function for Shan Kei Wan

The experimental and computed permeability functions for Shau Kei Wan are presented in Fig. 58. A total of 6 permeability functions were generated using the soil-water characteristic curves, SKW-S1, SKW-S2 and SKW-S3 along with two saturated coefficient of permeability values, k_{sat}; namely, 2.66 x 10^{-5} m/s and 6.26 x 10^{-8} m/s. For matric suction values between 0.01 kPa to about 5 kPa, the computed permeability functions using SKW-S3 with k_{sat} = 6.26 x 10^{-8} m/s appears to best represent the experimental curve. From matric suction values of 50 to 100 kPa, the experimental curve was better represented by the computed permeability function using SKW-S1 with k_{sat} = 2.66 x 10^{-5} m/s.

Comparison of the Measured and Computed Permeability Function for Nam Long Shan

The experimental and computed permeability functions for Nam Long Shan are presented in Fig. 59. A total of 6 permeability functions were computed using the soil-water characteristic curves, NLS-S1 and NLS-S2 with three k_{sat} values of 2.37 x 10^{-5} m/s, 3.08 x 10^{-5} m/s and 3.36 x 10^{-5} m/s, respectively. For matric suction values between 0.01 kPa to about 1 kPa, the generated k-functions using NLS-S2 with k_{sat} = 2.37 x 10^{-5} m/s appears to best represent the experimental curve. From matric suction values of 1 to 100 kPa, the experimental curve was better represented by the generated k-function using NLS-S1 with k_{sat} = 3.08 x 10^{-5} m/s.

Comparison of the Measured and Computed Permeability Function for Chai Wan Fei Tsui

The experimental and computed permeability functions for Chai Wan Fei Tsui are presented in Fig. 60. A total of 6 permeability functions were computed using the soil-water characteristic curves, TP3-S1, TP3-S2 and TP3-S3 along with two saturated coefficient of permeability, k_{sat} values; namely, 1.20 x 10^{-6} m/s and 8.23 x 10^{-6} m/s. The experimental curve appears to be best represented by the computed function using TP3-S3 with k_{sat} = 8.23 x 10^{-6} m/s.

Comparison of the Measured and Computed Permeability Function for Butterfly Valley

The experimental and computed permeability functions for Butterfly Valley are presented in Fig. 61. A total of 6 permeability functions were computed using the soil-water characteristic curves, BV-S1 and BV along with three saturated coefficient of permeability, k_{sat} values; namely, 2.29 x 10^{-6} m/s, 2.23 x 10^{-5} m/s and 3.92 x 10^{-5} m/s. The experimental permeability function was located well outside the computed permeability curves. This suggests that the specimen used for the soil-water characteristic curve test, and the specimen used for the permeability tests were substantially different (i.e., from BV-S1 and BV-S2).

Comparison of the Measured and Computed Permeability Function for Castle Peak

The experimental and computed permeability functions for Castle Peak are presented in Fig. 62. A total of 6 permeability functions were generated using the soil-water characteristic curves, C4-S1, C4-S2 and C4-S3 with two saturated coefficient of permeability, k_{sat} values; namely, 1.16 x 10^{-8} m/s and 8.60 x 10^{-5} m/s. The experimental curve matches the computed curve using C4-S3 with k_{sat} = 8.60 x 10^{-5} m/s at matric suction values greater than about 20 kPa.

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6.4 Summary of Observations on the Measured and Computed Permeability Functions

The predicted permeability functions show considerable variation from the experimentally measured permeability. The are numerous possible explanations for the deviations and a few of the factors involved are as follows:
1.) the residual and saprolitic soils from Hong Kong are highly heterogeneous,
2.) the highly heterogeneous soils have a variation in the soil-water characteristic curves (see for example, the soil-water characteristic curves for 3 soils specimens from Castle Peak in Fig. 57),
3.) the saturated coefficient of permeability of the soils tested, are difficult to measure in the laboratory, and
4.) there is a close relationship between the coefficient of permeability of the ceramic disks and the soil being tested. It is almost impossible to meet all the criteria related to impedance of flow when testing a soil over a range of suction values.

Design Criteria for the Permeameter

One of the main difficulties encountered in the testing of the Hong Kong soils is that the saturated coefficient of permeability of the 1-bar air entry ceramic disks is too low (i.e., the saturated coefficient of the ceramic disks is too close to the coefficient of permeability of the soils at low matric suction values). The coarse brass porous disks have high saturated coefficient of permeability but the air entry value is too low. The brass porous disks could only be used for testing at very low matric suctions (i.e., less than 1.5 kPa). A series of three ceramic disks with air entry value of 20 kPa, 50 kPa and 100 kPa would yield better results. However, ceramics disks with an air entry value of 20 kPa are not readily available. Also it is difficult to change ceramic disks during a permeability test, without destroying the specimens. Hence the decision was made to use only the 1-bar ceramic disks over the range of 10 kPa to 100 kPa suction.

The design criteria related to the design of the unsaturated soil permeameter can be summarized as follows:
1.) the coefficient of permeability of the high air entry disks (i.e., in the sense that it must always remain saturated), should be about one order of magnitude greater than the saturated coefficient of permeability of the soil being tested, and
2.) the ceramic disk must remain saturated, thereby not permitting the passage of air up to the highest matric suction value used during the test.

Reliability of the Shape of the Function

The most accurate values of coefficient of permeability measured during the testing program appear to be the values measured in the mid-range of operation of the apparatus (i.e., around 50 kPa). The largest coefficient of permeability measured could possibly be slightly influenced by the permeability of the ceramic disks. The smallest coefficient of permeability might also have some inaccuracy in its measurement. The inaccuracy could be due to poor contact between the soil and the ceramic or simply due to the small quantity of water being measured. However, in general, the shape of the measured coefficient of permeability function should be quite reliable.

The shape of the coefficient of permeability function computed from the soil-water characteristic curve and the saturated coefficient of permeability, appears to be of the same form as the

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measured permeability function. If the general shape of the measured and predicted permeability functions are not the same, it is likely due to a variation in the soil being tested in the permeability test and the soil-water characteristic curve test.

It should be noted that the computed permeability function retains its shape but is shifted vertically depending upon the saturated coefficient of permeability being used. In other words, the soil-water characteristic curve controls the general shape of the permeability function while the saturated coefficient of permeability controls the location of the permeability function. Therefore, it is equally (or more) important to have a correct value for the saturated coefficient of permeability of the soil.

Reliability in the Measurement of Saturated Coefficient of Permeability

The most noticeable variations between the measured and predicted coefficients of permeability appear to be due to the difficulty in measuring the saturated coefficient of permeability. Difficulties in preparing (trimming) specimens has a greater influence on the measurement of the saturated coefficient of permeability than on the measurement of the soil-water characteristic curve or on the measurement of the unsaturated coefficient of permeability. As a result, it is suggested that the area still in greatest need of research is the measurement of the saturated coefficient of permeability.

7. REFERENCES

Fredlund, D. G. (1998), "Bringing Unsaturated Soil Mechanics Into Engineering Practice", Proceedings of the Second International Conference on Unsaturated Soils, UNSAT2, Beijing, China, Vol. 2, August 27 – 30, pp. (In Print).

Fredlund, M. D. (1996), "SoilVision User's Guide, a Knowledge-Based System for Geotechnical Engineering", Version 1.20, SoilVision Systems Ltd., Saskatoon, Sask., Canada.

Fredlund, D.G. and Xing, A. (1994) "Equations for the Soil-Water Characteristic Curve", Canadian Geotechnical Journal, Vol. 31, No. 3, pp. 521-532.

Fredlund, D.G., Xing, A., and Huang, S.Y. (1994) "Predicting the Permeability Function for Unsaturated Soils Using the Soil-Water Characteristic Curve", Canadian Geotechnical Journal, Vol. 31, No. 4, pp. 533-546.

Gan, J. K-M. and Fredlund, D. G. (1998). "Study of the Application of Soil-Water Characteristic Curves and Permeability Functions to Slope Stability, Final Report on Part 1 – Permeability and Soil-Water Characteristic Curve Tests, and the Computation of Permeability Functions", Report for Geotechnical Engineering Office, Civil Engineering Department, Hong Kong, Oct. 16.

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Huang, S.-Y. 1994. "Evaluation and Laboratory Measurement of the Coefficient of Permeability in Deformable, Unsaturated soils", Ph.D. dissertation, University of Saskatchewan, Saskatoon, Saskatchewan, Canada, 317p.

Stolte, J. Freijer, J. I., Bouten, W., Dirksen, C., Halbertsma, J. M., Van Dam, J. C., Van den Berg, J. A., Veerman, G. J. and Wosten, J. H. M. (1994). "Comparison of Six Methods to Determine Unsaturated Soil Hydraulic Conductivity", Soil Science, **58**:1596-1603.

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Table 1 – Coefficient of Permeability of corundum, brass and stainless steel porous disks

Porous disk	Head across disk (mm)	Flow rate (cc/s)	Coefficient of permeability (m/s)
Corundum	50	0.918	1.892×10^{-5}
	100	1.579	2.488×10^{-5}
Brass	50	0.825	2.863×10^{-5}
	100	1.277	2.216×10^{-5}
Stainless steel	50	0.875	1.318×10^{-5}
	100	1.333	1.025×10^{-5}

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Table 2 - Test data for the soil specimen from Shau Kei Wan (Sheet 1 of 4)

Unsaturated hydraulic conductivity tests

Soil : Shau Kei Wan

Specimen Dimensions (mm)			
	Diameter	=	69.5
	Height	=	35

Start		End									
Time	Bottle + Water (g)	Time	Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
29/01/98 16:38	30.16	1/30/98 9:00	36.88	58920	58920	6.72	6.72	0	370	-1.9	10.6
30/01/98 16:05	30.17	02/02/98 10:30	52.5	152700	0	22.33	0	20	578	17.1	16.5
02/02/98 11:18	30.21	02/02/98 14:48	34.48	12600	12600	4.27	4.27	20	578	17.1	16.5
02/02/98 14:48	34.48	02/02/98 16:30	36.63	6120	18720	2.15	6.42	20	578	17.1	16.5
02/02/98 16:30	30.36	02/03/98 9:14	45.2	60240	78960	14.84	21.26	20	578	17.1	16.5
02/03/98 9:21	30.3	02/03/98 13:15	35.2	14040	93000	4.9	26.16	20	584	17.1	16.7
02/03/98 13:20	30.51	02/03/98 16:35	33.34	11700	0	2.83	0	40	584	37.1	16.7
02/03/98 16:38	30.22	02/04/98 9:10	39.26	59520	59520	9.04	9.04	40	584	37.1	16.7
04/02/98 9:13	30.21	04/02/98 14:34	33.16	19260	78780	2.95	11.99	40	584	37.1	16.7
04/02/98 15:45	25.26	05/02/98 9:31	33.9	63960	142740	8.64	20.63	40	550	37.2	15.7
05/02/98 9:31	33.9	05/02/98 13:21	35.73	13800	156540	1.83	22.46	40	550	37.2	15.7
05/02/98 13:21	35.73	05/02/98 17:04	37.5	13380	169920	1.77	24.23	40	550	37.2	15.7
05/02/98 17:05	25.45	06/02/98 9:19	33.13	58440	228360	7.68	31.91	40	550	37.2	15.7
06/02/98 10:38	25.33	06/02/98 16:30	28.07	21120	249480	2.74	34.65	40	550	37.2	15.7
06/02/98 16:30	28.07	08/02/98 16:30	50.52	172800	422280	22.45	57.1	40	550	37.2	15.7
08/02/98 16:30	25.59	09/02/98 9:19	33.21	60540	482820	7.62	64.72	40	550	37.2	15.7
09/02/98 9:37	25.56	09/02/98 12:11	27.07	9240	0	1.51	0	60	550	57.2	15.7
09/02/98 12:11	27.07	09/02/98 16:50	28.34	16740	16740	1.27	1.27	60	550	57.2	15.7
09/02/98 16:50	28.34	10/02/98 8:25	32.53	56100	72840	4.19	5.46	60	550	57.2	15.7
10/02/98 8:25	26.92	10/02/98 12:18	27.99	13980	86820	1.07	6.53	60	550	57.2	15.7
10/02/98 12:18	27.99	10/02/98 15:27	28.82	11340	98160	0.83	7.36	60	550	57.2	15.7
10/02/98 15:27	28.82	10/02/98 16:52	29.21	5100	103260	0.39	7.75	60	550	57.2	15.7
10/02/98 16:52	29.21	11/02/98 8:37	33.4	56700	159960	4.19	11.94	60	550	57.2	15.7
11/02/98 10:11	26.97	11/02/98 13:33	27.17	12120	172080	0.2	12.14	60	115	59.4	3.3

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Table 2 - Test data for the soil specimen from Shau Kei Wan (Sheet 2 of 4)

Start		End									
Time	Bottle + Water (g)	Time	Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
2/11/98 13:33	27.17	2/11/98 17:19	27.38	13560	185640	0.21	12.35	60	115	59.4	3.3
2/11/98 17:19	27.38	2/12/98 8:48	28.33	55740	241380	0.95	13.3	60	115	59.4	3.3
2/12/98 8:48	28.33	2/12/98 13:11	28.6	15780	257160	0.27	13.57	60	115	59.4	3.3
2/12/98 13:11	28.6	2/12/98 17:00	28.83	13740	270900	0.23	13.8	60	115	59.4	3.3
2/12/98 17:00	28.83	2/13/98 8:36	29.76	56160	327060	0.93	14.73	60	115	59.4	3.3
2/13/98 8:36	29.76	2/13/98 14:49	30.57	22380	0	0.81	0	80	115	79.4	3.3
2/13/98 14:49	30.57	2/16/98 8:42	33.25	237180	237180	2.68	2.68	80	115	79.4	3.3
2/16/98 8:42	27.08	2/16/98 12:38	27.22	14160	251340	0.14	2.82	80	115	79.4	3.3
2/16/98 12:38	27.22	2/16/98 16:55	27.38	15420	266760	0.16	2.98	80	115	79.4	3.3
2/16/98 16:55	27.38	2/17/98 10:19	28.09	62640	329400	0.71	3.69	80	115	79.4	3.3
2/17/98 10:19	28.09	2/18/98 9:50	29.02	84660	414060	0.93	4.62	80	115	79.4	3.3
2/18/98 10:15	29.02	2/19/98 13:21	29.74	97560	0	0.72	0	100	115	99.4	3.3 *
2/19/98 13:21	29.74	2/19/98 16:36	30.12	11700	11700	0.38	0.38	100	115	99.4	3.3 *
2/19/98 16:36	30.12	2/20/98 8:43	41.8	58020	69720	11.68	12.06	100	115	99.4	3.3 *
2/20/98 8:43	27.1	2/20/98 11:41	28.51	10680	80400	1.41	13.47	100	115	99.4	3.3 *
2/20/98 11:41	28.51	2/23/98 8:41	35.56	248400	328800	7.05	20.52	100	115	99.4	3.3 *
2/23/98 8:41	35.56	2/23/98 12:35	36.62	14040	342840	1.06	21.58	100	115	99.4	3.3 *
2/23/98 12:35	36.62	2/23/98 16:48	37.52	15180	358020	0.9	22.48	100	115	99.4	3.3 *
2/23/98 16:48	37.52	2/24/98 9:06	44.13	58680	416700	6.61	29.09	100	115	99.4	3.3
2/24/98 12:05	29.27	2/25/98 8:55	33.05	75000	491700	3.78	32.87	100	115	99.4	3.3
2/25/98 8:55	33.05	2/25/98 15:25	33.3	23400	515100	0.25	33.12	100	115	99.4	3.3
2/25/98 15:25	33.3	2/25/98 17:06	33.35	6060	521160	0.05	33.17	100	115	99.4	3.3
2/25/98 17:06	33.35	2/26/98 8:54	33.9	56880	578040	0.55	33.72	100	115	99.4	3.3
2/26/98 8:54	33.9	2/26/98 12:50	34.03	14160	592200	0.13	33.85	100	115	99.4	3.3
2/26/98 12:50	34.03	2/26/98 17:20	34.18	16200	608400	0.15	34	100	115	99.4	3.3
2/26/98 17:20	34.18	2/27/98 10:30	34.78	61800	670200	0.6	34.6	100	115	99.4	3.3
2/27/98 10:30	34.78	2/27/98 18:00	35.03	27000	697200	0.25	34.85	100	115	99.4	3.3
2/27/98 18:00	35.03	3/2/98 10:11	37.2	231060	928260	2.17	37.02	100	115	99.4	3.3
3/2/98 10:11	37.2	3/3/98 8:52	37.96	81660	1009920	0.76	37.78	100	115	99.4	3.3
3/3/98 8:52	37.96	3/3/98 16:03	38.2	25860	1035780	0.24	38.02	100	115	99.4	3.3
3/3/98 16:03	38.2	2/4/98 8:33	38.74	59400	1095180	0.54	38.56	100	115	99.4	3.3

* Airline not plugged in

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Table 2 - Test data for the soil specimen from Shau Kei Wan (Sheet 3 of 4)

Start		End									
Time	Bottle + Water (g)	Time	Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
04/02/98 8:33	38.74	04/02/98 15:40	38.98	25620	1120800	0.24	38.8	100	115	99.4	3.3
04/02/98 15:40	38.98	05/03/98 10:37	39.58	68220	1189020	0.6	39.4	100	115	99.4	3.3
05/03/98 10:37	39.58	06/03/98 10:55	40.39	87480	1276500	0.81	40.21	100	115	99.4	3.3
06/03/98 10:55	40.39	06/03/98 16:50	40.59	21300	1297800	0.2	40.41	100	115	99.4	3.3
06/03/98 16:50	40.59	09/03/98 9:05	42.79	231300	0	2.2	0	117	115	116.4	3.3
09/03/98 9:05	42.79	09/03/98 17:17	43.09	29520	29520	0.3	0.3	117	115	116.4	3.3
09/03/98 17:17	43.09	10/03/98 8:59	43.58	56520	86040	0.49	0.79	117	115	116.4	3.3
10/03/98 8:59	43.58	10/03/98 17:28	43.82	30540	116580	0.24	1.03	117	115	116.4	3.3
10/03/98 17:28	43.82	11/03/98 8:35	44.2	54420	171000	0.38	1.41	117	115	116.4	3.3
20/03/98 8:28	27.19	20/03/98 13:59	36.54	19860	0	9.35	0	0	115	-0.6	3.3
20/03/98 13:59	36.54	20/03/98 16:47	40.22	10080	10080	3.68	3.68	0	115	-0.6	3.3
20/03/98 16:47	27.09	23/03/98 8:35	62.09	229680	239760	35	38.68	0	115	-0.6	3.3
23/03/98 8:35	26.97	23/03/98 17:01	58.53	30360	270120	31.56	70.24	0	115	-0.6	3.3
24/03/98 10:20	27.12	24/03/98 13:27	36.04	11220	281340	8.92	79.16	0	115	-0.6	3.3
24/03/98 13:27	36.04	24/03/98 16:51	53.66	12240	293580	17.62	96.78	0	115	-0.6	3.3
25/03/98 8:48	27.21	25/03/98 12:08	31.13	12000	305580	3.92	100.7	0	115	-0.6	3.3
25/03/98 12:08	31.13	25/03/98 17:04	48.99	17760	323340	17.86	118.56	0	115	-0.6	3.3
25/03/98 17:04	27.01	26/03/98 8:37	69.18	55980	379320	42.17	160.73	0	115	-0.6	3.3
26/03/98 8:37	26.92	26/03/98 17:12	48.64	30900	410220	21.72	182.45	0	115	-0.6	3.3
27/03/98 8:37	27.12	27/03/98 17:02	47.17	30300	440520	20.05	202.5	0	115	-0.6	3.3
27/03/98 17:02	27.08	30/03/98 8:28	64.63	228360	668880	37.55	240.05	0	115	-0.6	3.3
30/03/98 8:28	27.03	30/03/98 14:53	27.8	23100	691980	0.77	240.82	0	115	-0.6	3.3
30/03/98 14:53	27.8	31/03/98 8:23	52.64	63000	754980	24.84	265.66	0	115	-0.6	3.3
02/04/98 16:19	30.69	03/04/98 8:32	30.77	58380	0	0.08	0	0	85	1.1	2.4
03/04/98 8:32	30.77	03/04/98 16:24	32.06	28320	28320	1.29	1.29	0	85	1.1	2.4
03/04/98 16:24	32.06	06/04/98 8:35	68.08	223860	252180	36.02	37.31	0	85	1.1	2.4
06/04/98 8:35	26.95	06/04/98 17:00	32.26	30300	282480	5.31	42.62	0	85	1.1	2.4
06/04/98 17:00	32.26	07/04/98 8:25	38.96	55500	337980	6.7	49.32	0	85	1.1	2.4

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Table 2 - Test data for the soil specimen from Shau Kei Wan (Sheet 4 of 4)

Start		End									
Time	Bottle + Water (g)	Time	Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
07/04/98 8:25	38.96	07/04/98 17:22	42.5	32220	370200	3.54	52.86	0	85	1.1	2.4
08/04/98 16:27	27.1	09/04/98 8:25	27.14	57480	427680	0.04	52.9	0	85	1.1	2.4
13/04/98 8:37	27.01	13/04/98 16:46	32.31	29340	457020	5.3	58.2	0	85	1.1	2.4
14/04/98 13:09	27.1	14/04/98 16:40	68.94	12660	469680	41.84	100.04	0	85	1.1	2.4
14/04/98 16:40	34.6	15/04/98 8:08	204.71	55680	525360	170.11	270.15	0	85	1.1	2.4
15/04/98 8:08	36.63	15/04/98 11:56	78.98	13680	539040	42.35	312.5	0	85	1.1	2.4
15/04/98 11:56	78.98	15/04/98 17:21	137.98	19500	558540	59	371.5	0	85	1.1	2.4
15/04/98 17:21	36.8	16/04/98 8:17	184.7	53760	612300	147.9	519.4	0	85	1.1	2.4

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Table 3 - Test data for the soil specimen from Nam Long Shan (Sheet 1 of 3)

Unsaturated hydraulic conductivity tests											
Soil : Nam Long Shan											
Specimen Dimensions (mm)	**Diameter**	=	69.5								
	Height	=	35								
Start		**End**									
Time	**Bottle + Water (g)**	**Time**	**Bottle + Water (g)**	**Elapsed Time (s)**	**Cumulative Time (s)**	**Water Vol. (cc)**	**Cumulative volume of water (cc)**	**Air Pres. (kPa)**	**Head across specimen (mm)**	**Average Matric suction (kPa)**	**Gradient across specimen**
2/3/98 14:21	34.75	2/3/98 16:30	38.34	7740	0	3.59	0	0	520	-2.6	14.9
2/3/98 16:34	36.18	2/4/98 9:14	51.15	60000	60000	14.97	14.97	0	520	-2.6	14.9
2/4/98 9:15	36.23	2/4/98 14:32	43.36	19020	79020	7.13	22.1	0	520	-2.6	14.9
2/4/98 15:50	25.19	2/5/98 9:32	51.93	63720	142740	26.74	48.84	0	550	-2.6	15.7
2/5/98 9:32	51.93	2/5/98 13:20	57.4	13680	156420	5.47	54.31	0	550	-2.6	15.7
2/5/98 13:20	57.4	2/5/98 17:05	63.25	13500	169920	5.85	60.16	0	550	-2.6	15.7
2/5/98 17:06	25.53	2/6/98 9:20	50.87	58440	228360	25.34	85.5	0	550	-2.6	15.7
2/6/98 10:39	25.58	2/6/98 12:56	27.61	8220	236580	2.03	87.53	0	550	-2.6	15.7
2/6/98 12:56	27.61	2/6/98 16:31	33.19	12900	249480	5.58	93.11	0	550	-2.6	15.7
2/8/98 16:30	27.43	2/9/98 9:22	58.63	60720	310200	31.2	124.31	0	550	-2.6	15.7
2/9/98 9:22	27.08	2/9/98 12:12	32.44	10200	320400	5.36	129.67	0	550	-2.6	15.7
2/9/98 12:12	32.44	2/9/98 16:50	41.13	16680	337080	8.69	138.36	0	550	-2.6	15.7
2/26/98 12:50	35.7	2/26/98 17:20	36.23	16200	0	0.53	0	10	115	9.4	3.3
2/26/98 17:20	36.23	2/27/98 10:30	37.47	61800	61800	1.24	1.24	10	115	9.4	3.3
2/27/98 10:30	37.47	2/27/98 18:00	37.94	27000	88800	0.47	1.71	10	115	9.4	3.3
2/27/98 18:00	37.94	3/2/98 10:11	41.59	231060	319860	3.65	5.36	10	115	9.4	3.3
3/2/98 10:11	25.63	3/3/98 8:52	26.95	81660	401520	1.32	6.68	10	115	9.4	3.3
3/3/98 8:52	26.95	3/3/98 16:03	27.81	25860	0	0.86	0	20	115	19.4	3.3
3/3/98 16:03	27.81	2/4/98 8:33	28.14	59400	59400	0.33	0.33	20	115	19.4	3.3
2/4/98 8:33	28.14	2/4/98 15:40	28.3	25620	85020	0.16	0.49	20	115	19.4	3.3
2/4/98 15:40	28.3	3/5/98 10:37	28.66	68220	153240	0.36	0.85	20	115	19.4	3.3
3/5/98 10:37	28.66	3/6/98 10:55	29.13	87480	240720	0.47	1.32	20	115	19.4	3.3
3/6/98 10:55	29.13	3/6/98 16:50	29.25	21300	262020	0.12	1.44	20	115	19.4	3.3

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Table 3 - Test data for the soil specimen from Nam Long Shan (Sheet 2 of 3)

Start		End									
Time	Bottle + Water (g)	Time	Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
3/6/98 16:50	29.25	3/9/98 9:05	30.59	231300	0	1.34	0	40	115	39.4	3.3
3/9/98 9:05	30.59	3/9/98 17:17	30.68	29520	29520	0.09	0.09	40	115	39.4	3.3
3/9/98 17:17	30.68	3/10/98 8:59	30.86	56520	86040	0.18	0.27	40	115	39.4	3.3
3/10/98 8:59	30.86	3/10/98 17:28	30.95	30540	116580	0.09	0.36	40	115	39.4	3.3
3/10/98 17:28	30.95	3/11/98 8:35	31.14	54420	171000	0.19	0.55	40	115	39.4	3.3
3/11/98 8:35	31.14	3/11/98 16:28	31.23	28380	199380	0.09	0.64	40	115	39.4	3.3
3/11/98 16:28	31.23	3/12/98 8:44	31.39	58560	257940	0.16	0.8	40	115	39.4	3.3
3/12/98 8:44	31.39	3/12/98 17:26	31.86	31320	0	0.47	0	60	115	59.4	3.3
3/12/98 17:26	31.86	3/13/98 9:37	32.01	58260	58260	0.15	0.15	60	115	59.4	3.3
3/13/98 9:37	32.01	3/13/98 13:20	32.07	13380	71640	0.06	0.21	60	115	59.4	3.3
3/13/98 13:20	32.07	3/16/98 8:40	32.71	242400	314040	0.64	0.85	60	115	59.4	3.3
3/16/98 8:40	32.71	3/16/98 17:10	32.75	30600	344640	0.04	0.89	60	115	59.4	3.3
3/16/98 17:10	32.75	3/17/98 8:15	32.96	54300	398940	0.21	1.1	60	115	59.4	3.3
3/17/98 8:15	32.96	3/17/98 17:35	33.06	33600	432540	0.1	1.2	60	115	59.4	3.3
3/17/98 17:35	33.06	3/18/98 8:34	33.18	53940	486480	0.12	1.32	60	115	59.4	3.3
3/18/98 8:34	33.18	3/18/98 12:17	33.22	13380	499860	0.04	1.36	60	115	59.4	3.3
3/18/98 12:17	33.22	3/18/98 17:25	33.25	18480	518340	0.03	1.39	60	115	59.4	3.3
3/18/98 17:25	33.25	3/19/98 8:34	33.4	54540	572880	0.15	1.54	60	115	59.4	3.3
3/19/98 8:34	33.4	3/19/98 13:23	33.43	17340	590220	0.03	1.57	60	115	59.4	3.3
3/19/98 13:23	33.43	3/20/98 8:28	33.68	68700	658920	0.25	1.82	60	115	59.4	3.3
3/20/98 8:28	33.68	3/20/98 13:59	34	19860	0	0.32	0	80	115	79.4	3.3
3/20/98 13:59	34	3/20/98 16:47	34.02	10080	10080	0.02	0.02	80	115	79.4	3.3
3/20/98 16:47	25.35	3/23/98 8:35	26.09	229680	239760	0.74	0.76	80	115	79.4	3.3
3/23/98 8:35	26.09	3/23/98 17:01	26.19	30360	270120	0.1	0.86	80	115	79.4	3.3
3/23/98 17:01	26.19	3/24/98 10:20	26.33	62340	332460	0.14	1	80	115	79.4	3.3
3/24/98 10:20	26.33	3/24/98 13:27	26.34	11220	343680	0.01	1.01	80	115	79.4	3.3
3/24/98 13:27	26.34	3/24/98 16:51	26.4	12240	355920	0.06	1.07	80	115	79.4	3.3
3/24/98 16:51	26.4	3/25/98 8:48	26.58	57420	413340	0.18	1.25	80	115	79.4	3.3
3/25/98 8:48	26.58	2/25/98 12:08	26.61	12000	425340	0.03	1.28	80	115	79.4	3.3
3/25/98 12:08	26.61	3/25/98 17:04	26.68	17760	443100	0.07	1.35	80	115	79.4	3.3
3/25/98 17:04	26.68	3/26/98 8:37	26.8	55980	499080	0.12	1.47	80	115	79.4	3.3

Table 3 - Test data for the soil specimen from Nam Long Shan (Sheet 3 of 3)

Start		End									
Time	Bottle + Water (g)	Time	Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
3/26/98 8:37	26.8	3/26/98 17:12	26.91	30900	529980	0.11	1.58	80	115	79.4	3.3
3/26/98 17:12	26.91	3/27/98 8:37	27.04	53520	583500	0.13	1.71	80	115	79.4	3.3
3/27/98 8:37	27.04	3/27/98 17:02	27.12	32880	616380	0.08	1.79	80	115	79.4	3.3
3/27/98 17:02	27.12	3/30/98 8:28	27.94	228360	0	0.82	0	100	115	99.4	3.3
3/30/98 8:28	27.94	3/30/98 14:53	28.02	23100	23100	0.08	0.08	100	115	99.4	3.3
3/30/98 14:53	28.02	3/31/98 8:23	28.15	63000	86100	0.13	0.21	100	115	99.4	3.3
3/31/98 8:23	28.15	3/31/98 17:10	28.25	31620	117720	0.1	0.31	100	115	99.4	3.3
3/31/98 17:10	28.25	4/1/98 8:34	28.31	55440	173160	0.06	0.37	100	115	99.4	3.3
4/1/98 8:34	28.31	4/1/98 13:24	28.39	17400	190560	0.08	0.45	100	115	99.4	3.3
4/1/98 13:24	28.39	4/2/98 8:30	28.48	68760	259320	0.09	0.54	100	115	99.4	3.3
4/2/98 8:30	28.48	4/2/98 15:05	28.54	23700	283020	0.06	0.6	100	115	99.4	3.3
4/2/98 15:05	28.54	4/2/98 16:19	28.58	4440	287460	0.04	0.64	100	115	99.4	3.3
4/2/98 16:19	28.58	4/3/98 8:32	28.7	58380	345840	0.12	0.76	100	115	99.4	3.3
4/3/98 8:32	28.7	4/3/98 16:24	28.82	28320	374160	0.12	0.88	100	115	99.4	3.3
4/8/98 11:24	25.32	4/8/98 16:27	33.42	18180	0	8.1	0	0	85	1.1	2.4
4/8/98 16:27	25.35	4/9/98 8:25	35.67	57480	57480	10.32	10.32	0	85	1.1	2.4
4/9/98 8:25	35.67	4/9/98 16:54	43.39	30540	88020	7.72	18.04	0	85	1.1	2.4
4/13/98 8:37	25.55	4/13/98 16:46	57.96	29340	117360	32.41	50.45	0	85	1.1	2.4
4/13/98 16:46	25.72	4/14/98 8:50	43.22	57840	175200	17.5	67.95	0	85	1.1	2.4
4/14/98 8:50	25.6	4/14/98 16:40	35.18	28200	203400	9.58	77.53	0	85	1.1	2.4
4/14/98 16:40	25.71	4/15/98 8:08	41.81	55680	259080	16.1	93.63	0	85	1.1	2.4
4/15/98 8:08	25.46	4/15/98 11:56	29.76	13680	272760	4.3	97.93	0	85	1.1	2.4
4/15/98 11:56	29.76	4/15/98 17:21	35.9	19500	292260	6.14	104.07	0	85	1.1	2.4
4/15/98 17:21	25.52	4/16/98 8:17	41.23	53760	346020	15.71	119.78	0	85	1.1	2.4

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Table 4 - Test data for the soil specimen from Chai Wan Fei Tsui (Sheet 1 of 4)

Unsaturated hydraulic conductivity tests											
Soil : Chai Wan Fei Tsui											
Specimen Dimensions (mm)	**Diameter**	=	69.5								
	Height	=	35								
Start		**End**									
Time	**Bottle + Water (g)**	**Time**	**Bottle + Water (g)**	**Elapsed Time (s)**	**Cumulative Time (s)**	**Water Vol. (cc)**	**Cumulative volume of water (cc)**	**Air Pres. (kPa)**	**Head across specimen (mm)**	**Average Matric suction (kPa)**	**Gradient across specimen**
2/5/98 11:30	27.8	2/5/98 13:19	31.9	6540	0	4.1	0	0	550	-2.8	15.7
2/5/98 13:19	31.9	2/5/98 17:07	40.62	13680	13680	8.72	8.72	0	550	-2.8	15.7
2/5/98 17:08	25.9	2/6/98 9:22	64.08	58440	72120	38.18	46.9	0	550	-2.8	15.7
2/6/98 10:40	25.98	2/6/98 16:31	40.35	21060	93180	14.37	61.27	0	550	-2.8	15.7
2/8/98 16:30	26.31	2/9/98 9:22	66.66	60720	153900	40.35	101.62	0	550	-2.8	15.7
2/9/98 9:22	26.06	2/9/98 12:12	33.01	10200	164100	6.95	108.57	0	550	-2.8	15.7
2/9/98 12:12	33.01	2/9/98 16:51	43.99	16740	180840	10.98	119.55	0	550	-2.8	15.7
2/9/98 16:51	25.92	2/10/98 8:25	62.76	67500	248340	36.84	156.39	0	550	-2.8	15.7
2/26/98 12:50	29	2/26/98 17:20	30.78	16200	0	1.78	0	10	115	9.4	3.3
2/26/98 17:20	30.78	2/27/98 10:30	38.08	61800	61800	7.3	7.3	10	115	9.4	3.3
2/27/98 10:30	38.08	2/27/98 18:00	41.1	27000	88800	3.02	10.32	10	115	9.4	3.3
2/27/98 18:00	41.1	3/2/98 10:11	64.76	231060	319860	23.66	33.98	10	115	9.4	3.3
3/2/98 10:11	25.93	3/3/98 8:52	34.36	81660	401520	8.43	42.41	10	115	9.4	3.3
3/3/98 8:52	34.36	3/3/98 16:03	37.06	25860	0	2.7	0	20	115	19.4	3.3
3/3/98 16:03	37.06	2/4/98 8:33	42.28	59400	59400	5.22	5.22	20	115	19.4	3.3
2/4/98 8:33	42.28	2/4/98 15:40	44.55	25620	85020	2.27	7.49	20	115	19.4	3.3
2/4/98 15:40	44.55	3/5/98 10:37	50.23	68220	153240	5.68	13.17	20	115	19.4	3.3
3/5/98 10:37	50.23	3/6/98 10:55	57.94	87480	240720	7.71	20.88	20	115	19.4	3.3
3/6/98 10:55	25.77	3/6/98 16:50	27.66	21300	262020	1.89	22.77	20	115	19.4	3.3
3/6/98 16:50	27.66	3/9/98 9:05	44.43	231300	0	16.77	0	40	115	39.4	3.3
3/9/98 9:05	44.43	3/9/98 17:17	46.69	29520	29520	2.26	2.26	40	115	39.4	3.3
3/9/98 17:17	46.69	3/10/98 8:59	50.52	56520	86040	3.83	6.09	40	115	39.4	3.3
3/10/98 8:59	50.52	3/10/98 17:28	52.62	30540	116580	2.1	8.19	40	115	39.4	3.3

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Table 4 - Test data for the soil specimen from Chai Wan Fei Tsui (Sheet 2 of 4)

Start		End									
Time	Bottle + Water (g)	Time	Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
3/10/98 17:28	52.62	3/11/98 8:35	56.4	54420	171000	3.78	11.97	40	115	39.4	3.3
3/11/98 8:35	25.68	3/11/98 16:28	27.64	28380	199380	1.96	13.93	40	115	39.4	3.3
3/11/98 16:28	27.64	3/12/98 8:44	31.68	58560	257940	4.04	17.97	40	115	39.4	3.3
3/12/98 8:44	31.68	3/12/98 17:26	34.23	31320	0	2.55	0	60	115	59.4	3.3
3/12/98 17:26	34.23	3/13/98 9:37	37.39	58260	58260	3.16	3.16	60	115	59.4	3.3
3/13/98 9:37	37.39	3/13/98 13:20	38.15	13380	71640	0.76	3.92	60	115	59.4	3.3
3/13/98 13:20	38.15	3/16/98 8:40	51.17	242400	314040	13.02	16.94	60	115	59.4	3.3
3/16/98 8:40	25.91	3/16/98 17:10	26.78	30600	344640	0.87	17.81	60	115	59.4	3.3
3/16/98 17:10	26.78	3/17/98 8:15	30.42	54300	398940	3.64	21.45	60	115	59.4	3.3
3/17/98 8:15	30.42	3/17/98 17:35	32.2	33600	432540	1.78	23.23	60	115	59.4	3.3
3/17/98 17:35	32.2	3/18/98 8:34	34.9	53940	486480	2.7	25.93	60	115	59.4	3.3
3/18/98 8:34	34.9	3/18/98 12:17	35.6	13380	499860	0.7	26.63	60	115	59.4	3.3
3/18/98 12:17	35.6	3/18/98 17:25	36.51	18480	518340	0.91	27.54	60	115	59.4	3.3
3/18/98 17:25	36.51	3/19/98 8:34	39.32	54540	572880	2.81	30.35	60	115	59.4	3.3
3/19/98 8:34	39.32	3/19/98 13:23	40.16	17340	590220	0.84	31.19	60	115	59.4	3.3
3/19/98 13:23	40.16	3/20/98 8:28	43.71	68700	658920	3.55	34.74	60	115	59.4	3.3
3/20/98 8:28	33.68	3/20/98 13:59	45.6	19860	0	11.92	0	80	115	79.4	3.3
3/20/98 13:59	45.6	3/20/98 16:47	46.06	10080	10080	0.46	0.46	80	115	79.4	3.3
3/20/98 16:47	25.77	3/23/98 8:35	38.58	229680	239760	12.81	13.27	80	115	79.4	3.3
3/23/98 8:35	38.58	3/23/98 17:01	39.83	30360	270120	1.25	14.52	80	115	79.4	3.3
3/23/98 17:01	39.83	3/24/98 10:20	42.48	62340	332460	2.65	17.17	80	115	79.4	3.3
3/24/98 10:20	42.48	3/24/98 13:27	42.92	11220	343680	0.44	17.61	80	115	79.4	3.3
3/24/98 13:27	42.92	3/24/98 16:51	43.54	12240	355920	0.62	18.23	80	115	79.4	3.3
3/24/98 16:51	43.54	3/25/98 8:48	46.13	57420	413340	2.59	20.82	80	115	79.4	3.3
3/25/98 8:48	46.13	2/25/98 12:08	46.66	12000	425340	0.53	21.35	80	115	79.4	3.3
3/25/98 12:08	46.66	3/25/98 17:04	47.48	17760	443100	0.82	22.17	80	115	79.4	3.3
3/25/98 17:04	47.48	3/26/98 8:37	49.89	55980	499080	2.41	24.58	80	115	79.4	3.3
3/26/98 8:37	25.72	3/26/98 17:12	27.17	30900	529980	1.45	26.03	80	115	79.4	3.3
3/26/98 17:12	27.17	3/27/98 8:37	29.59	53520	583500	2.42	28.45	80	115	79.4	3.3
3/27/98 8:37	29.59	3/27/98 17:02	30.96	32880	616380	1.37	29.82	80	115	79.4	3.3

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Table 4 - Test data for the soil specimen from Chai Wan Fei Tsui (Sheet 3 of 4)

Start		End									
Time	Bottle + Water (g)	Time	Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
3/27/98 17:02	30.96	3/30/98 8:28	39.16	228360	0	8.2	0	100	115	99.4	3.3
3/30/98 8:28	39.16	3/30/98 14:53	39.83	23100	23100	0.67	0.67	100	115	99.4	3.3
3/30/98 14:53	39.83	3/31/98 8:23	41.64	63000	86100	1.81	2.48	100	115	99.4	3.3
3/31/98 8:23	41.64	3/31/98 17:10	42.48	31620	117720	0.84	3.32	100	115	99.4	3.3
3/31/98 17:10	42.48	4/1/98 8:34	44.02	55440	173160	1.54	4.86	100	115	99.4	3.3
4/1/98 8:34	44.02	4/1/98 13:24	44.53	17400	190560	0.51	5.37	100	115	99.4	3.3
4/1/98 13:24	44.53	4/2/98 8:30	46.49	68760	259320	1.96	7.33	100	115	99.4	3.3
4/2/98 8:30	46.49	4/2/98 15:05	47.14	23700	283020	0.65	7.98	100	115	99.4	3.3
4/2/98 15:05	47.14	4/2/98 16:19	47.29	4440	287460	0.15	8.13	100	115	99.4	3.3
4/2/98 16:19	47.29	4/3/98 8:32	48.65	58380	345840	1.36	9.49	100	115	99.4	3.3
4/3/98 8:32	48.65	4/3/98 16:24	49.35	28320	374160	0.7	10.19	100	115	99.4	3.3
4/3/98 16:24	25.84	4/6/98 8:35	29.99	223860	598020	4.15	14.34	100	115	99.4	3.3
4/6/98 8:35	29.99	4/6/98 17:00	30.45	30300	628320	0.46	14.8	100	115	99.4	3.3
4/6/98 17:00	30.45	4/7/98 8:25	30.45	55500	683820	0	14.8	100	115	99.4	3.3 *
4/7/98 8:25	30.45	4/7/98 17:22	30.46	32220	716040	0.01	14.81	100	115	99.4	3.3 *
4/7/98 17:22	30.46	4/8/98 10:32	31.07	61800	777840	0.61	15.42	100	115	99.4	3.3 *
4/8/98 10:32	31.07	4/8/98 16:27	35.99	21300	799140	4.92	20.34	100	115	99.4	3.3
4/8/98 16:27	35.99	4/9/98 8:25	37.91	57480	856620	1.92	22.26	100	115	99.4	3.3
4/9/98 8:25	37.91	4/9/98 16:54	38.9	30540	887160	0.99	23.25	100	115	99.4	3.3
4/9/98 16:54	38.9	4/13/98 8:37	48.27	315780	1202940	9.37	32.62	100	115	99.4	3.3
4/13/98 8:37	25.81	4/13/98 16:46	26.58	29340	1232280	0.77	33.39	100	115	99.4	3.3
4/13/98 16:46	26.58	4/14/98 8:50	28.11	57840	1290120	1.53	34.92	100	115	99.4	3.3
4/14/98 8:50	28.11	4/14/98 16:40	28.88	28200	1318320	0.77	35.69	100	115	99.4	3.3
4/14/98 16:40	28.88	4/15/98 8:08	30.32	55680	1374000	1.44	37.13	100	115	99.4	3.3
4/15/98 8:08	30.32	4/15/98 17:21	31.22	33180	1407180	0.9	38.03	100	115	99.4	3.3
4/15/98 17:21	31.22	4/16/98 8:17	32.53	53760	1460940	1.31	39.34	100	115	99.4	3.3
4/20/98 11:42	35.46	4/20/98 14:22	48.56	9600	9600	13.1	13.1	0	85	1.1	2.4
4/20/98 14:22	48.56	4/20/98 16:48	58.84	8760	18360	10.28	23.38	0	85	1.1	2.4
4/20/98 16:48	58.84	4/21/98 9:02	119.33	58440	76800	60.49	83.87	0	85	1.1	2.4

* Supply turned off

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Table 4 - Test data for the soil specimen from Chai Wan Fei Tsui (Sheet 4 of 4)

Start		End									
Time	Bottle + Water (g)	Time	Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
4/23/98 8:41	32.19	4/23/98 14:55	83.9	22440	0	51.71	0	0	50	-0.3	1.4
4/23/98 14:55	83.9	4/23/98 16:57	101.99	7320	7320	18.09	18.09	0	50	-0.3	1.4
4/24/98 9:22	32.11	4/24/98 11:45	69.07	8580	15900	36.96	55.05	0	50	-0.3	1.4
4/24/98 11:45	69.07	4/24/98 16:10	132.82	15900	31800	63.75	118.8	0	50	-0.3	1.4
4/27/98 8:41	32.35	4/27/98 14:04	160.83	19380	51180	128.48	247.28	0	50	-0.3	1.4

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Table 5 - Test data for the soil specimen from Butterfly Valley (Sheet 1 of 4)

Unsaturated hydraulic conductivity tests

Soil :Butterfly Valley

Specimen Dimensions (mm)	**Diameter**	=	69.5
	Height	=	35

Start Time	**Start** Bottle + Water (g)	**End** Time	**End** Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
2/5/98 11:30	27.25	2/5/98 13:18	34.68	6480	0	7.43	0	0	550	-2.8	15.7
2/5/98 13:18	34.68	2/5/98 17:09	51.05	13860	13860	16.37	16.37	0	550	-2.8	15.7
2/5/98 17:08	25.9	2/6/98 9:22	64.08	58440	72300	38.18	54.55	0	550	-2.8	15.7
2/6/98 10:41	25.41	2/6/98 16:32	50.37	21060	93360	24.96	79.51	0	550	-2.8	15.7
2/8/98 16:30	25.74	2/9/98 9:24	49.28	60840	154200	23.54	103.05	0	550	-2.8	15.7 *
2/9/98 9:24	25.55	2/9/98 12:13	37.56	10140	164340	12.01	115.06	0	550	-2.8	15.7
2/9/98 12:13	37.56	2/9/98 16:51	38.41	16680	181020	0.85	115.91	0	550	-2.8	15.7
2/9/98 16:51	25.47	2/10/98 8:29	58.89	56280	237300	33.42	149.33	0	550	-2.8	15.7 *
2/26/98 12:50	37.76	2/26/98 17:20	39.31	16200	0	1.55	0	10	115	9.4	3.3
2/26/98 17:20	39.31	2/27/98 10:30	48.36	61800	61800	9.05	9.05	10	115	9.4	3.3
2/27/98 10:30	25.37	2/27/98 18:00	29.16	27000	88800	3.79	12.84	10	115	9.4	3.3
2/27/98 18:00	29.16	3/2/98 10:11	58.4	231060	319860	29.24	42.08	10	115	9.4	3.3
3/2/98 10:11	25.46	3/3/98 8:52	36.4	81660	401520	10.94	53.02	10	115	9.4	3.3
3/3/98 8:52	36.4	3/3/98 16:03	39.16	25860	0	2.76	0	20	115	19.4	3.3
3/3/98 16:03	39.16	2/4/98 8:33	41.23	59400	59400	2.07	2.07	20	115	19.4	3.3
2/4/98 8:33	41.23	2/4/98 15:40	42.19	25620	85020	0.96	3.03	20	115	19.4	3.3
2/4/98 15:40	42.19	3/5/98 10:37	44.62	68220	153240	2.43	5.46	20	115	19.4	3.3
3/5/98 10:37	44.62	3/6/98 10:55	47.71	87480	240720	3.09	8.55	20	115	19.4	3.3
3/6/98 10:55	25.28	3/6/98 16:50	26.07	21300	262020	0.79	9.34	20	115	19.4	3.3
3/6/98 16:50	26.07	3/9/98 9:05	29.53	231300	0	3.46	0	40	115	39.4	3.3
3/9/98 9:05	29.53	3/9/98 17:17	29.81	29520	29520	0.28	0.28	40	115	39.4	3.3
3/9/98 17:17	29.81	3/10/98 8:59	30.31	56520	86040	0.5	0.78	40	115	39.4	3.3
3/10/98 8:59	30.31	3/10/98 17:28	30.39	30540	116580	0.08	0.86	40	115	39.4	3.3

* Overflow

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Table 5 - Test data for the soil specimen from Butterfly Valley (Sheet 2 of 4)

Start		End									
Time	Bottle + Water (g)	Time	Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
3/10/98 17:28	30.39	3/11/98 8:35	30.85	54420	171000	0.46	1.32	40	115	39.4	3.3
3/11/98 8:35	30.85	3/11/98 16:28	31.11	28380	199380	0.26	1.58	40	115	39.4	3.3
3/11/98 16:28	31.11	3/12/98 8:44	31.59	58560	257940	0.48	2.06	40	115	39.4	3.3
3/12/98 8:44	31.59	3/12/98 17:26	32.77	31320	0	1.18	0	60	115	59.4	3.3
3/12/98 17:26	32.77	3/13/98 9:37	33.02	58260	58260	0.25	0.25	60	115	59.4	3.3
3/13/98 9:37	33.02	3/13/98 13:20	33.09	13380	71640	0.07	0.32	60	115	59.4	3.3
3/13/98 13:20	33.09	3/16/98 8:40	34.2	242400	314040	1.11	1.43	60	115	59.4	3.3
3/16/98 8:40	34.2	3/16/98 17:10	34.28	30600	344640	0.08	1.51	60	115	59.4	3.3
3/16/98 17:10	34.28	3/17/98 8:15	34.57	54300	398940	0.29	1.8	60	115	59.4	3.3
3/17/98 8:15	34.57	3/17/98 17:35	34.74	33600	432540	0.17	1.97	60	115	59.4	3.3
3/17/98 17:35	34.74	3/18/98 8:34	34.99	53940	486480	0.25	2.22	60	115	59.4	3.3
3/18/98 8:34	34.99	3/18/98 12:17	35.04	13380	499860	0.05	2.27	60	115	59.4	3.3
3/18/98 12:17	35.04	3/18/98 17:25	35.1	18480	518340	0.06	2.33	60	115	59.4	3.3
3/18/98 17:25	35.1	3/19/98 8:34	35.33	54540	572880	0.23	2.56	60	115	59.4	3.3
3/19/98 8:34	35.33	3/19/98 13:23	35.41	17340	590220	0.08	2.64	60	115	59.4	3.3
3/19/98 13:23	35.41	3/20/98 8:28	35.72	68700	658920	0.31	2.95	60	115	59.4	3.3
3/20/98 8:28	35.72	3/20/98 13:59	36.57	19860	0	0.85	0	80	115	79.4	3.3
3/20/98 13:59	36.57	3/20/98 16:47	36.59	10080	10080	0.02	0.02	80	115	79.4	3.3
3/20/98 16:47	25.15	3/23/98 8:35	25.48	229680	239760	0.33	0.35	80	115	79.4	3.3
3/23/98 8:35	25.48	3/23/98 17:01	25.61	30360	270120	0.13	0.48	80	115	79.4	3.3
3/23/98 17:01	25.61	3/24/98 10:20	25.78	62340	332460	0.17	0.65	80	115	79.4	3.3
3/24/98 10:20	25.78	3/24/98 13:27	25.79	11220	343680	0.01	0.66	80	115	79.4	3.3
3/24/98 13:27	25.79	3/24/98 16:51	25.84	12240	355920	0.05	0.71	80	115	79.4	3.3
3/24/98 16:51	25.84	3/25/98 8:48	26	57420	413340	0.16	0.87	80	115	79.4	3.3
3/25/98 8:48	26	2/25/98 12:08	26.01	12000	425340	0.01	0.88	80	115	79.4	3.3
3/25/98 12:08	26.01	3/25/98 17:04	26.07	17760	443100	0.06	0.94	80	115	79.4	3.3
3/25/98 17:04	26.07	3/26/98 8:37	26.22	55980	499080	0.15	1.09	80	115	79.4	3.3
3/26/98 8:37	26.22	3/26/98 17:12	26.32	30900	529980	0.1	1.19	80	115	79.4	3.3
3/26/98 17:12	26.32	3/27/98 8:37	26.44	53520	583500	0.12	1.31	80	115	79.4	3.3
3/27/98 8:37	26.44	3/27/98 17:02	26.55	32880	616380	0.11	1.42	80	115	79.4	3.3

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Table 5 - Test data for the soil specimen from Butterfly Valley (Sheet 3 of 4)

Start		End									
Time	Bottle + Water (g)	Time	Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
3/27/98 17:02	26.55	3/30/98 8:28	27.35	228360	0	0.8	0	100	115	99.4	3.3
3/30/98 8:28	27.35	3/30/98 14:53	27.41	23100	23100	0.06	0.06	100	115	99.4	3.3
3/30/98 14:53	27.41	3/31/98 8:23	27.52	63000	86100	0.11	0.17	100	115	99.4	3.3
3/31/98 8:23	27.52	3/31/98 17:10	27.61	31620	117720	0.09	0.26	100	115	99.4	3.3
3/31/98 17:10	27.61	4/1/98 8:34	27.68	55440	173160	0.07	0.33	100	115	99.4	3.3
4/1/98 8:34	27.68	4/1/98 13:24	27.75	17400	190560	0.07	0.4	100	115	99.4	3.3
4/1/98 13:24	27.75	4/2/98 8:30	27.85	68760	259320	0.1	0.5	100	115	99.4	3.3
4/2/98 8:30	27.85	4/2/98 15:05	27.9	23700	283020	0.05	0.55	100	115	99.4	3.3
4/2/98 15:05	27.9	4/2/98 16:19	27.94	4440	287460	0.04	0.59	100	115	99.4	3.3
4/2/98 16:19	27.94	4/3/98 8:32	28.05	58380	345840	0.11	0.7	100	115	99.4	3.3
4/3/98 8:32	28.05	4/3/98 16:24	28.11	28320	374160	0.06	0.76	100	115	99.4	3.3
4/3/98 16:24	28.11	4/6/98 8:35	28.54	223860	598020	0.43	1.19	100	115	99.4	3.3
4/6/98 8:35	28.54	4/6/98 17:00	28.6	30300	628320	0.06	1.25	100	115	99.4	3.3
4/8/98 16:27	33.86	4/9/98 8:25	34.06	57480	685800	0.2	1.45	100	115	99.4	3.3
4/9/98 8:25	34.06	4/9/98 16:54	34.15	30540	716340	0.09	1.54	100	115	99.4	3.3
4/9/98 16:54	34.15	4/13/98 8:37	34.82	315780	1032120	0.67	2.21	100	115	99.4	3.3
4/13/98 8:37	34.82	4/13/98 16:46	34.89	29340	1061460	0.07	2.28	100	115	99.4	3.3
4/13/98 16:46	34.89	4/14/98 8:50	34.99	57840	1119300	0.1	2.38	100	115	99.4	3.3
4/14/98 8:50	34.99	4/14/98 16:40	35.05	28200	1147500	0.06	2.44	100	115	99.4	3.3
4/14/98 16:40	35.05	4/15/98 8:08	35.17	55680	1203180	0.12	2.56	100	115	99.4	3.3
4/15/98 8:08	35.17	4/15/98 17:21	35.26	33180	1236360	0.09	2.65	100	115	99.4	3.3
4/15/98 17:21	35.26	4/16/98 8:17	35.37	53760	1290120	0.11	2.76	100	115	99.4	3.3
4/17/98 15:07	31.11	4/17/98 16:56	226.69	6540	0	195.58	0	0	85	1.1	2.4
4/20/98 8:43	32.67	4/20/98 11:42	239.47	10740	10740	206.8	206.8	0	85	1.1	2.4
4/20/98 11:42	32.33	4/20/98 14:22	239.27	9600	20340	206.94	413.74	0	85	1.1	2.4
4/20/98 14:22	31.95	4/20/98 16:48	217.57	8760	29100	185.62	599.36	0	85	1.1	2.4
4/20/98 16:48	32.75										

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Table 5 - Test data for the soil specimen from Butterfly Valley (Sheet 4 of 4)

Start		End									
Time	Bottle + Water (g)	Time	Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
4/23/98 8:41	32.19	4/23/98 14:55	83.9	22440	0	51.71	0	0	50	-0.3	1.4
4/23/98 14:55	83.9	4/23/98 16:57	101.99	7320	7320	18.09	18.09	0	50	-0.3	1.4
4/24/98 9:22	32.11	4/24/98 11:45	69.07	8580	15900	36.96	55.05	0	50	-0.3	1.4
4/24/98 11:45	69.07	4/24/98 16:10	132.82	15900	31800	63.75	118.8	0	50	-0.3	1.4
4/27/98 8:41	32.35	4/27/98 14:04	160.83	19380	51180	128.48	247.28	0	50	-0.3	1.4

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Table 6 - Test data for the soil specimen from Castle Peak (Sheet 1 of 2)

Unsaturated hydraulic conductivity tests

Soil : Castle Peak

Specimen Dimensions (mm)			
	Diameter	=	69.5
	Height	=	35

Start Time	Start Bottle + Water (g)	End Time	End Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
27/5/98 11:35	29.49	29/5/98 11:42	62.04	173220	173220	32.55	32.55	0	150	-0.8	4.3
29/5/98 09:46	29.4	29/5/98 16:06	38.89	22800	22800	9.49	9.49	10	150	9.2	4.3
1/6/98 16:30	29.58	2/6/98 8:32	39.06	57720	57720	9.48	9.48	10	150	9.2	4.3
2/6/98 8:32	39.06	3/6/98 11:08	55.22	95760	153480	16.16	25.64	10	150	9.2	4.3
3/6/98 11:08	29.13	4/6/98 8:44	43.12	77760	231240	13.99	39.63	10	150	9.2	4.3
4/6/98 8:44	29.26	5/6/98 8:41	43.73	86220	317460	14.47	54.1	10	150	9.2	4.3
8/6/98 8:44	29.34	8/6/98 16:55	34.94	29460	29460	5.6	5.6	10	150	9.2	4.3
8/6/98 16:55	29.34	9/6/98 8:49	45.52	57240	86700	16.18	21.78	10	150	9.2	4.3
9/6/98 8:49	29.23	9/6/98 16:51	35.78	28920	115620	6.55	28.33	10	150	9.2	4.3
12/6/98 8:36	29.26	12/6/98 15:43	34.3	25620	25620	5.04	5.04	10	150	9.2	4.3
15/6/1998 08:47	29.29	16/6/1998 08:44	46.24	86620	86620	16.95	16.95	10	150	9.2	4.3
16/6/1998 08:44	29.25	16/6/1998 13:19	32.72	16500	16500	3.47	3.47	15	150	14.2	4.3
16/6/1998 13:19	32.72	17/6/1998 08:42	43.24	69780	86280	10.52	13.99	15	150	14.2	4.3
25/6/1998 15:34	29.29	26/6/1998 08:52	33.57	62280	62280	4.28	4.28	30	150	29.2	4.3
26/6/1998 08:52	33.57	29/6/1998 10:50	46.78	266280	328560	13.21	17.49	30	150	29.2	4.3
29/6/1998 10:50	29.3	29/6/1998 16:55	30.75	21900	21900	1.45	1.45	40	150	39.2	4.3
29/6/1998 16:55	30.75	30/6/1998 07:50	32.22	53700	75600	1.47	2.92	40	150	39.2	4.3
30/6/1998 07:50	32.22	2/7/98 9:37	37.08	179220	254820	4.86	7.78	40	150	39.2	4.3

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Table 6 - Test data for the soil specimen from Castle Peak (Sheet 2 of 2)

Start		End									
Time	Bottle + Water (g)	Time	Bottle + Water (g)	Elapsed Time (s)	Cumulative Time (s)	Water Vol. (cc)	Cumulative volume of water (cc)	Air Pres. (kPa)	Head across specimen (mm)	Average Matric suction (kPa)	Gradient across specimen
2/7/98 9:37	37.08	2/7/98 13:32	38.32	14100	14100	1.24	1.24	60	150	59.2	4.3
2/7/98 13:32	38.32	3/7/98 7:12	39.36	63600	77700	1.04	2.28	60	150	59.2	4.3
3/7/98 7:12	39.36	6/7/98 8:53	43.44	265260	342960	4.08	6.36	60	150	59.2	4.3
6/7/98 8:53	43.44	7/7/98 9:14	44.82	87660	430620	1.38	7.74	60	150	59.2	4.3
7/798 9:14	44.82	7/7/98 16:38	45.19	26640	26640	0.37	0.37	80	150	79.2	4.3
7/7/98 16:38	45.19	7/8/98 17:07	45.59	88140	114780	0.4	0.77	80	150	79.2	4.3
7/8/98 17:07	45.59	7/9/98 8:51	46.01	56640	171420	0.42	1.19	80	150	79.2	4.3
7/9/98 8:51	46.01	7/9/98 13:54	46.4	18180	189600	0.39	1.58	80	150	79.2	4.3
7/9/98 13:54	46.4	7/10/98 8:57	46.79	68580	258180	0.39	1.97	80	150	79.2	4.3

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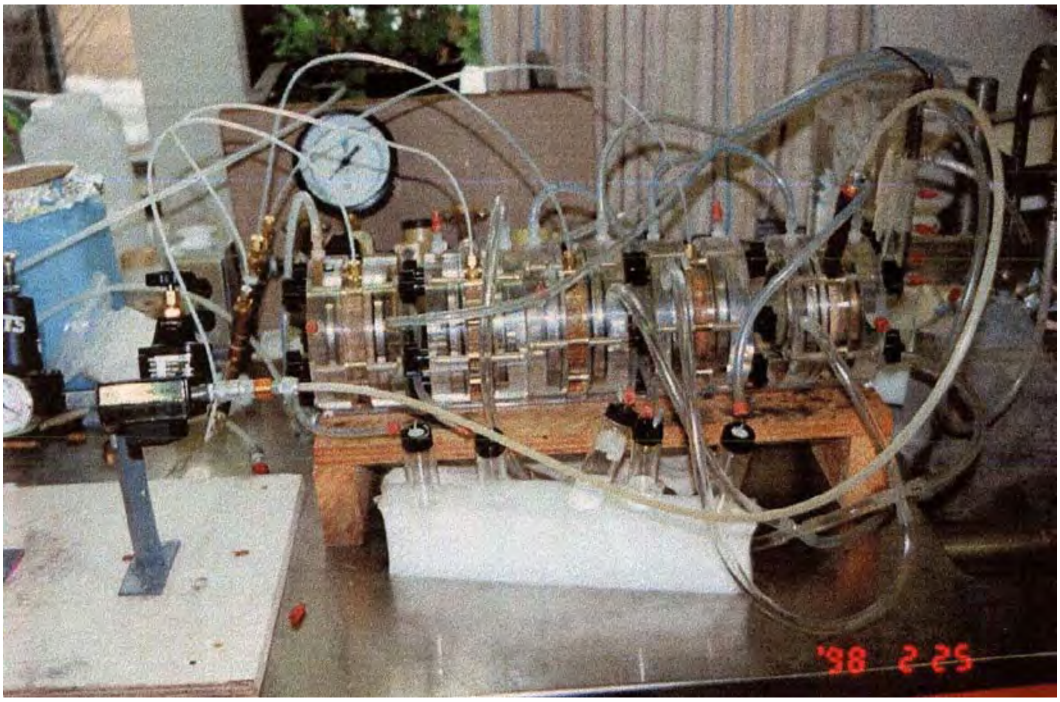

Plate 1 - Five unsaturated coefficient of permeability setups with the same gradients applied but the water flow measured independently.

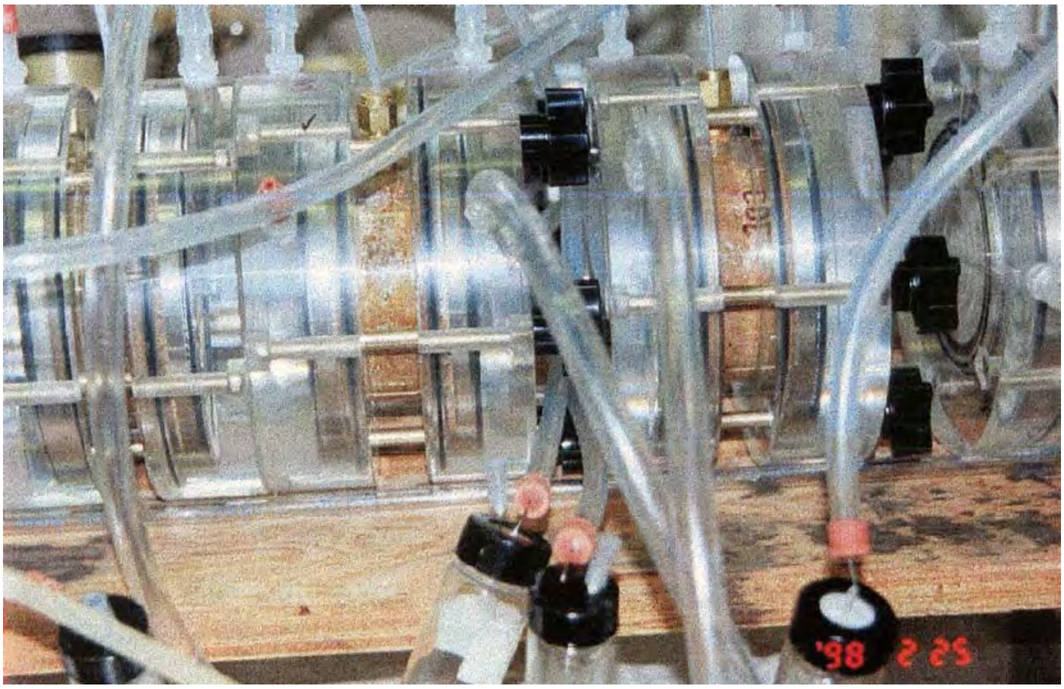

Plate 2 - Close-up view of the unsaturated coefficient of permeability cell with the Hong Kong residual soil

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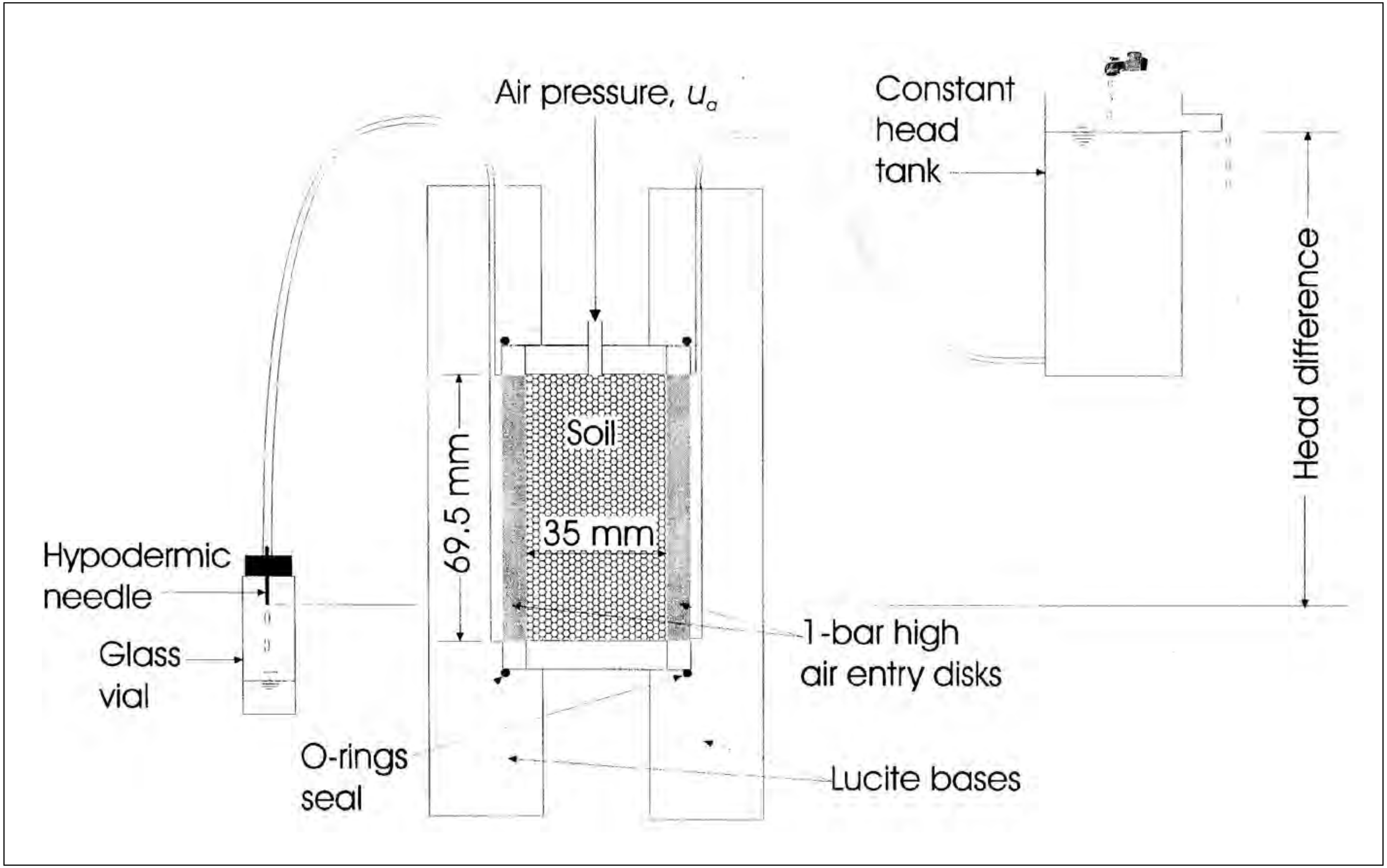

Figure 1 - Experimental set-up for the determination of the coefficient of permeability for matric suction values greater than 10 kPa

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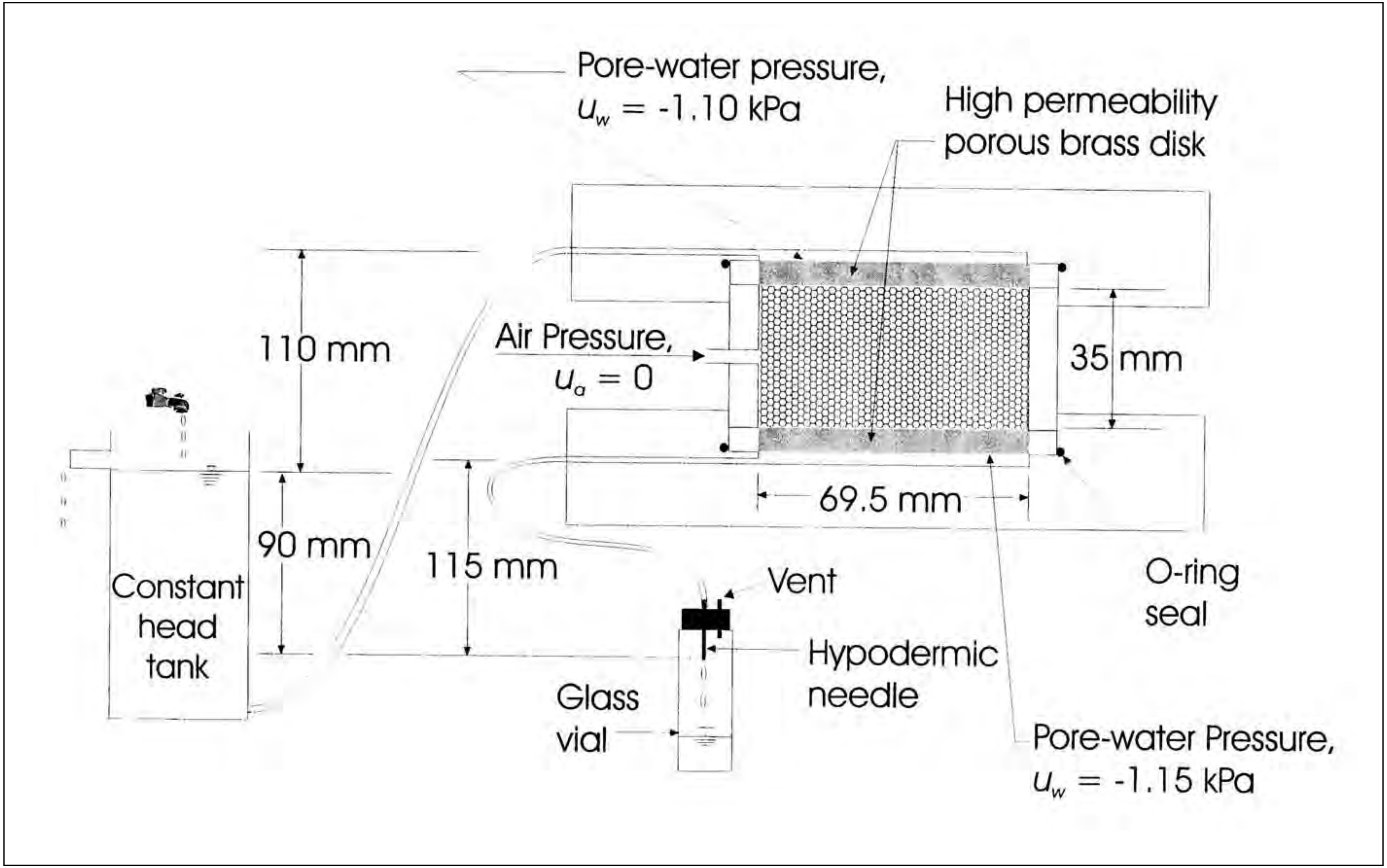

Figure 2 - Experimental set-up for the determination of the coefficient of permeability for low matric suction values of less than 1.5 kPa

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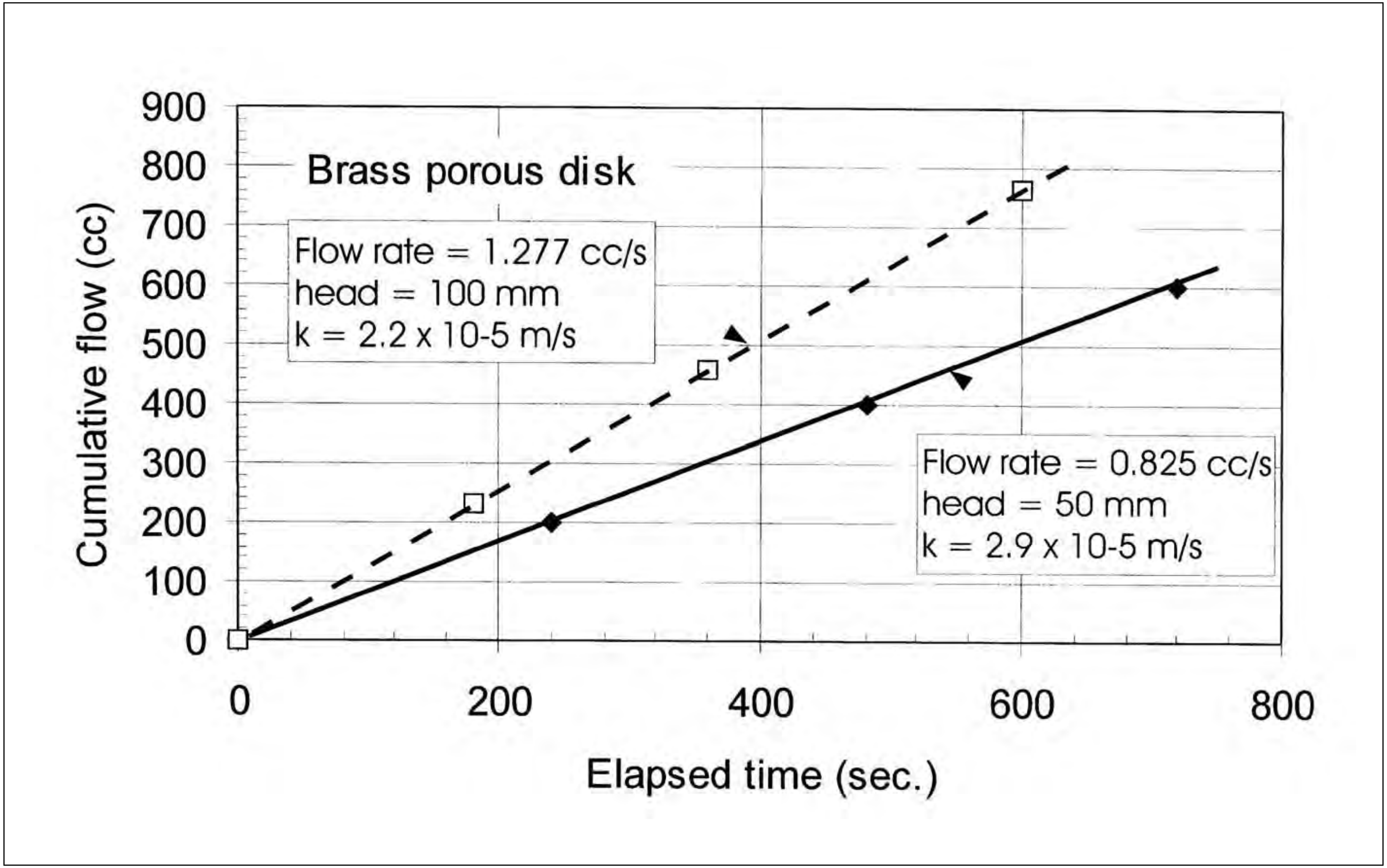

Figure 3 - Water flow rate data for the brass porous disk subjected to heads of 50 mm and 100mm, respectively

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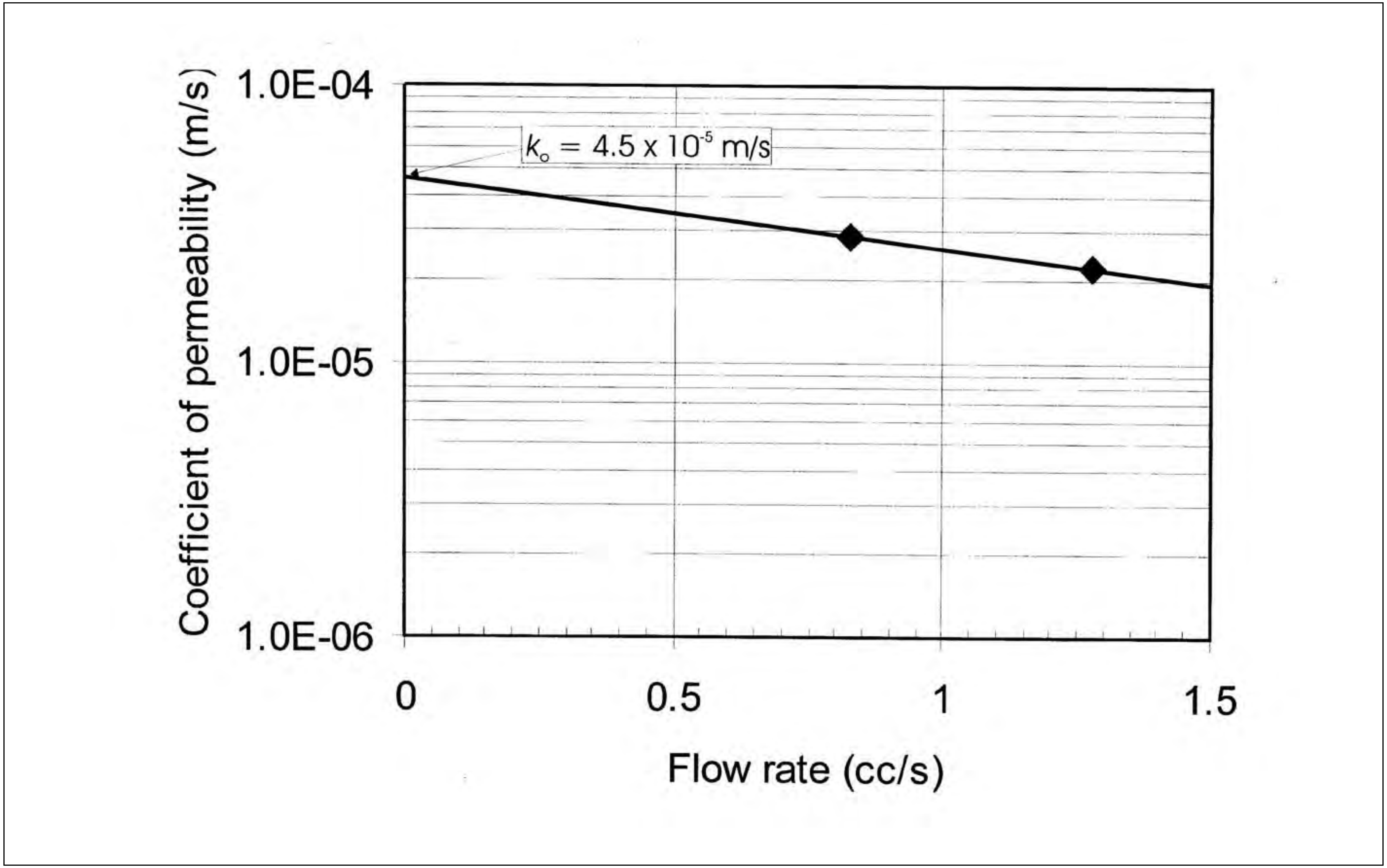

Figure 4 - Coefficient of permeability of the brass porous disk as a function of flow rate

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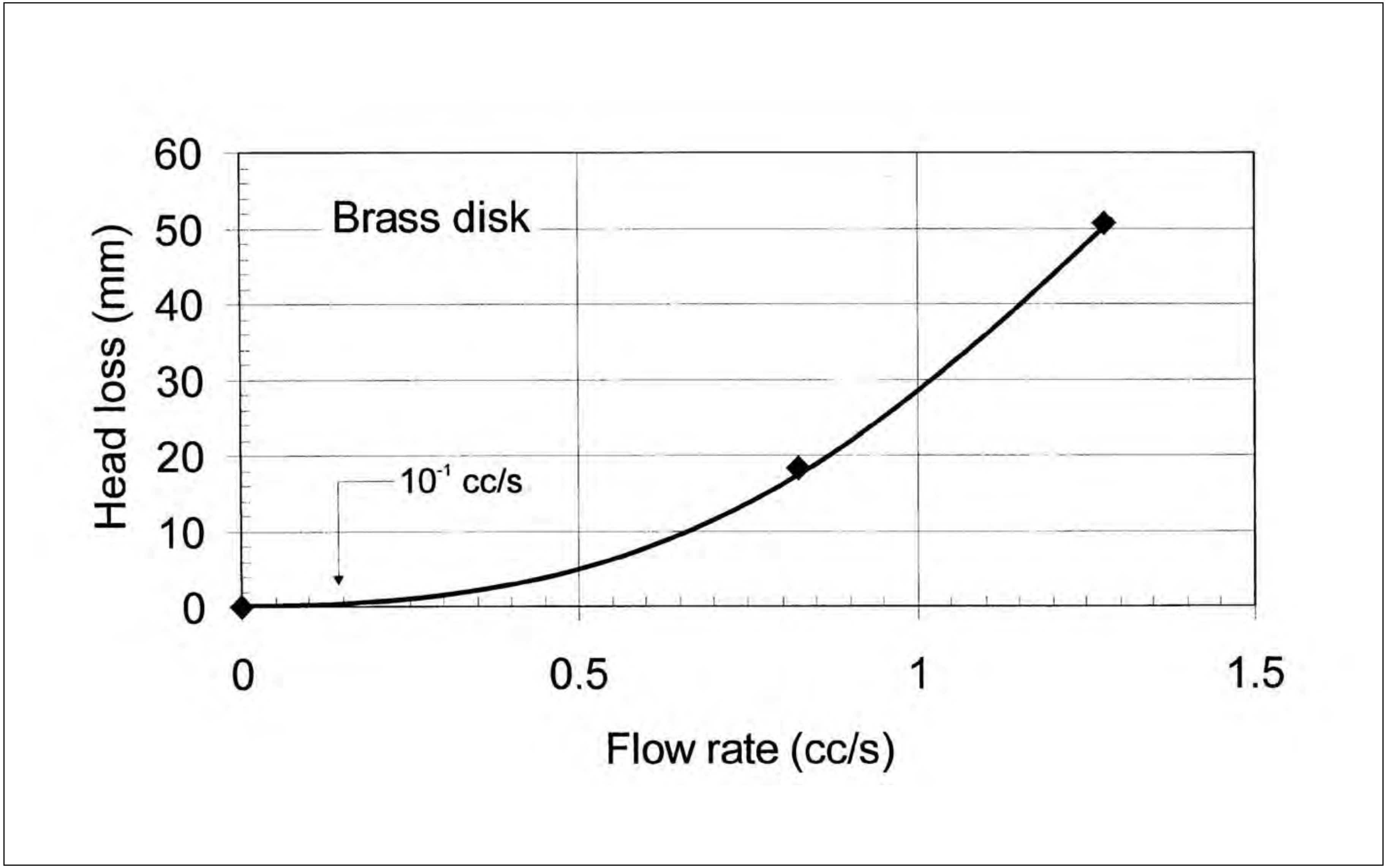

Figure 5 - Head loss across the brass porous disk as a function of flow rate

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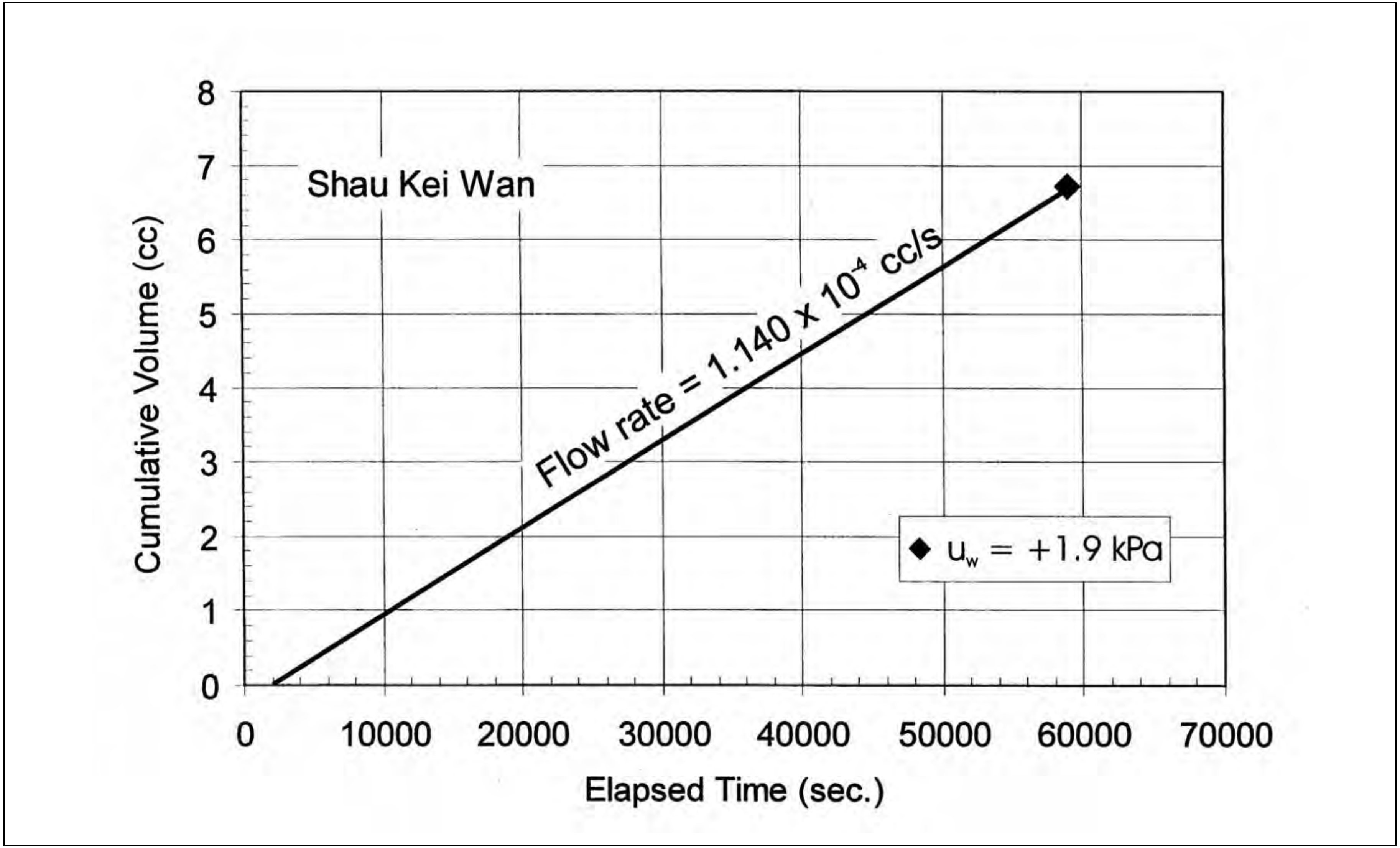

Figure 6 - Water flow rate data for a soil specimen from Shau Kei Wan at a positive pore-water pressure of 1.9 kPa under a head difference of 370 mm across the specimen

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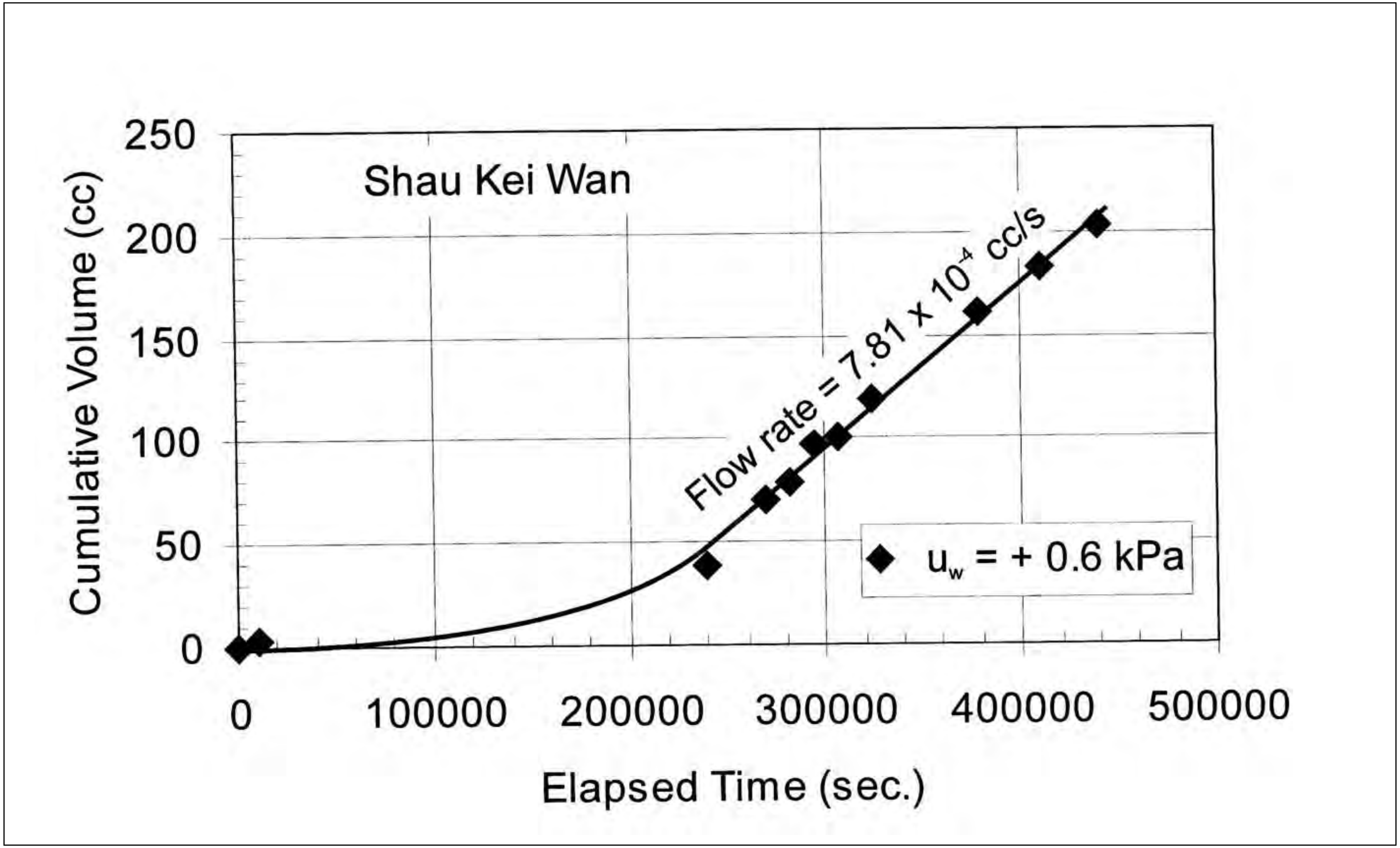

Figure 7 - Water flow rate data for a soil specimen from Shau Kei Wan at a positive pore-water pressure of 0.6 kPa under a head difference of 115 mm across the specimen

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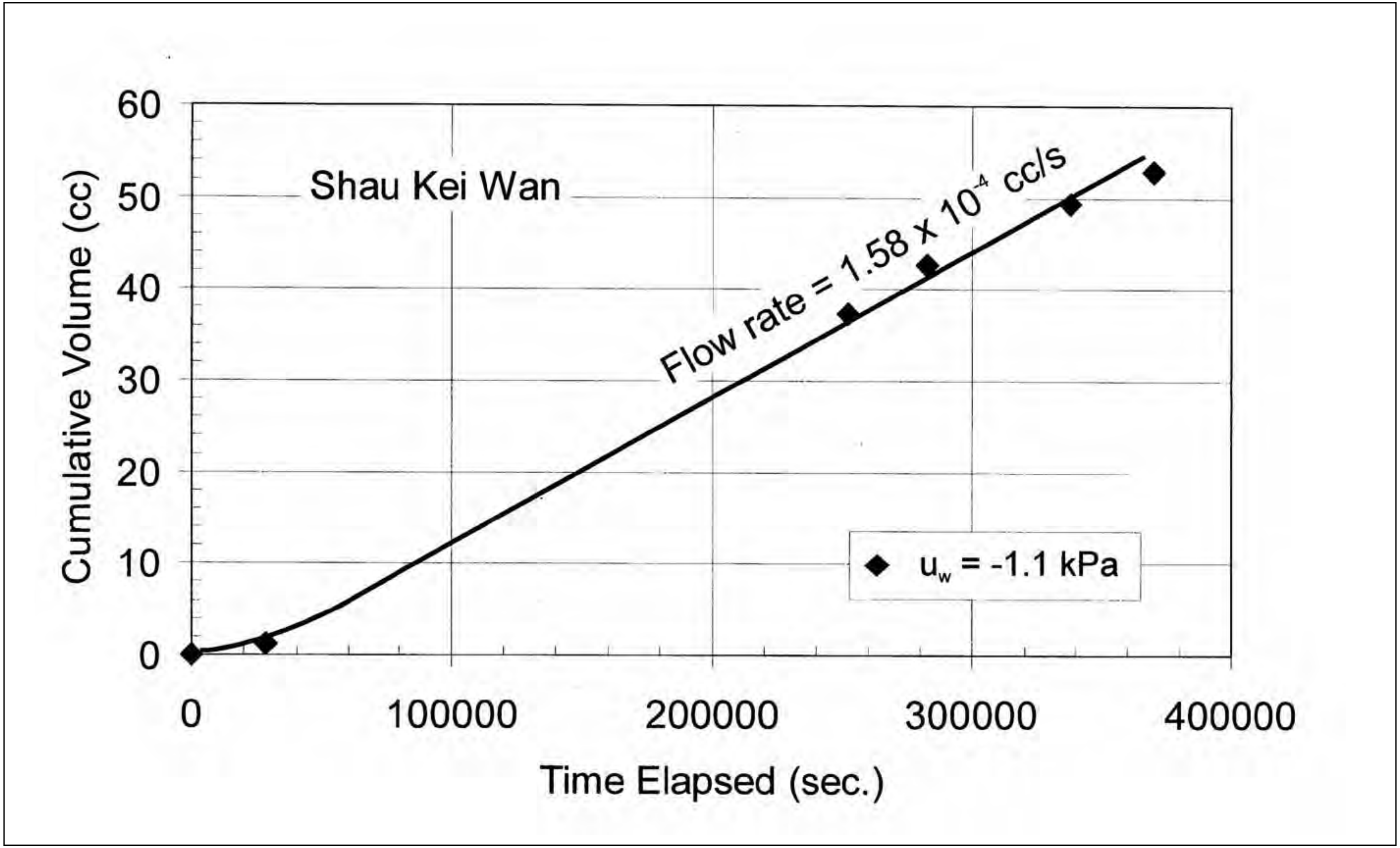

Figure 8 - Water flow rate data for a soil specimen from Shau Kei Wan at a matric suction of 1.1 kPa (i.e., pore-water pressure of -17.1 kPa) under a head difference of 85 mm across the specimen

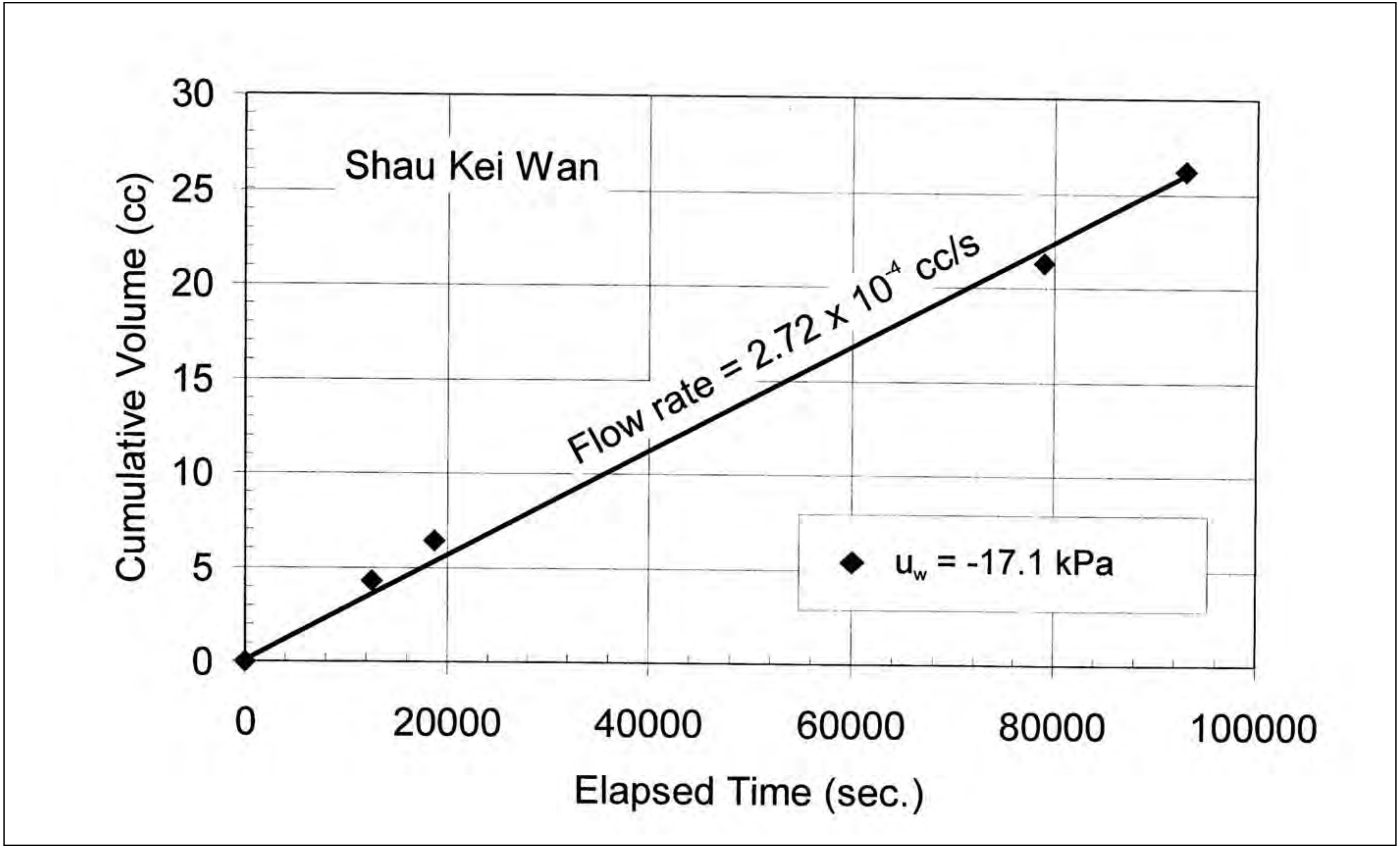

Figure 9 - Water flow rate data for a soil specimen from Shau Kei Wan at a matric suction of 17.1 kPa (i.e., pore-water pressure of -1.1 kPa) under a head difference of 578 mm across the specimen

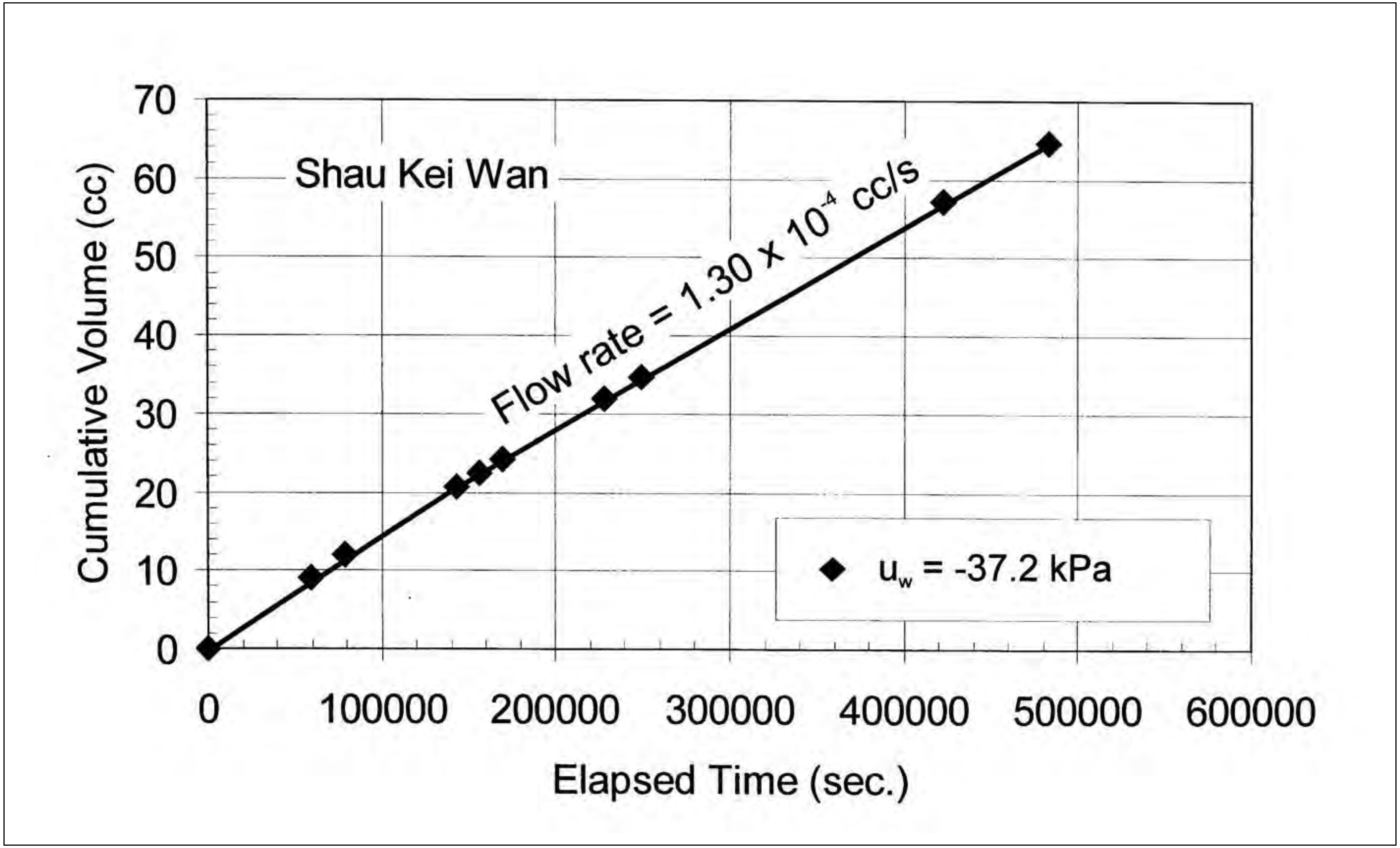

Figure 10 - Water flow rate data for a soil specimen from Shau Kei Wan at a matric suction of 37.2 kPa under a head difference of 550 mm across the specimen

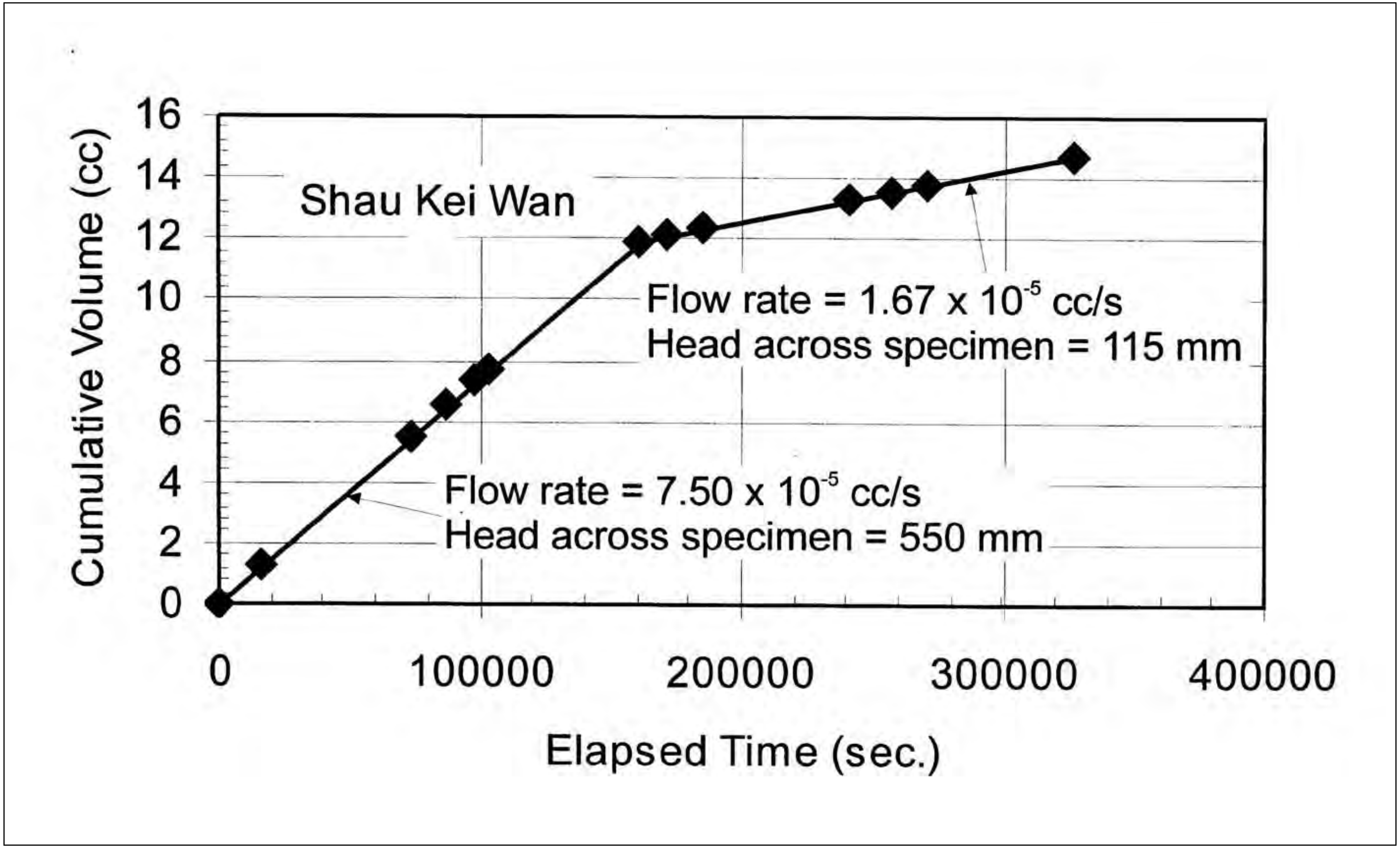

Figure 11 - Water flow rate data for a soil specimen from Shau Kei Wan at a matric suction values of 57.2 kPa and 59.4 kPa under head differences of 550 mm and 115mm, respectively, across the specimen

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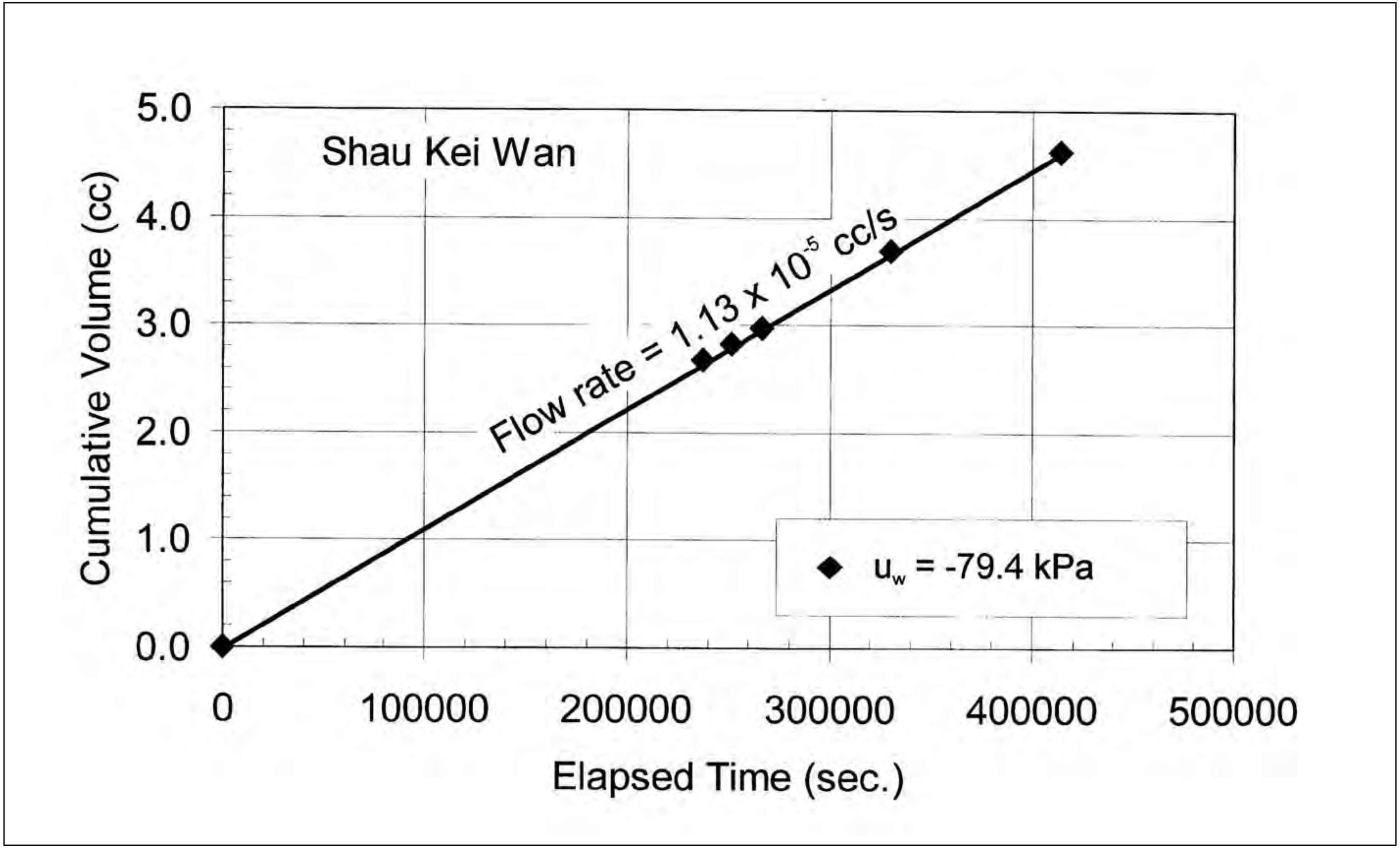

Figure 12 - Water flow rate data for a soil specimen from Shau Kei Wan at a matric suction of 79.4 kPa under a head difference of 115 mm across the specimen

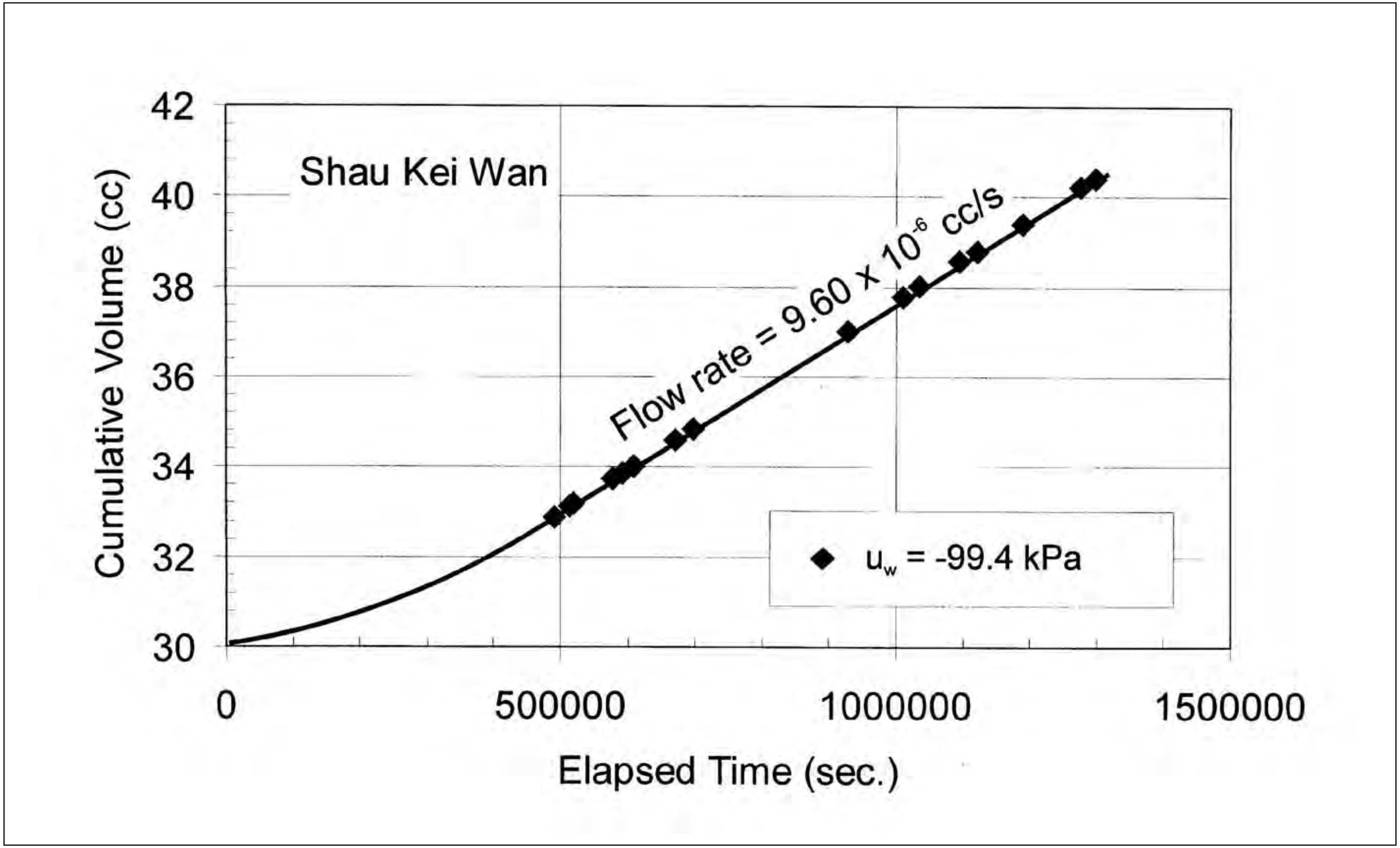

Figure 13 - Water flow rate data for a soil specimen from Shau Kei Wan at a matric suction of 99.4 kPa under a head difference of 115 mm across the specimen

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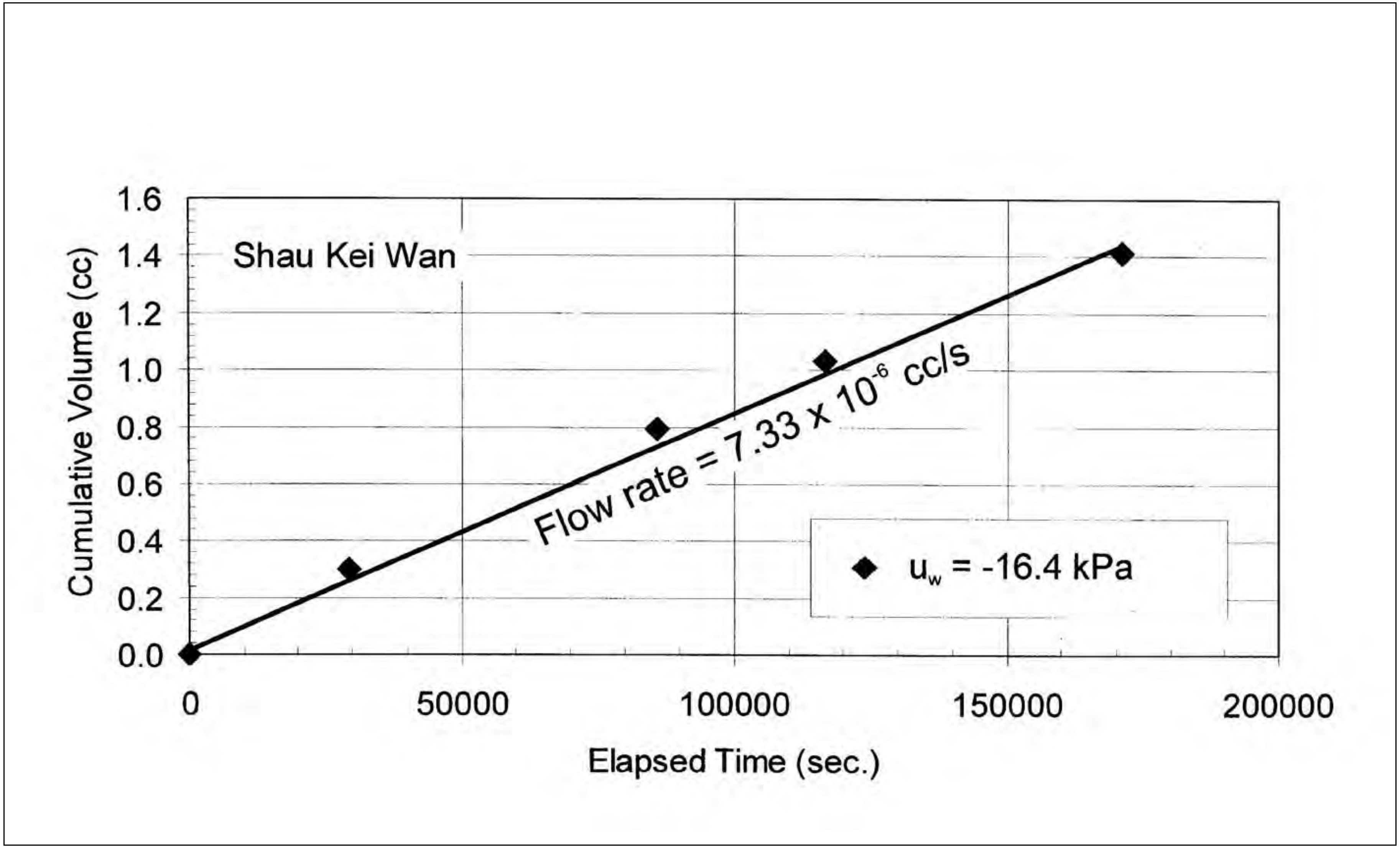

Figure 14 - Water flow rate data for a soil specimen from Shau Kei Wan at a matric suction of 116.4 kPa under a head difference of 115 mm across the specimen

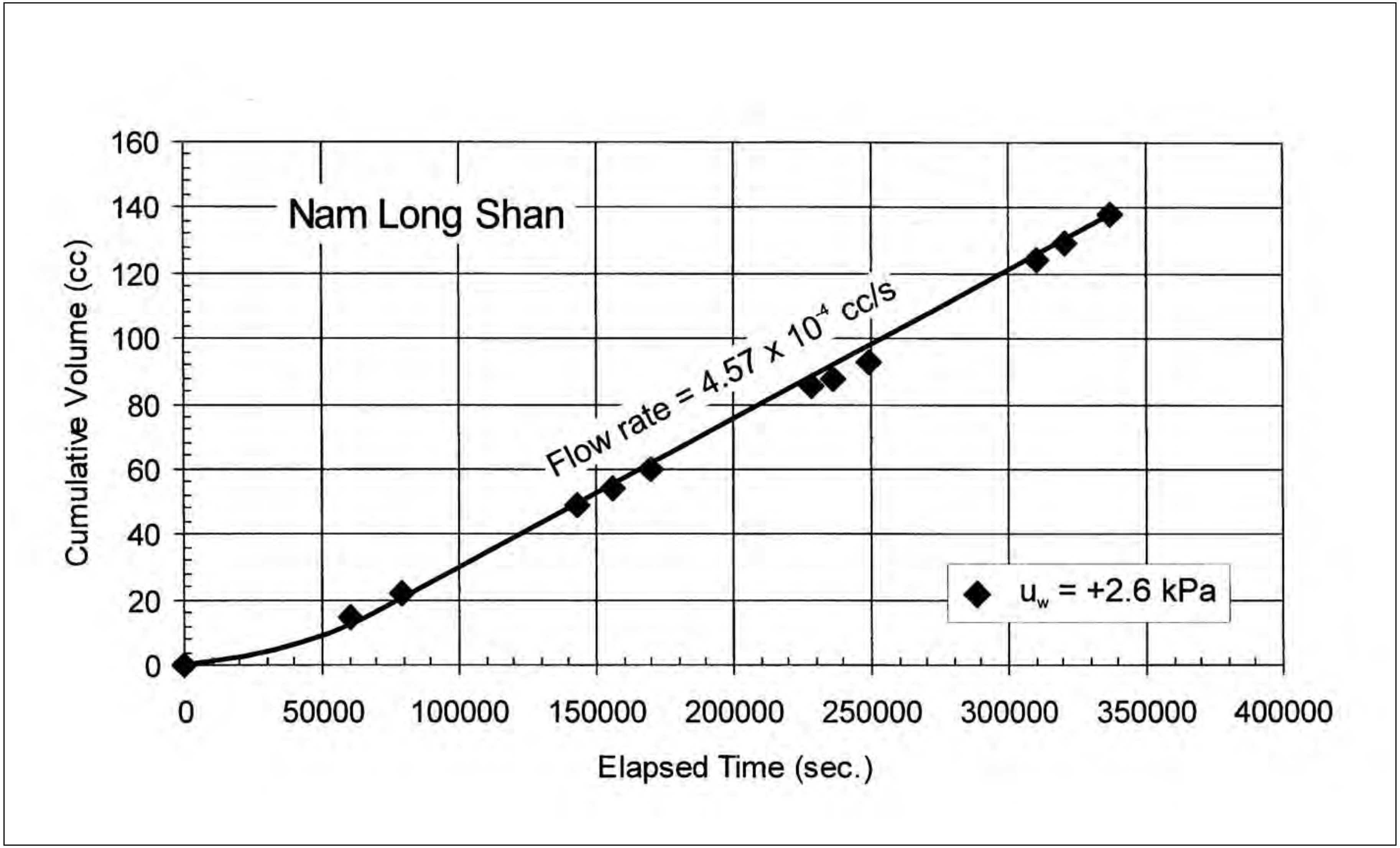

Figure 15 - Water flow rate data for a soil specimen from Nam Long Shan at a positive pore-water pressure of 2.6 kPa under a head difference of 550 mm across the specimen

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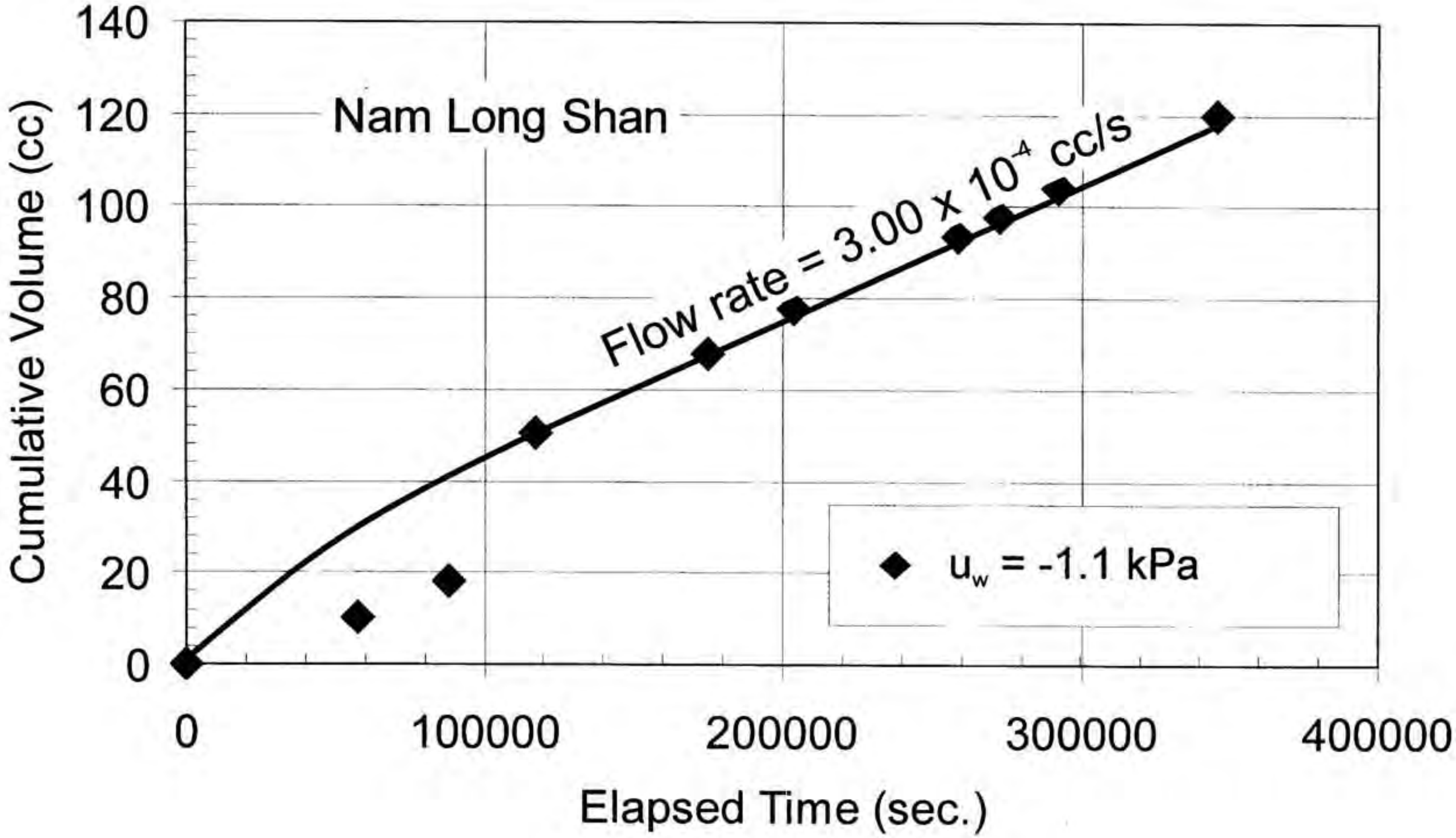

Figure 16 - Water flow rate data for a soil specimen from Nam Long Shan at a matric suction of 1.1 kPa (i.e., pore-water pressure of -1.1 kPa) under a head difference of 85 mm across the specimen

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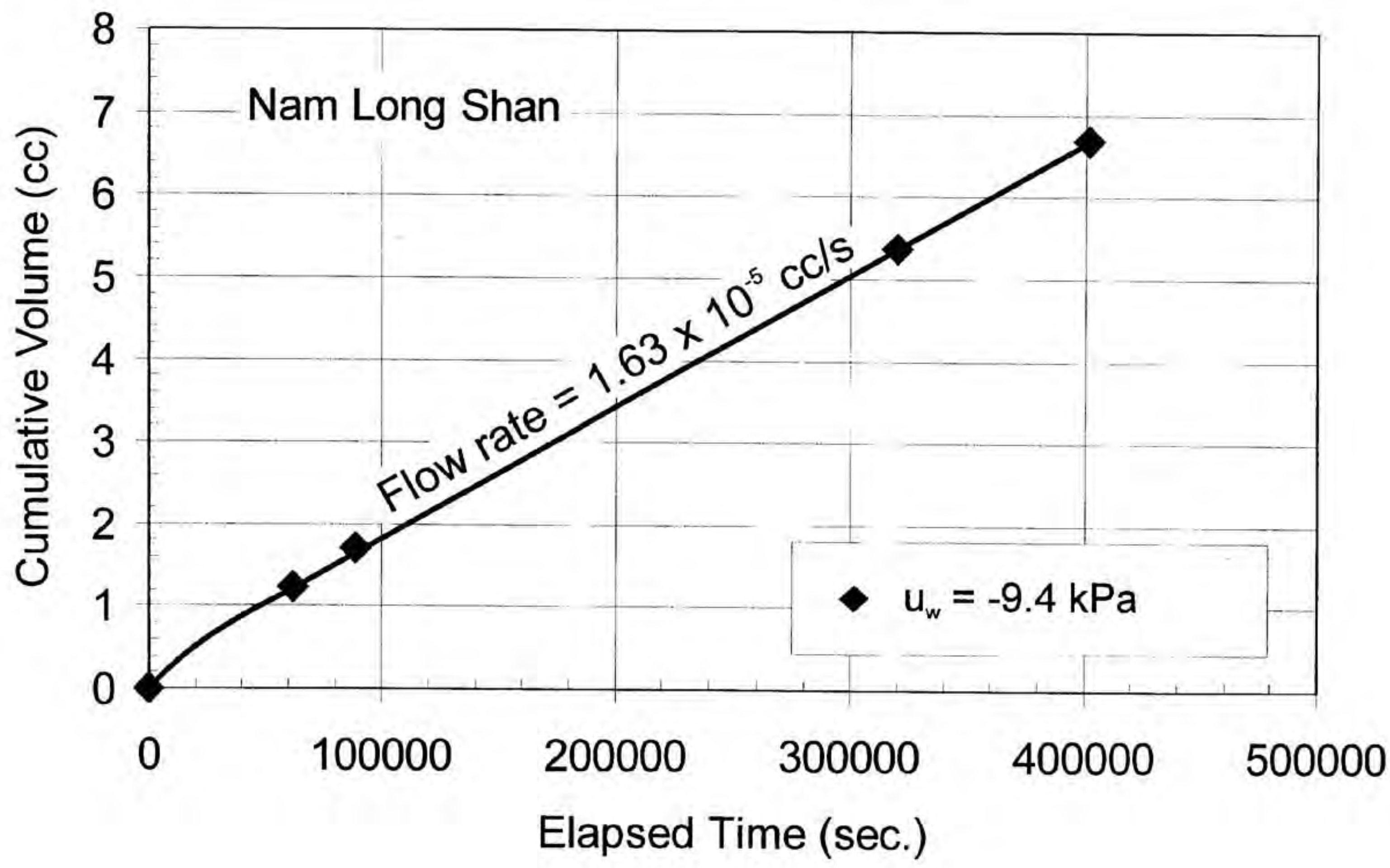

Figure 17 - Water flow rate data for a soil specimen from Nam Long Shan at a matric suction of 9.4 kPa (i.e., pore-water pressure of -9.4 kPa) under a head difference of 115 mm across the specimen

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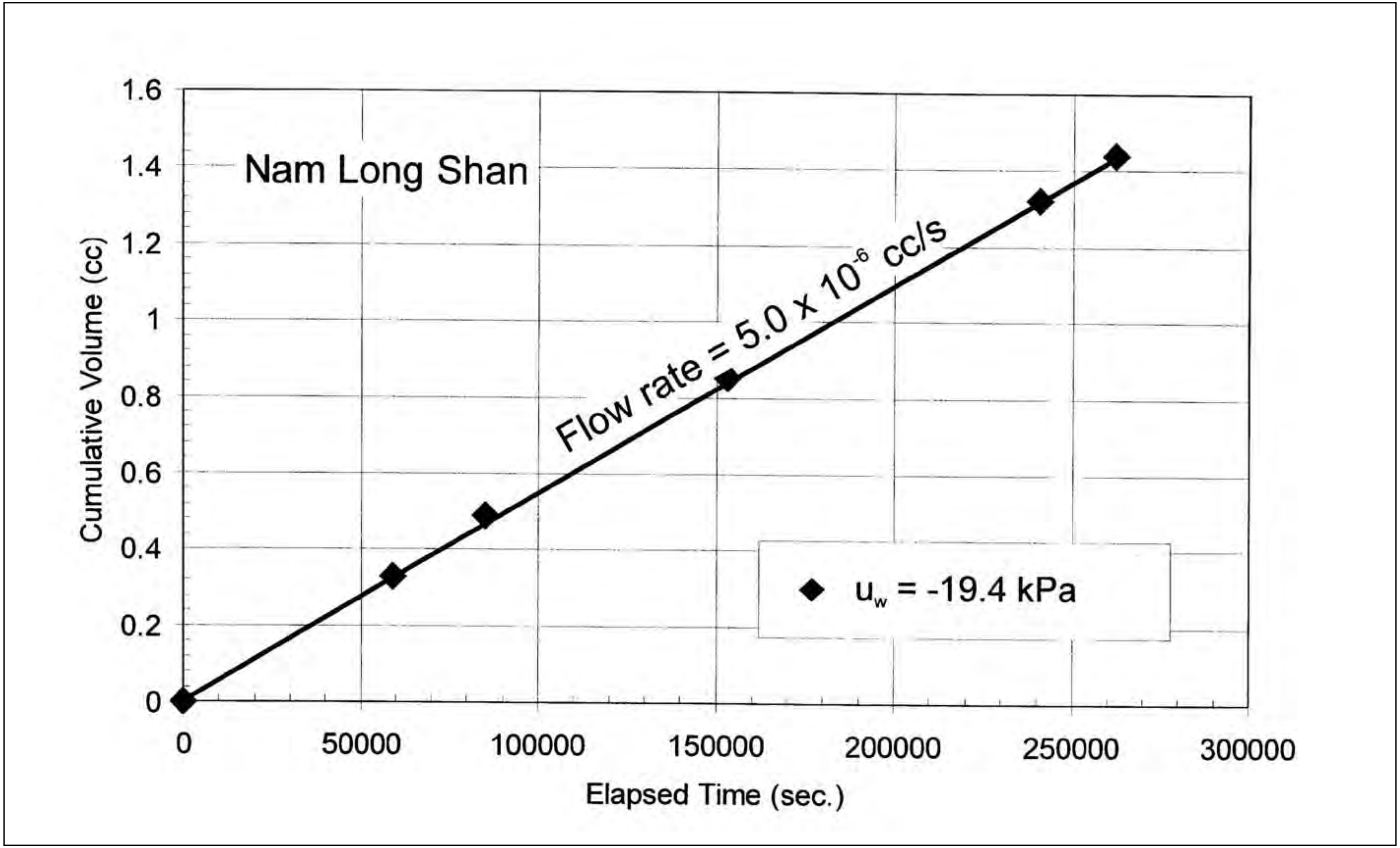

Figure 18 - Water flow rate data for a soil specimen from Nam Long Shan at a matric suction of 19.4 kPa under a head difference of 115 mm across the specimen

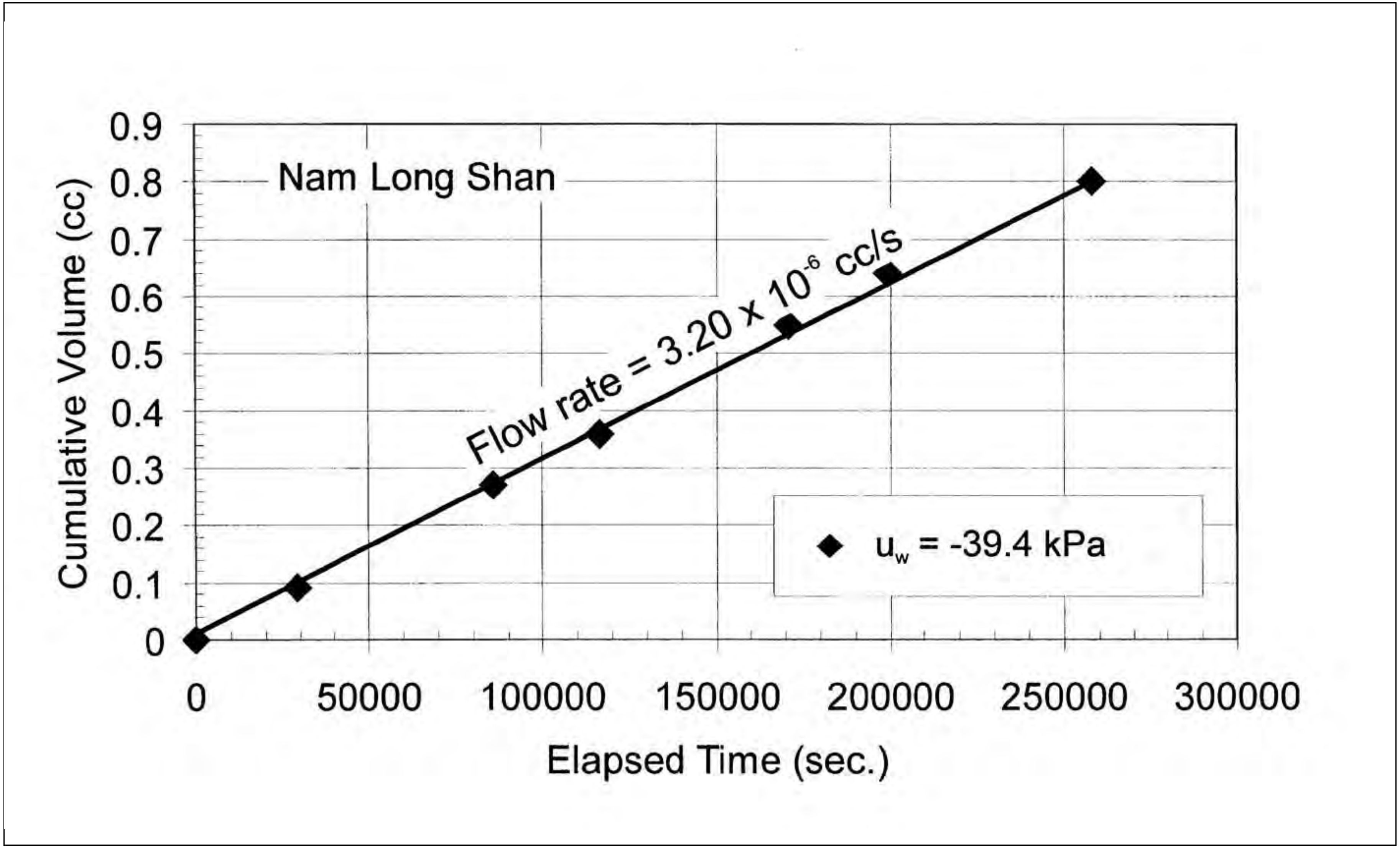

Figure 19 - Water flow rate data for a soil specimen from Nam Long Shan at a matric suction of 39.4 kPa under a head difference of 115 mm across the specimen

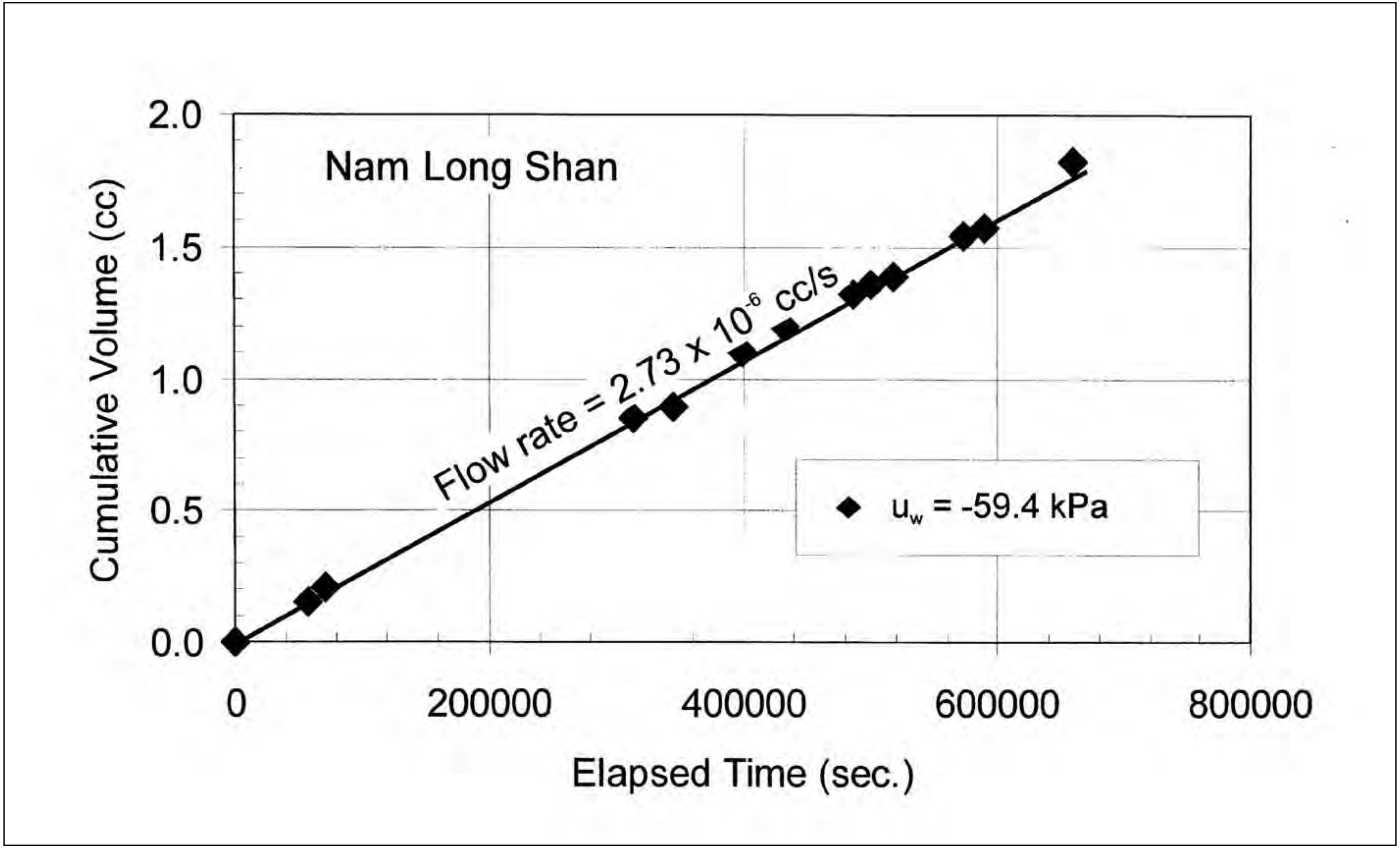

Figure 20 - Water flow rate data for a soil specimen from Nam Long Shan at a matric suction of 59.4 kPa under a head difference of 115 mm across the specimen

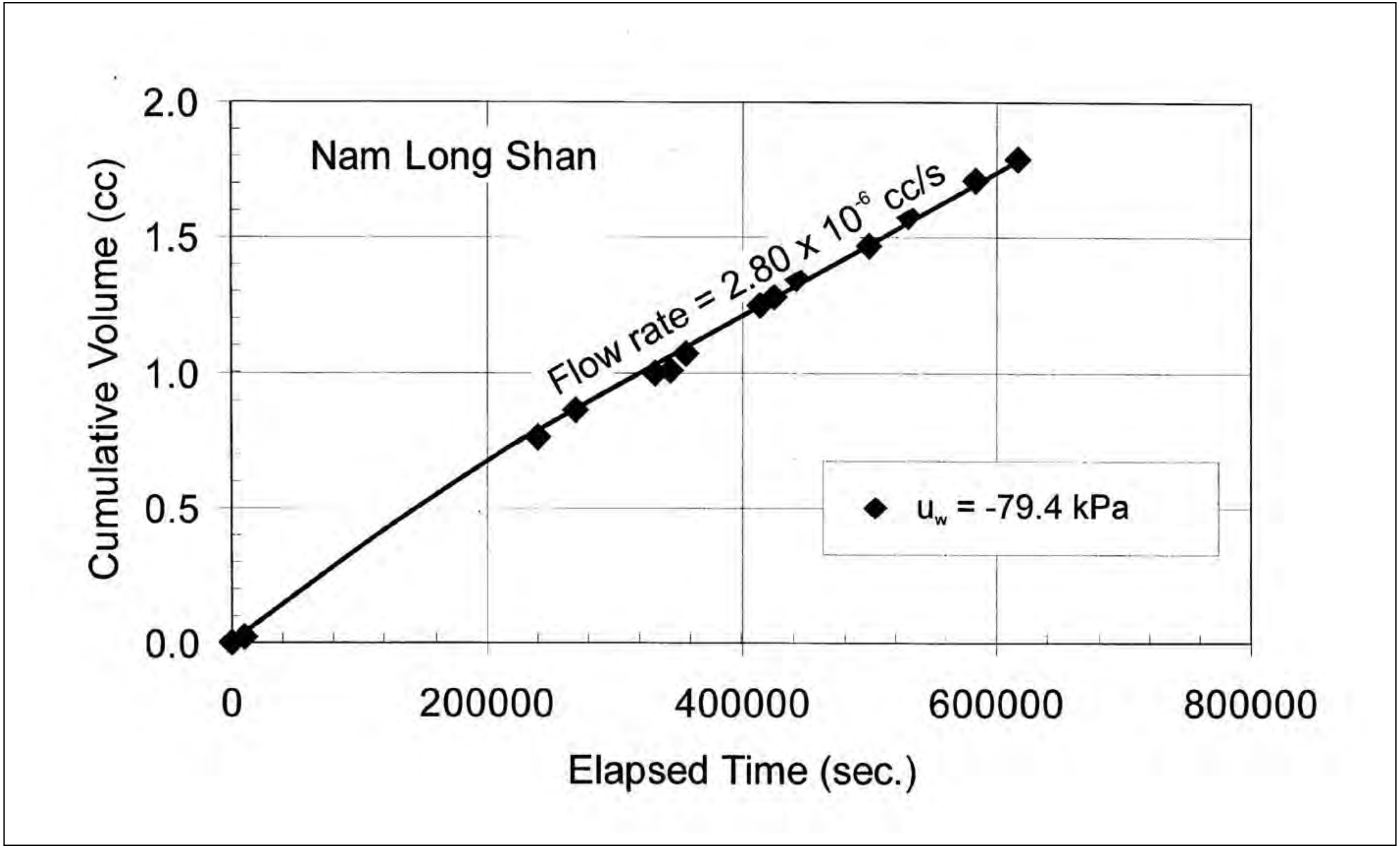

Figure 21 - Water flow rate data for a soil specimen from Nam Long Shan at a matric suction of 79.4 kPa under a head difference of 115 mm across the specimen

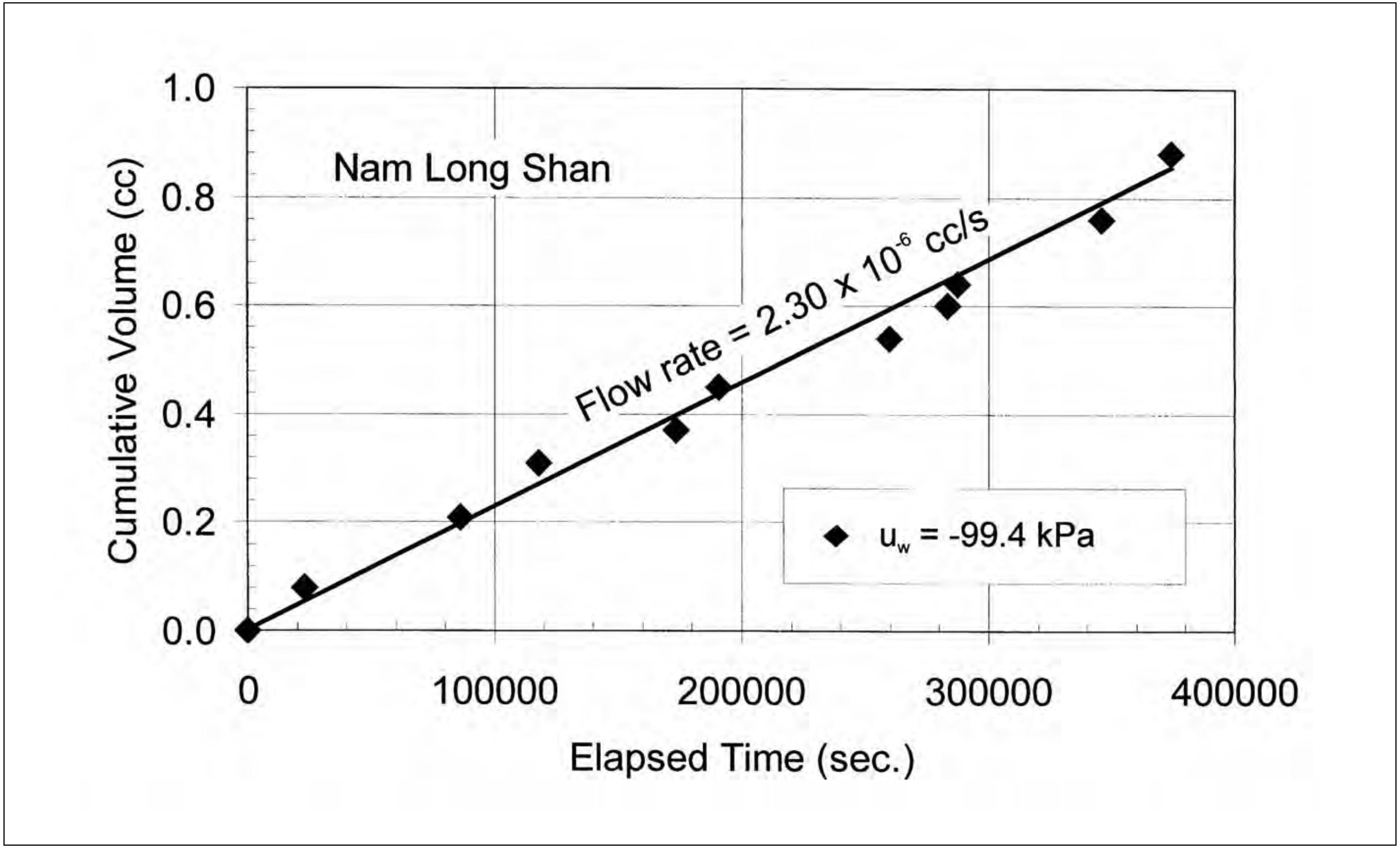

Figure 22 - Water flow rate data for a soil specimen from Nam Long Shan at a matric suction of 99.4 kPa under a head difference of 115 mm across the specimen

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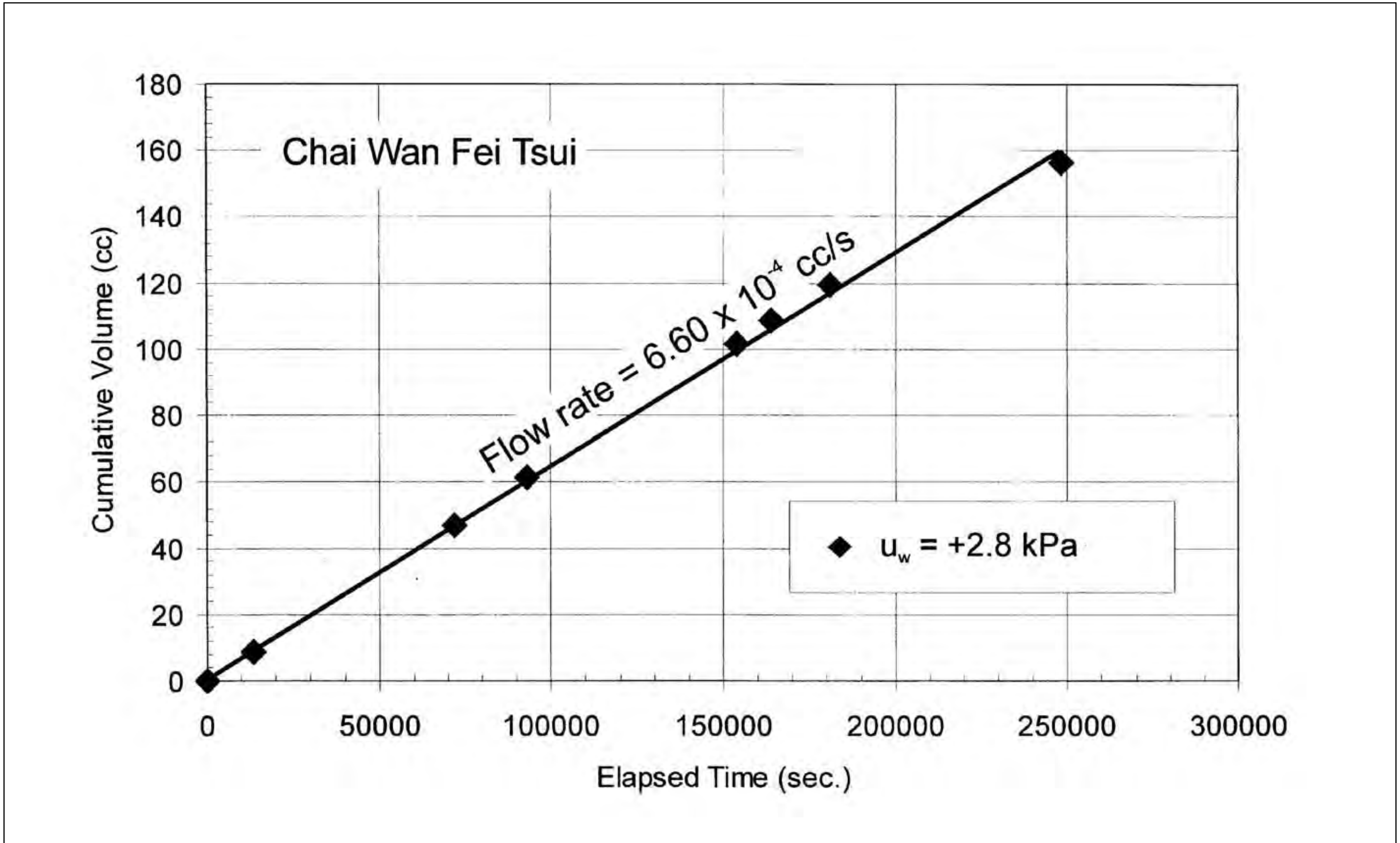

Figure 23 - Water flow rate data for a soil specimen from Chai Wan Fei Tsui at a positive pore-water pressure of 2.8 kPa under a head difference of 550 mm across the specimen

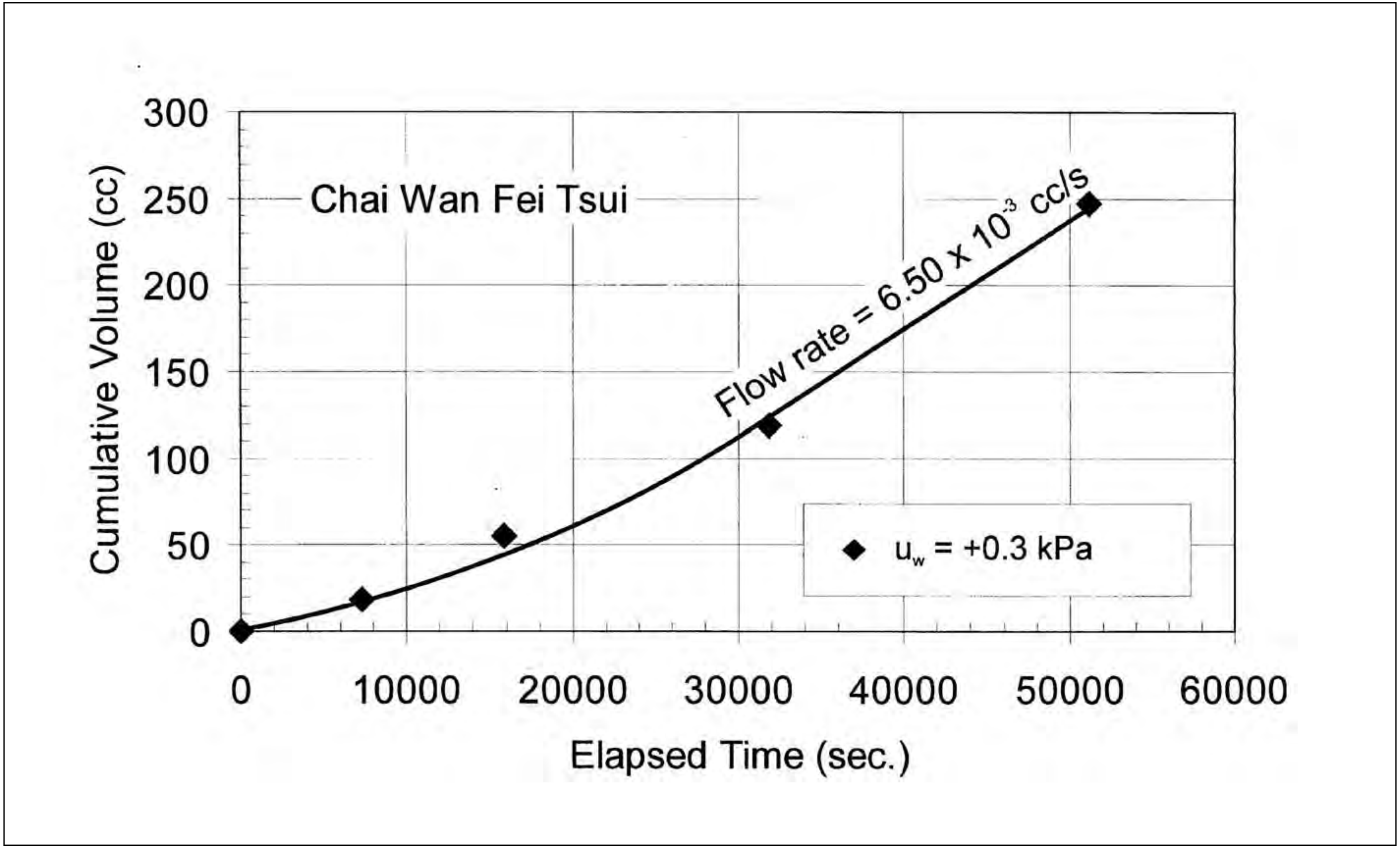

Figure 24 - Water flow rate data for a soil specimen from Chai Wan Fei Tsui at a positive pore-water pressure of 0.3 kPa under a head difference of 50 mm across the specimen

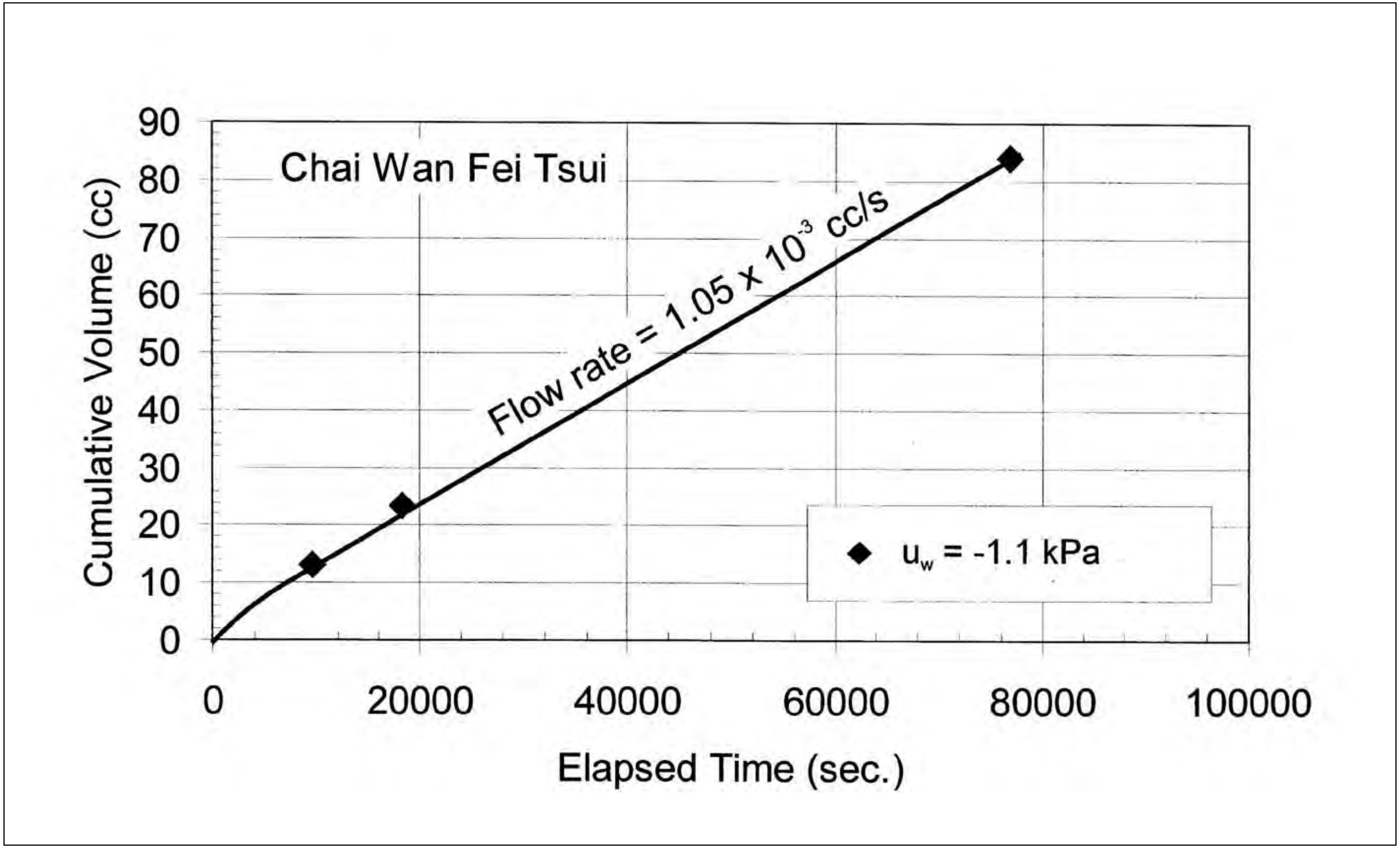

Figure 25 - Water flow rate data for a soil specimen from Chai Wan Fei Tsui at a matric suction of 1.1 kPa (i.e., pore-water pressure of -1.1 kPa) under a head difference of 85 mm across the specimen

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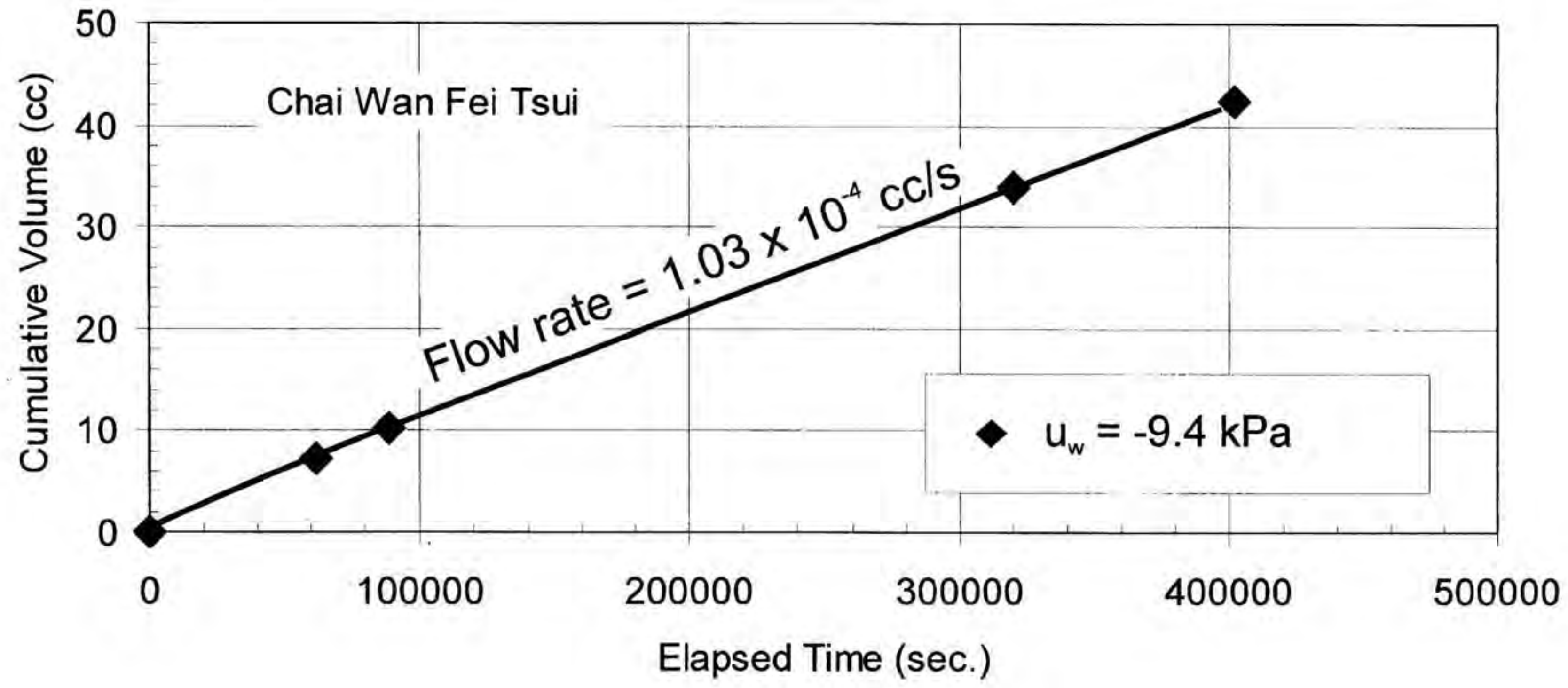

Figure 26 - Water flow rate data for a soil specimen from Chai Wan Fei Tsui at a matric suction of 9.4 kPa (i.e., pore-water pressure of -9.4 kPa) under a head difference of 115 mm across the specimen

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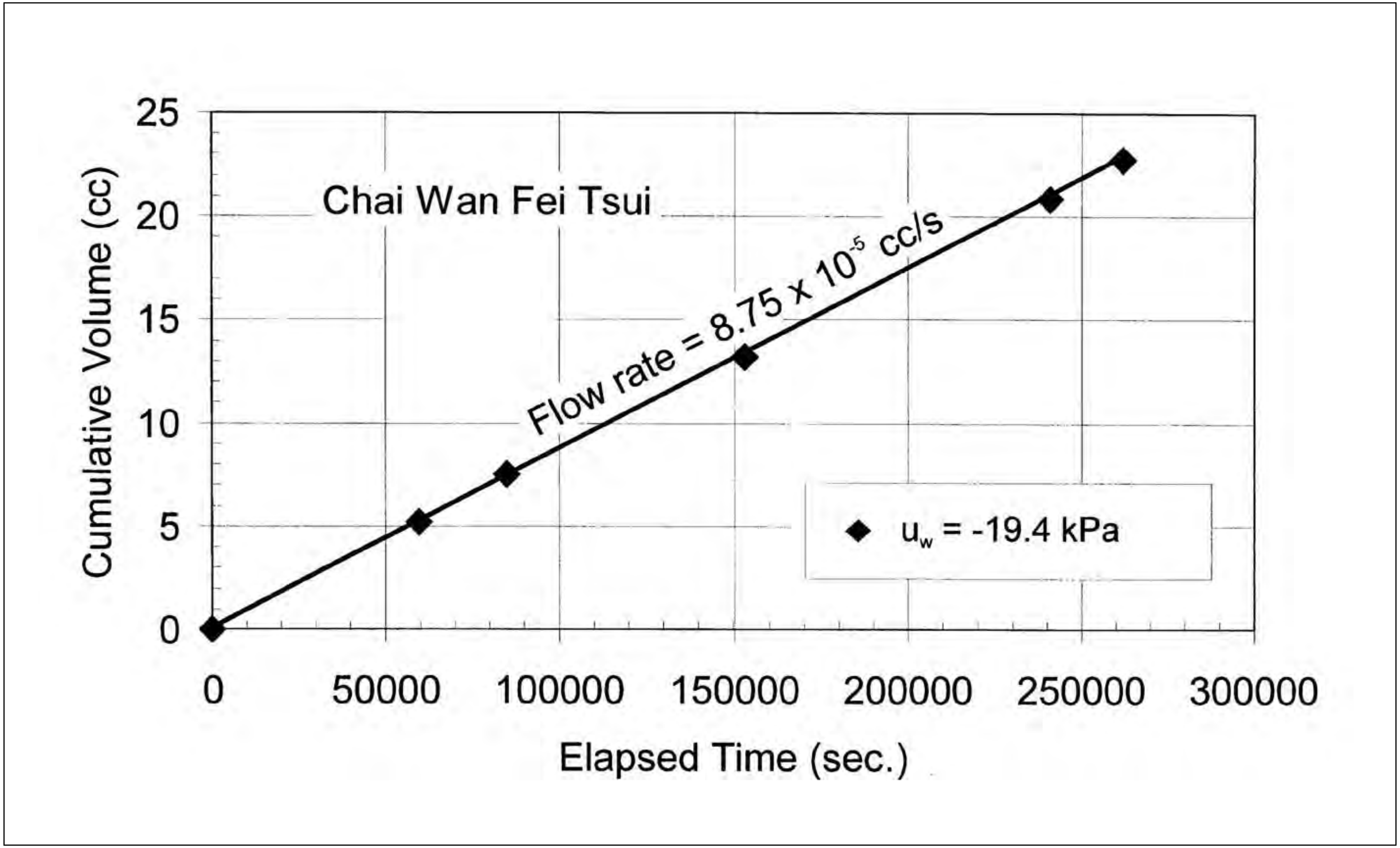

Figure 27 - Water flow rate data for a soil specimen from Chai Wan Fei Tsui at a matric suction of 19.4 kPa under a head difference of 115 mm across the specimen

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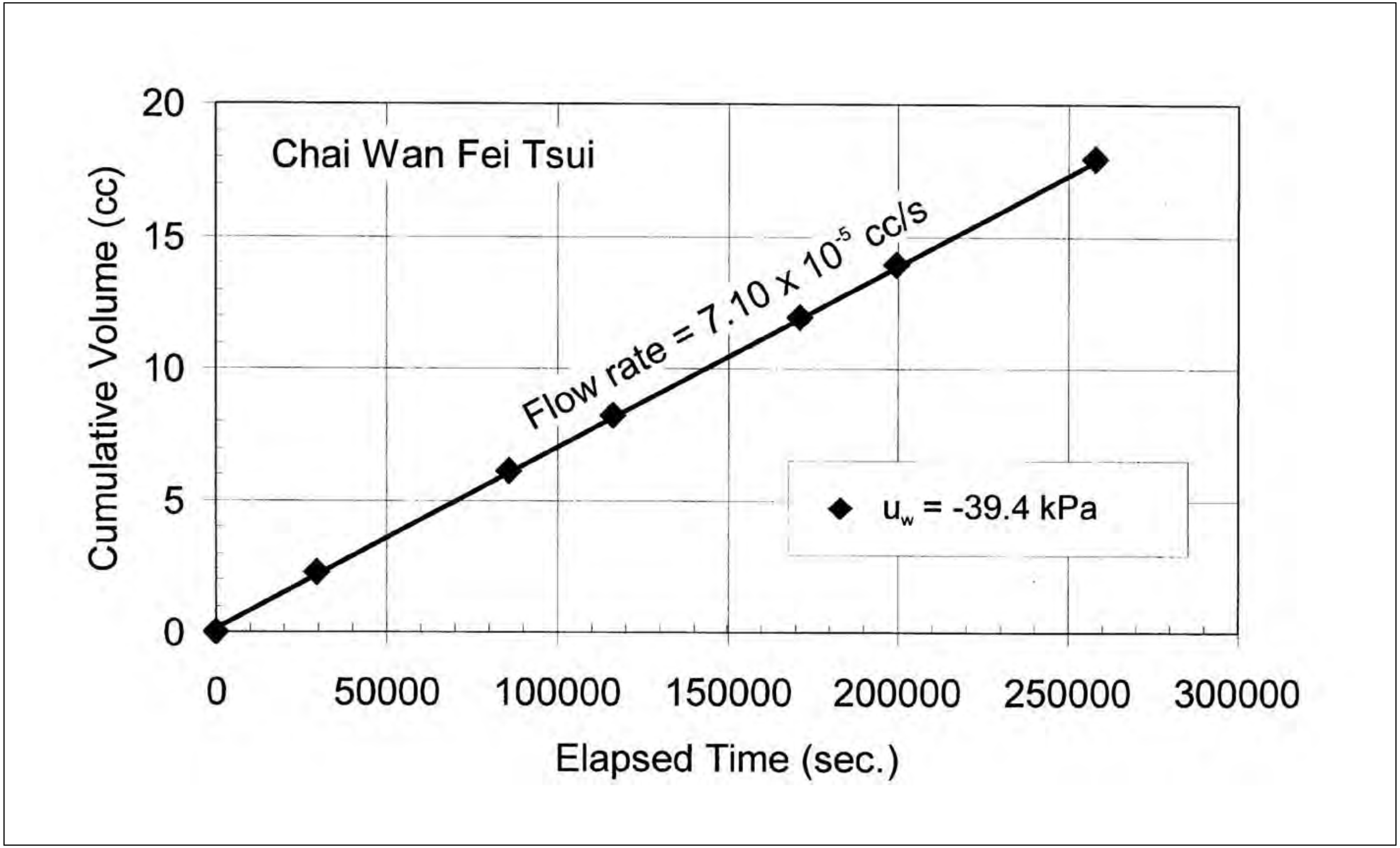

Figure 28 - Water flow rate data for a soil specimen from Chai Wan Fei Tsui at a matric suction of 39.4 kPa under a head difference of 115 mm across the specimen

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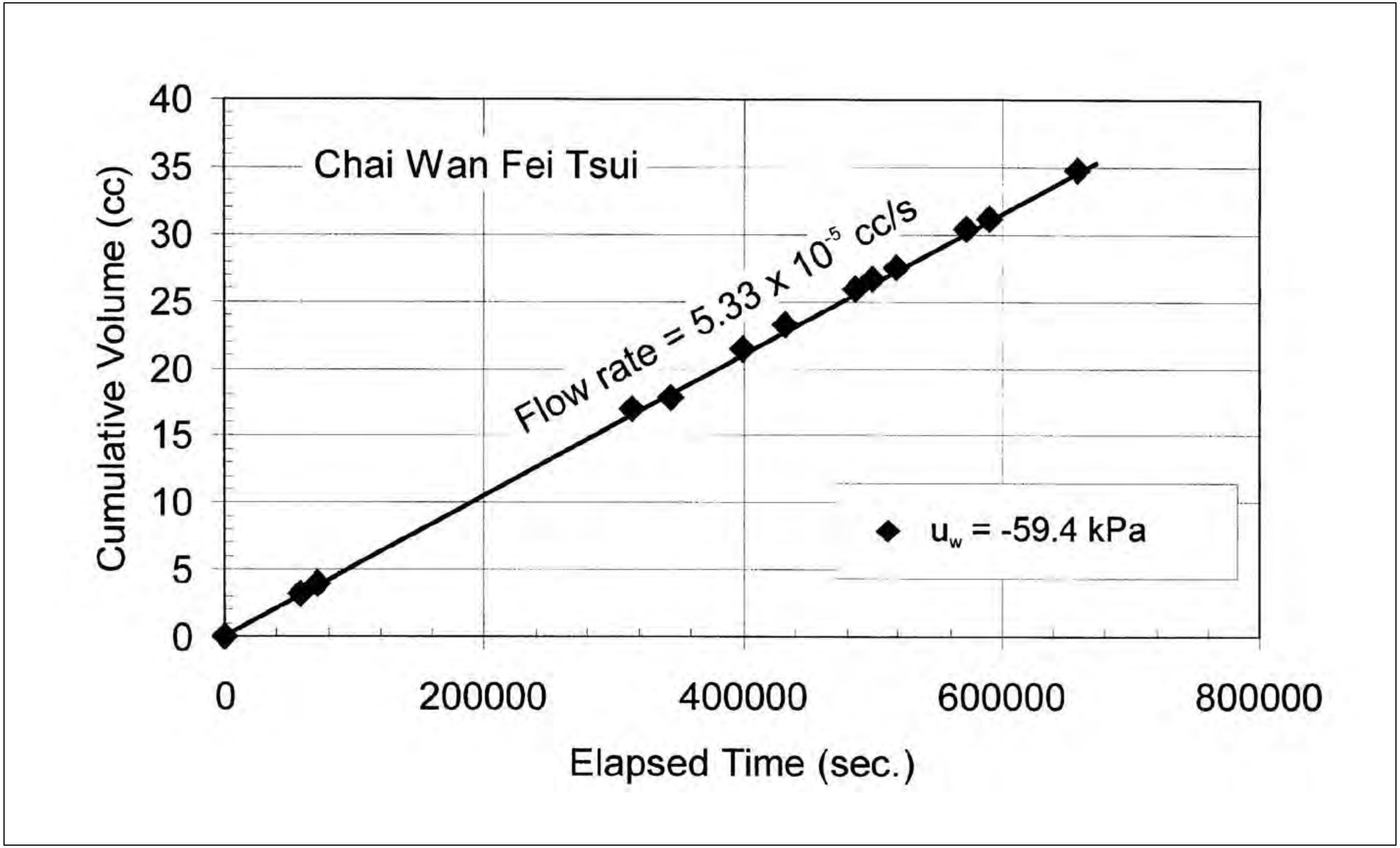

Figure 29 - Water flow rate data for a soil specimen from Chai Wan Fei Tsui at a matric suction of 59.4 kPa under a head difference of 115 mm across the specimen

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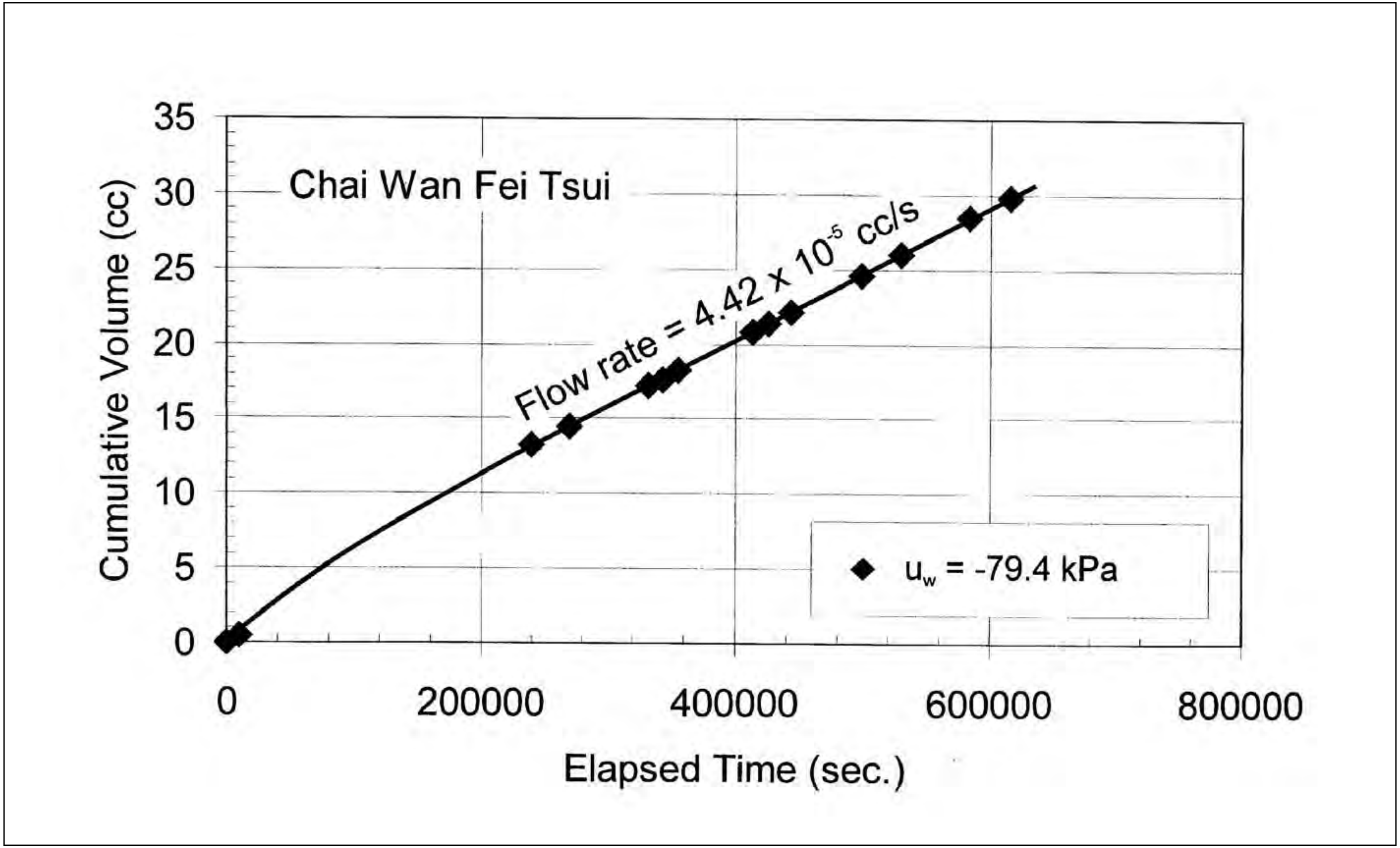

Figure 30 - Water flow rate data for a soil specimen from Chai Wan Fei Tsui at a matric suction of 79.4 kPa under a head difference of 115 mm across the specimen

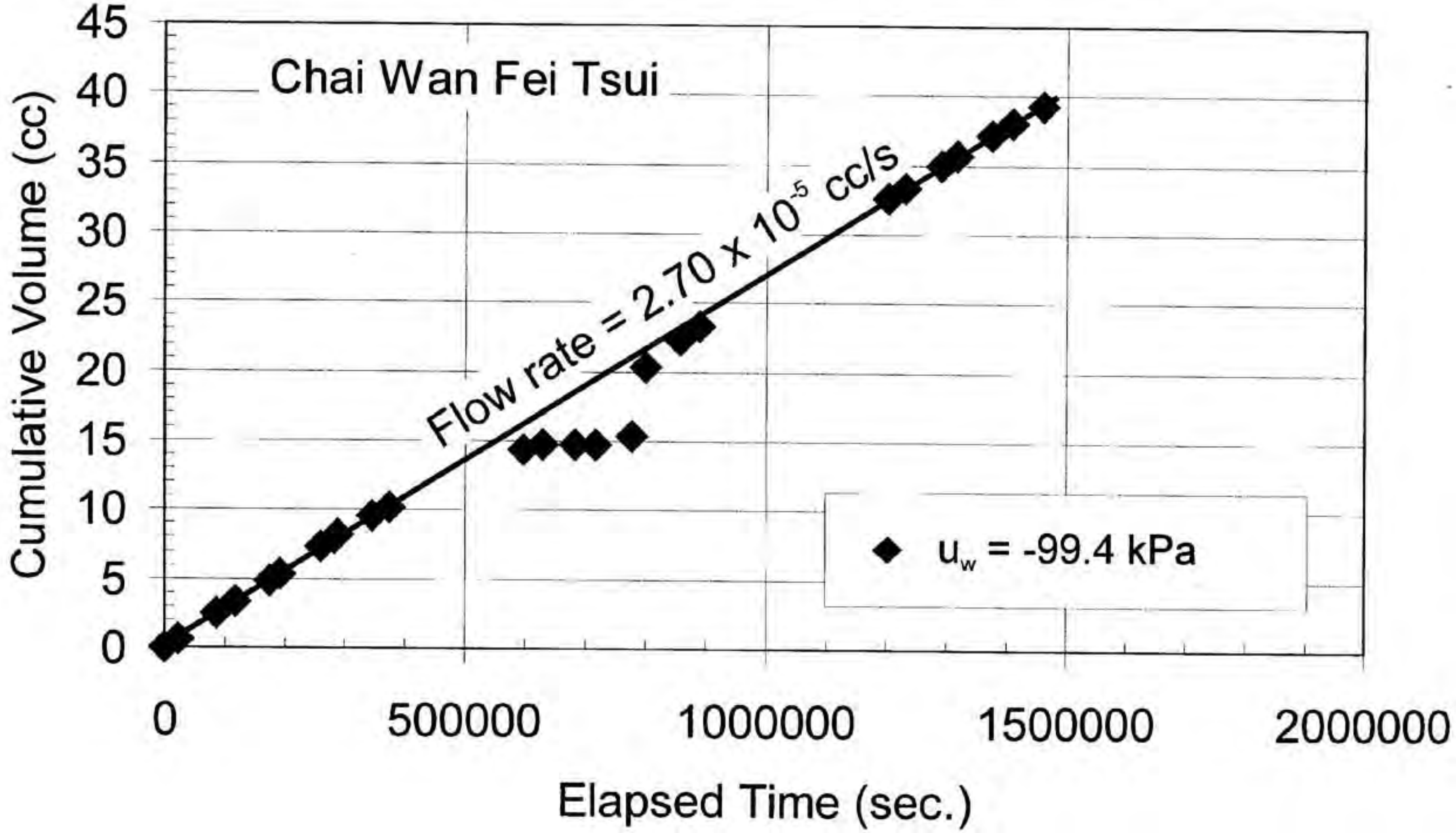

Figure 31 - Water flow rate data for a soil specimen from Chai Wan Fei Tsui at a matric suction of 99.4 kPa under a head difference of 115 mm across the specimen

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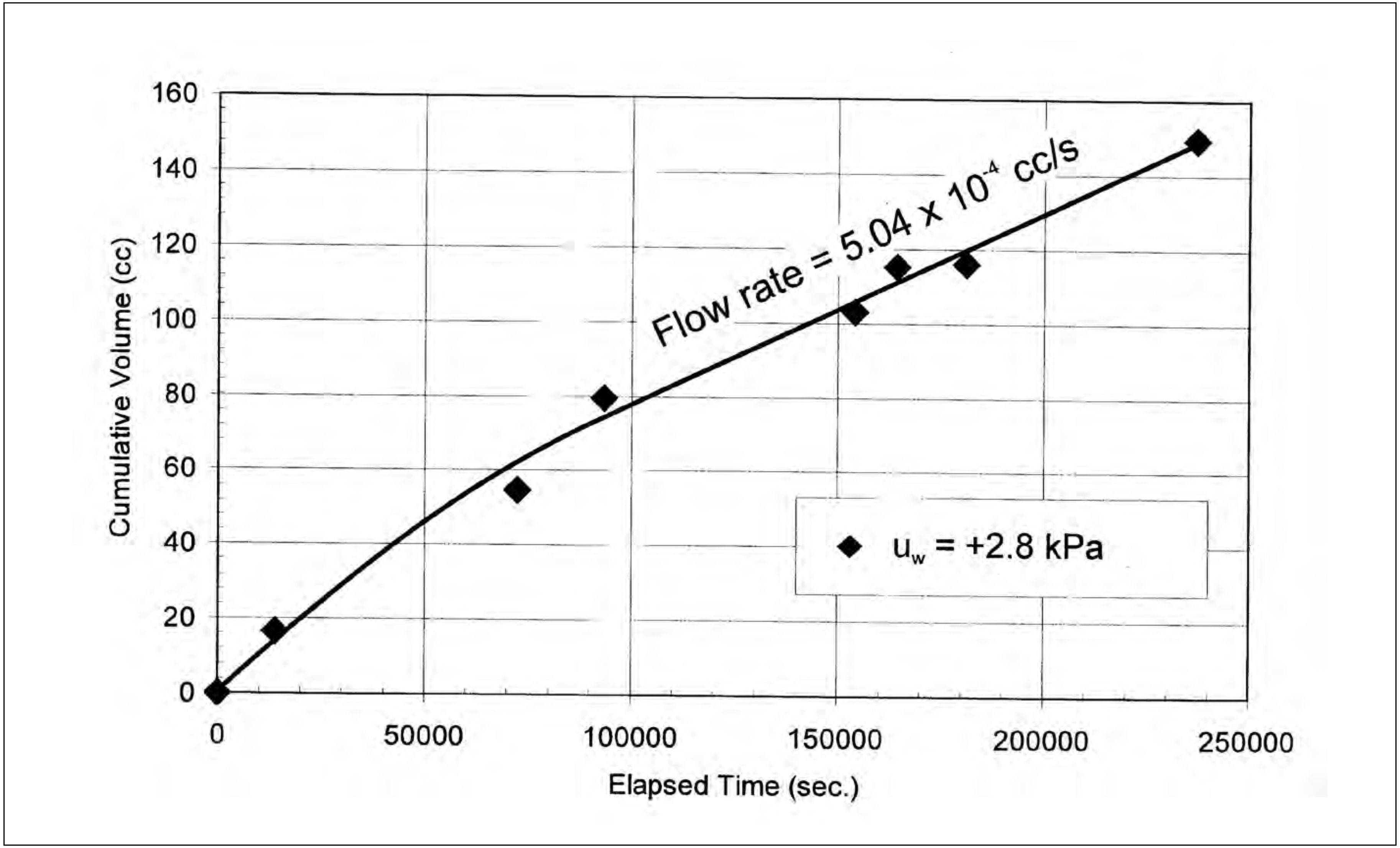

Figure 32 - Water flow rate data for a soil specimen from Butterfly Valley at a positive pore-water pressure of 2.8 kPa under a head difference of 550 mm across the specimen

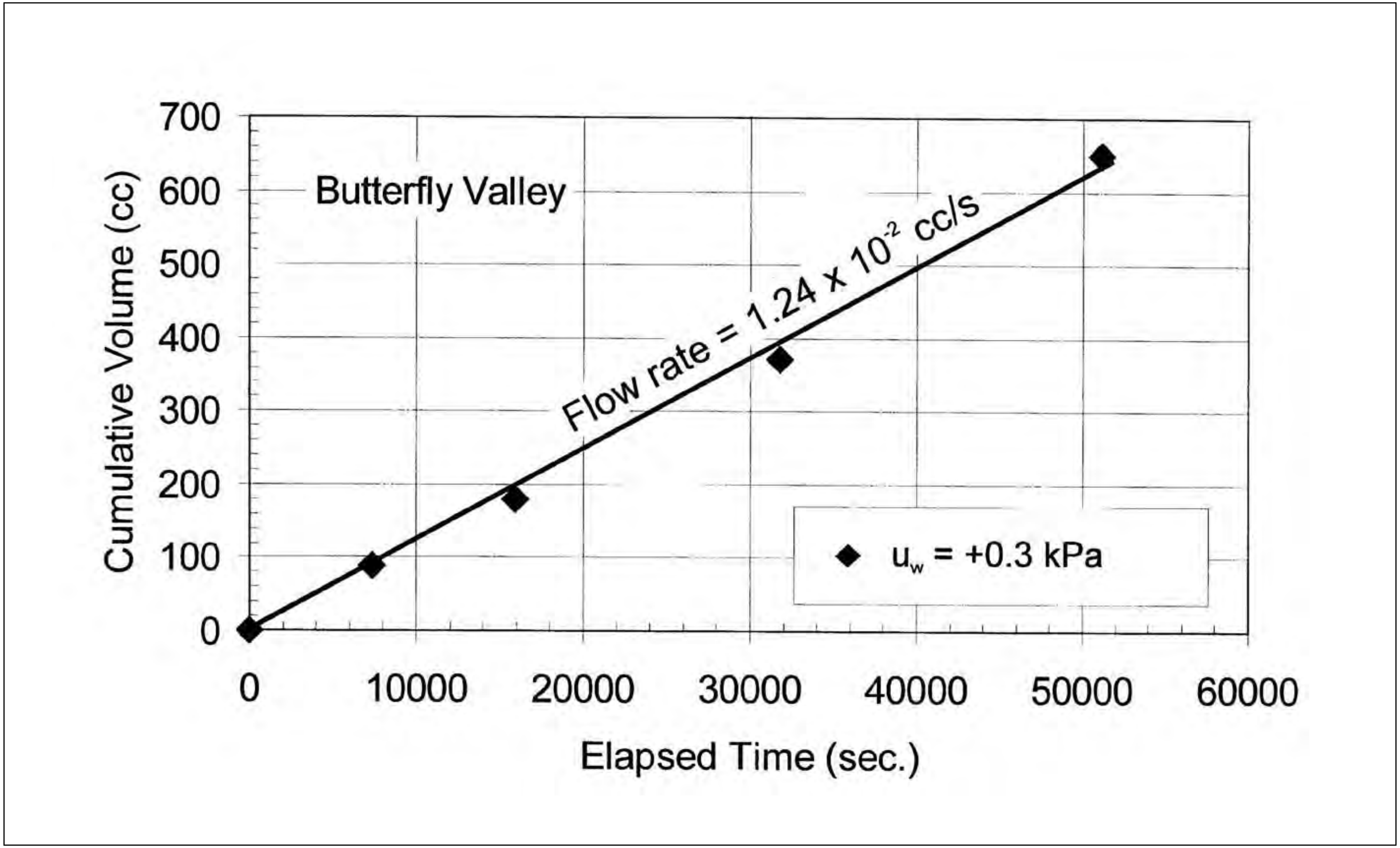

Figure 33 - Water flow rate data for a soil specimen from Butterfly Valley at a positive pore-water pressure of 0.3 kPa under a head difference of 50 mm across the specimen

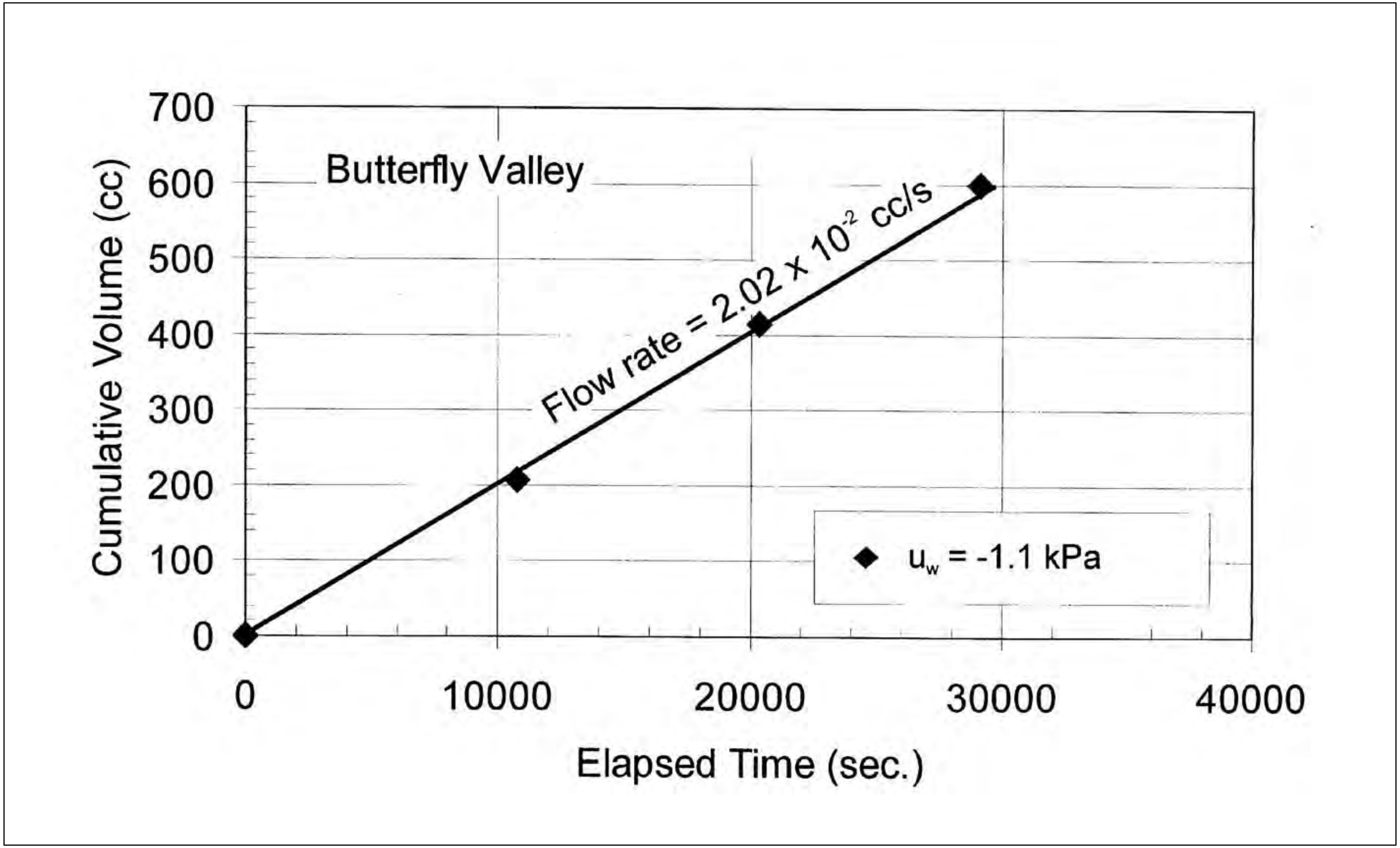

Figure 34 - Water flow rate data for a soil specimen from Butterfly Valley at a matric suction of 1.1 kPa (i.e., pore-water pressure of -1.1 kPa) under a head difference of 85 mm across the specimen

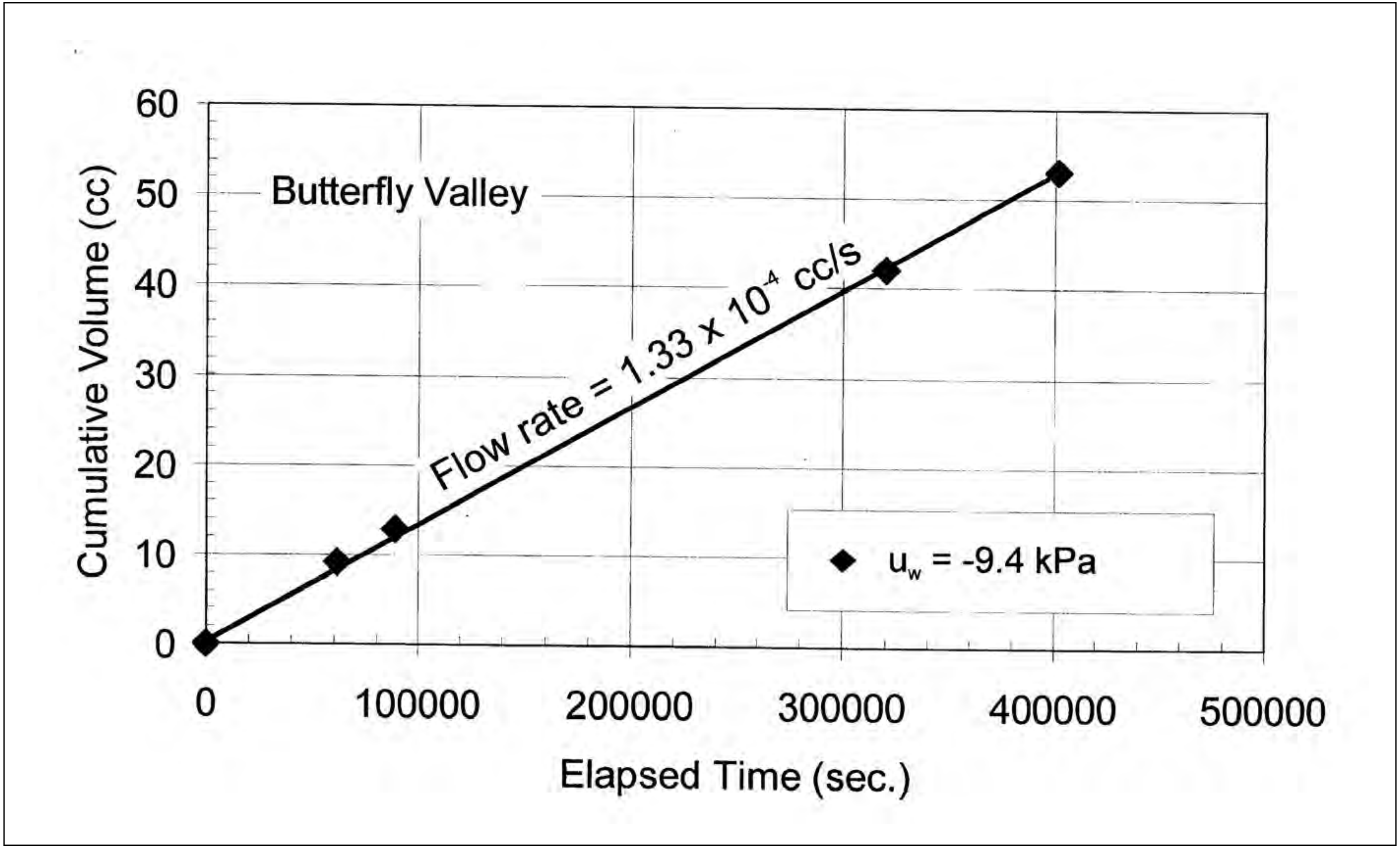

Figure 35 - Water flow rate data for a soil specimen from Butterfly Valley at a matric suction of 9.4 kPa (i.e., pore-water pressure of -9.4 kPa) under a head difference of 115 mm across the specimen

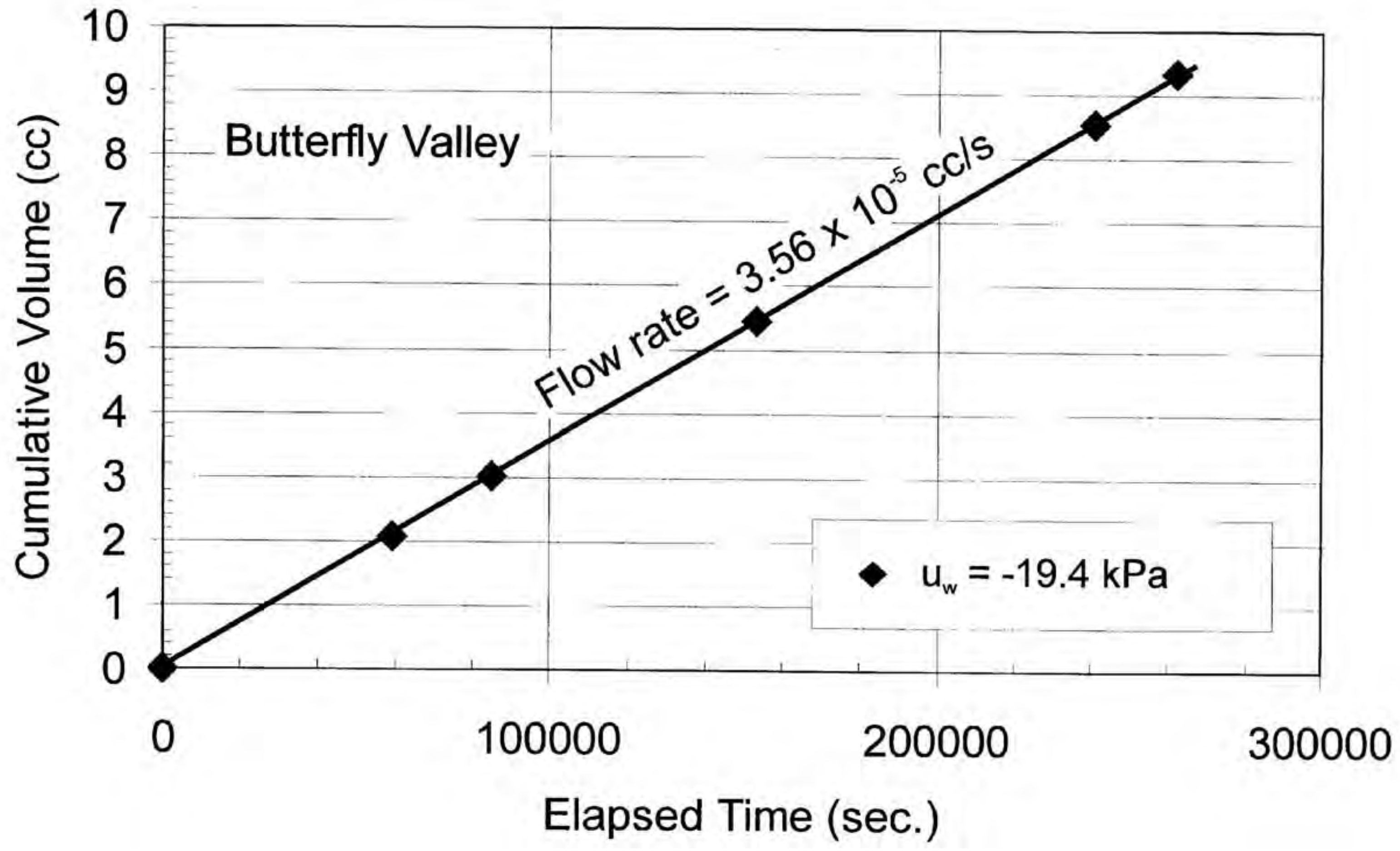

Figure 36 - Water flow rate data for a soil specimen from Butterfly Valley at a matric suction of 19.4 kPa under a head difference of 115 mm across the specimen

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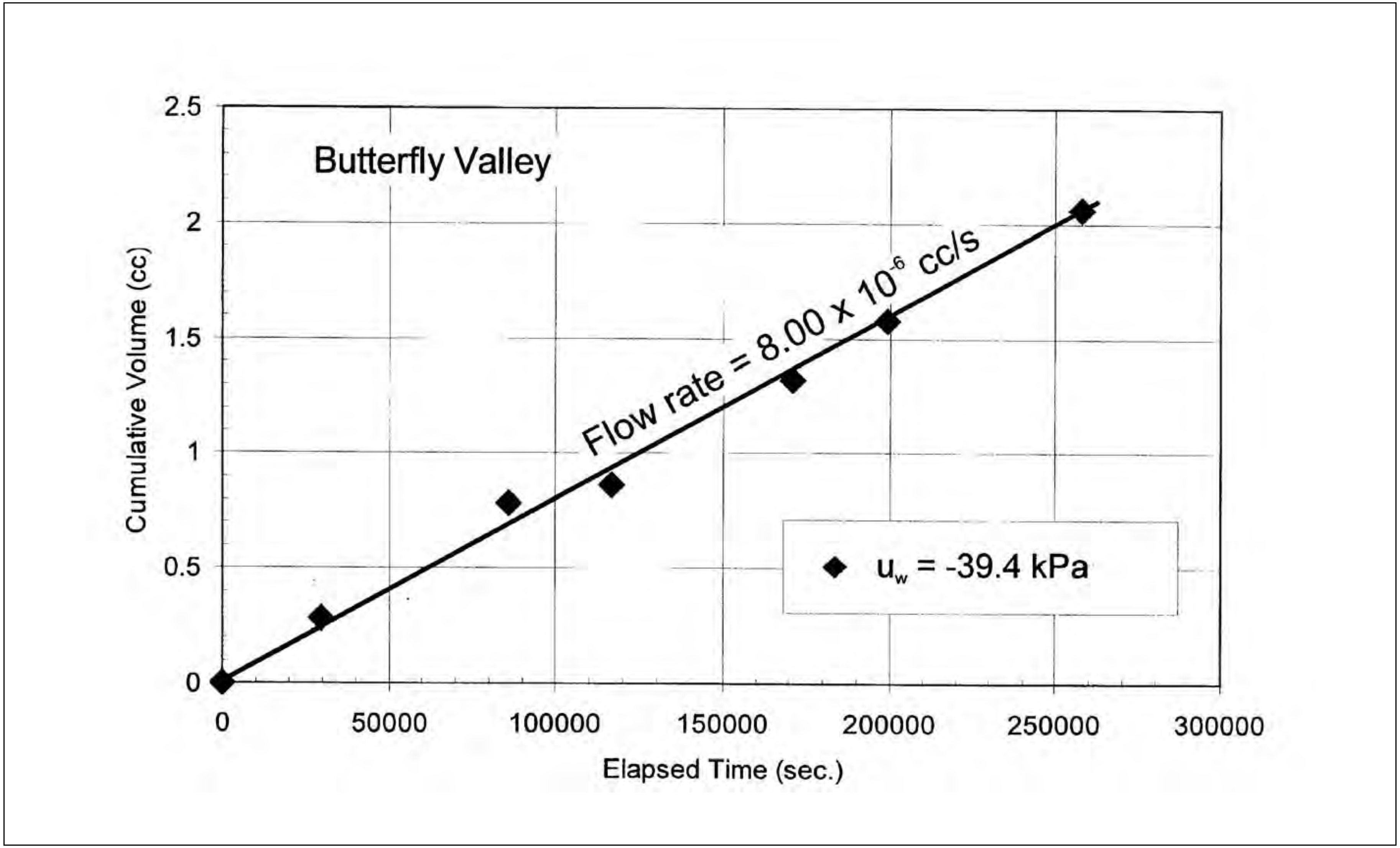

Figure 37 - Water flow rate data for a soil specimen from Butterfly Valley at a matric suction of 39.4 kPa under a head difference of 115 mm across the specimen

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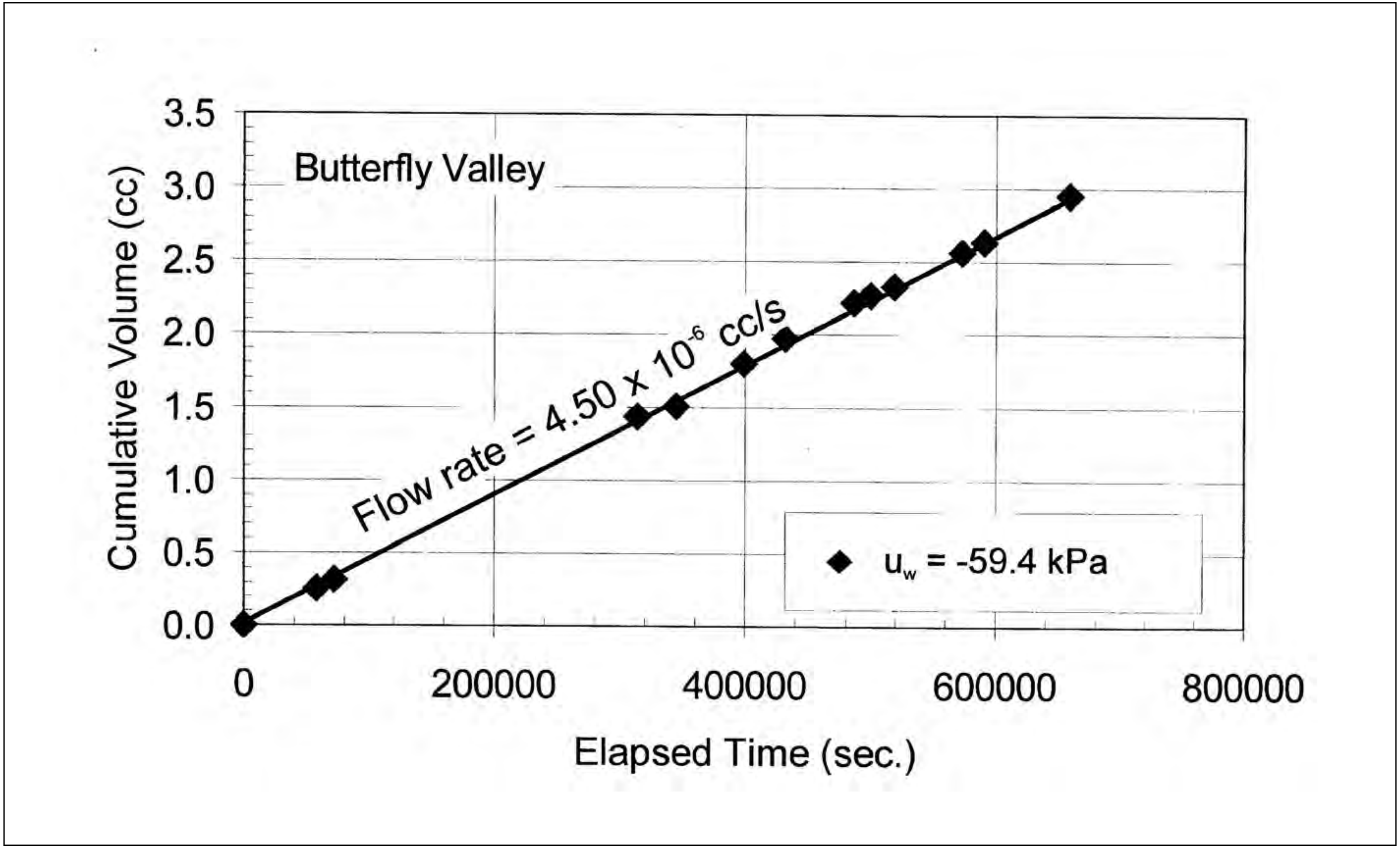

Figure 38 - Water flow rate data for a soil specimen from Butterfly Valley at a matric suction of 59.4 kPa under a head difference of 115 mm across the specimen

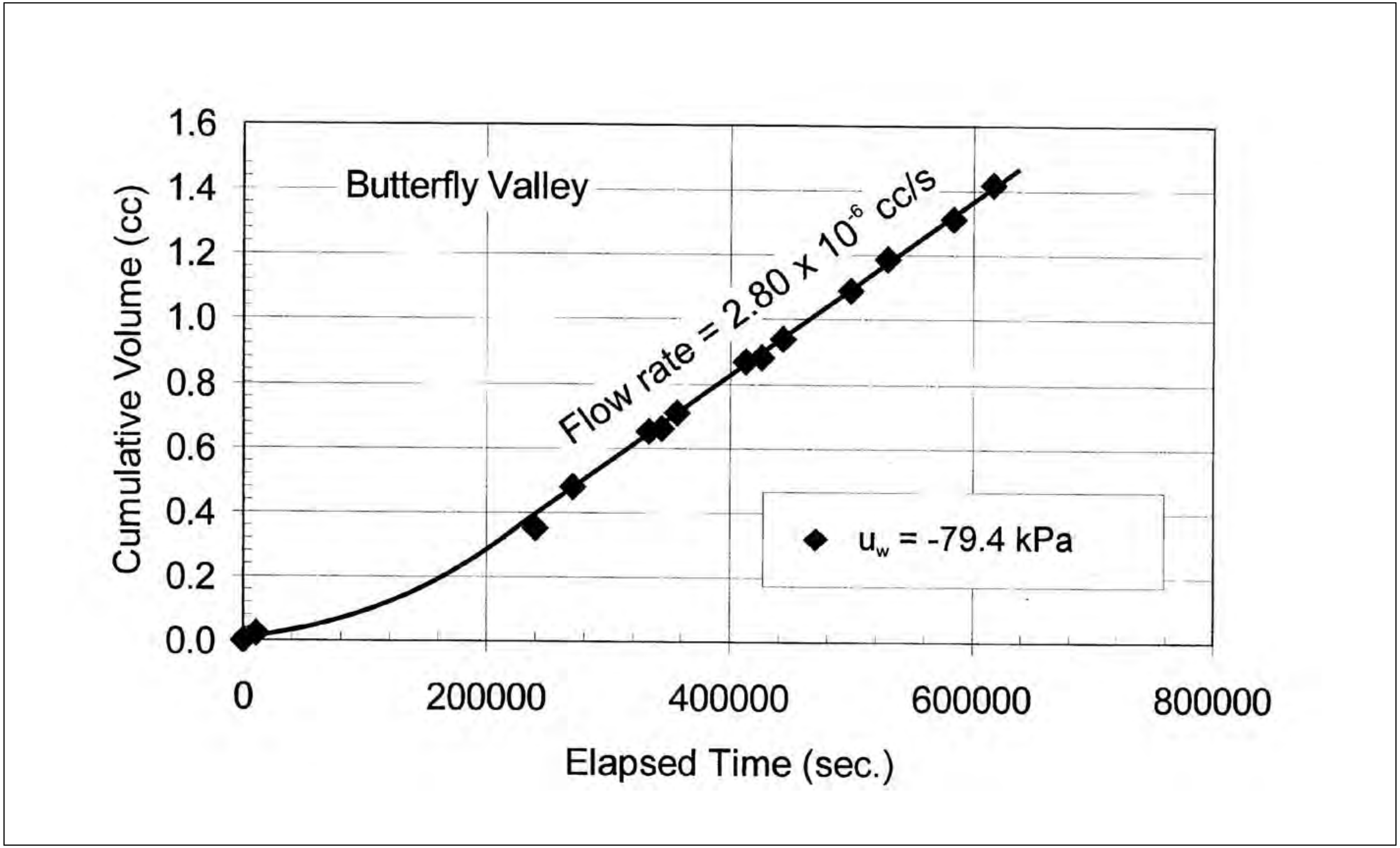

Figure 39 - Water flow rate data for a soil specimen from Butterfly Valley at a matric suction of 79.4 kPa under a head difference of 115 mm across the specimen

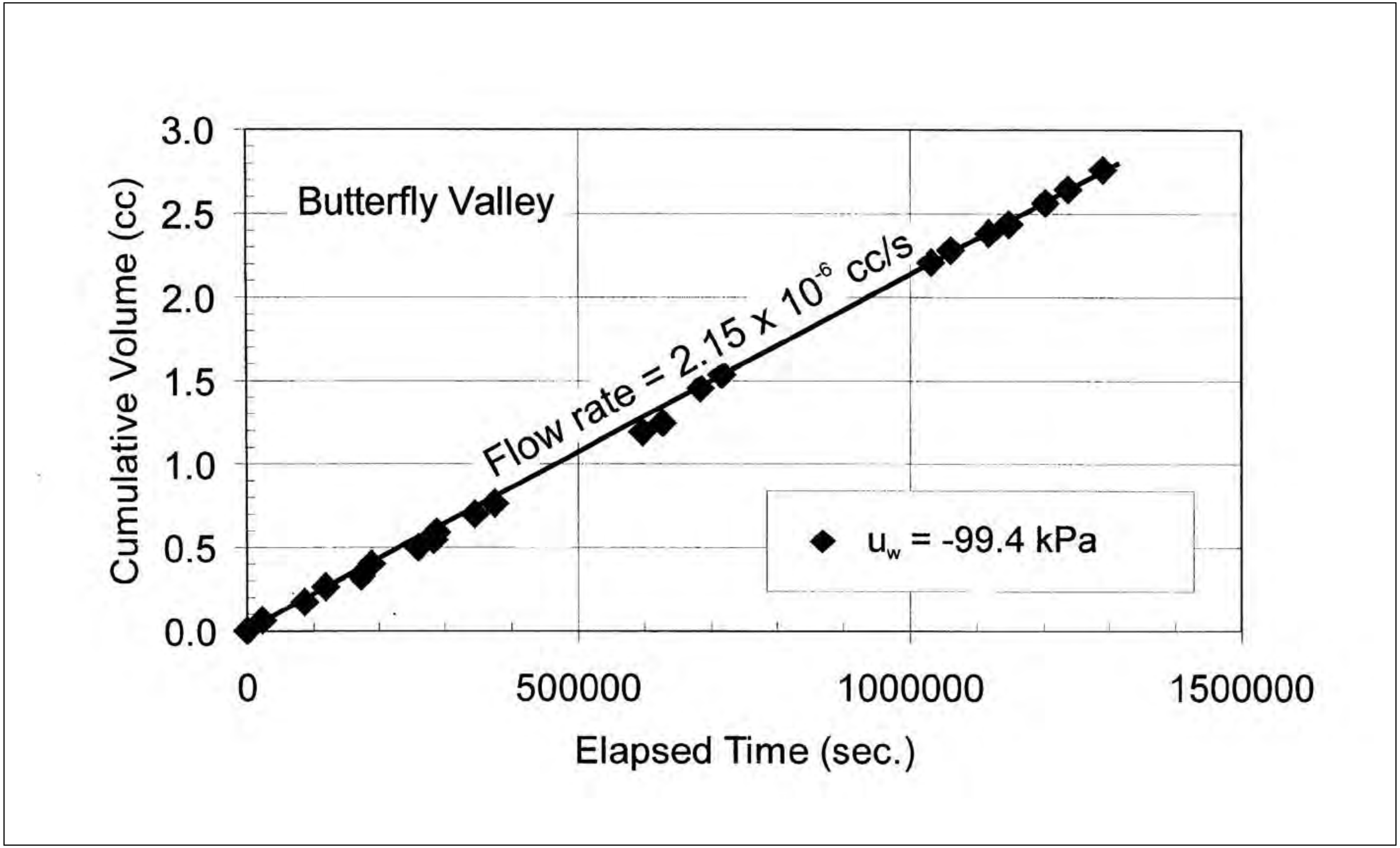

Figure 40 - Water flow rate data for a soil specimen from Butterfly Valley at a matric suction of 99.4 kPa under a head difference of 115 mm across the specimen

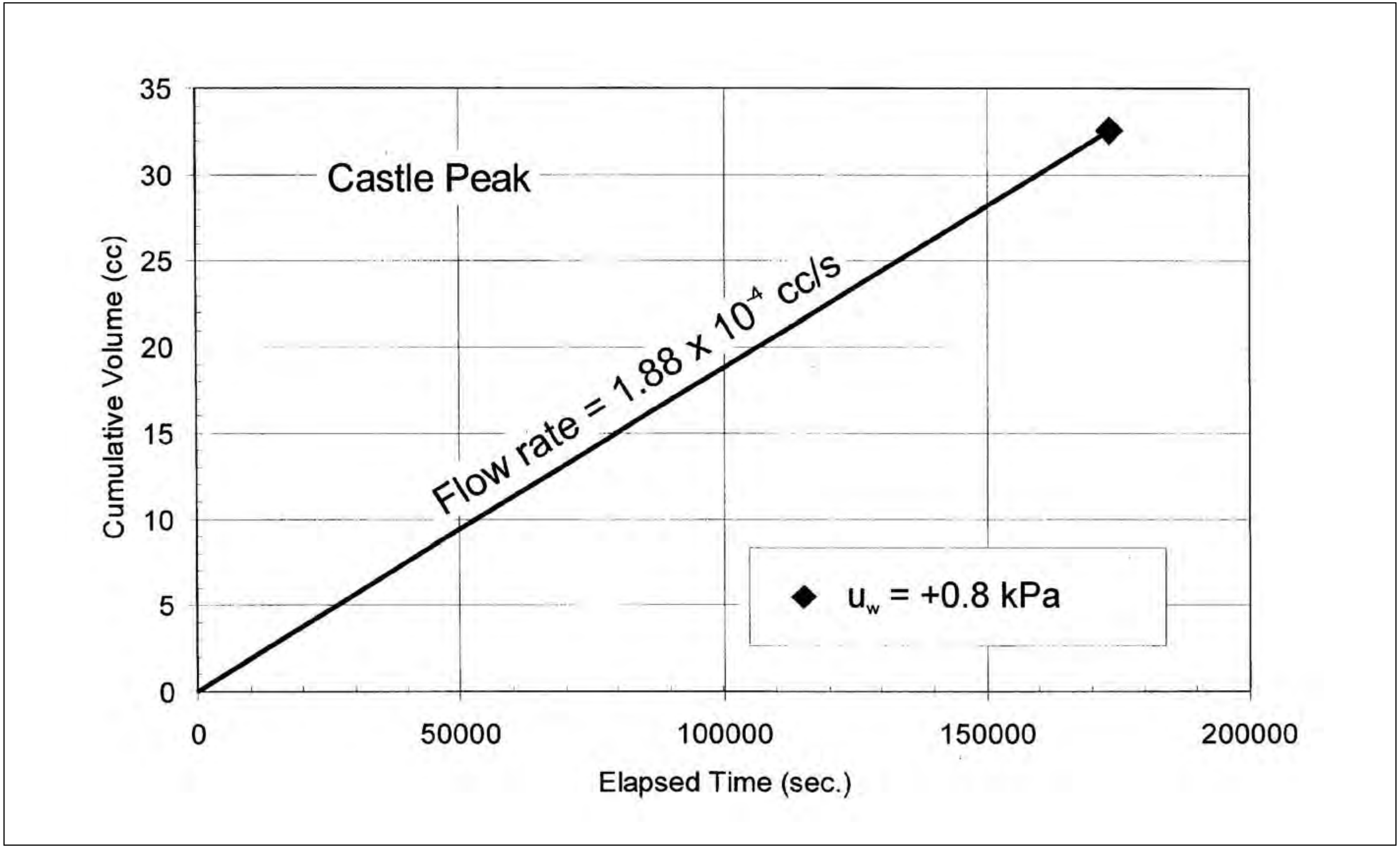

Figure 41 - Water flow rate data for a soil specimen from Castle Peak at a positive pore-water pressure of 0.8 kPa under a head difference of 150 mm across the specimen

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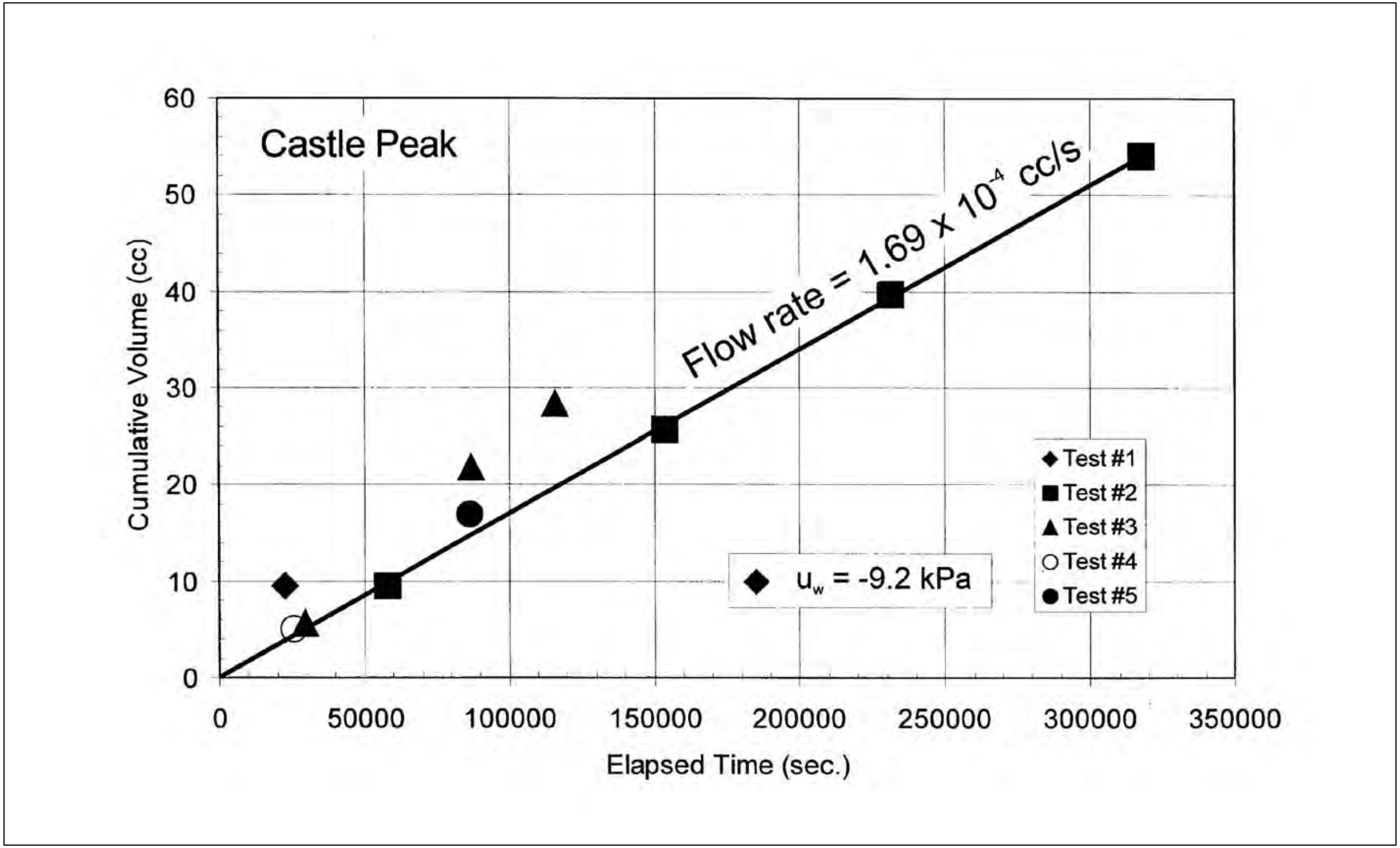

Figure 42 - Water flow rate data for a soil specimen from Castle Peak at a matric suction of 9.2 kPa (i.e., pore-water pressure of -9.2 kPa) under a head difference of 150 mm across the specimen

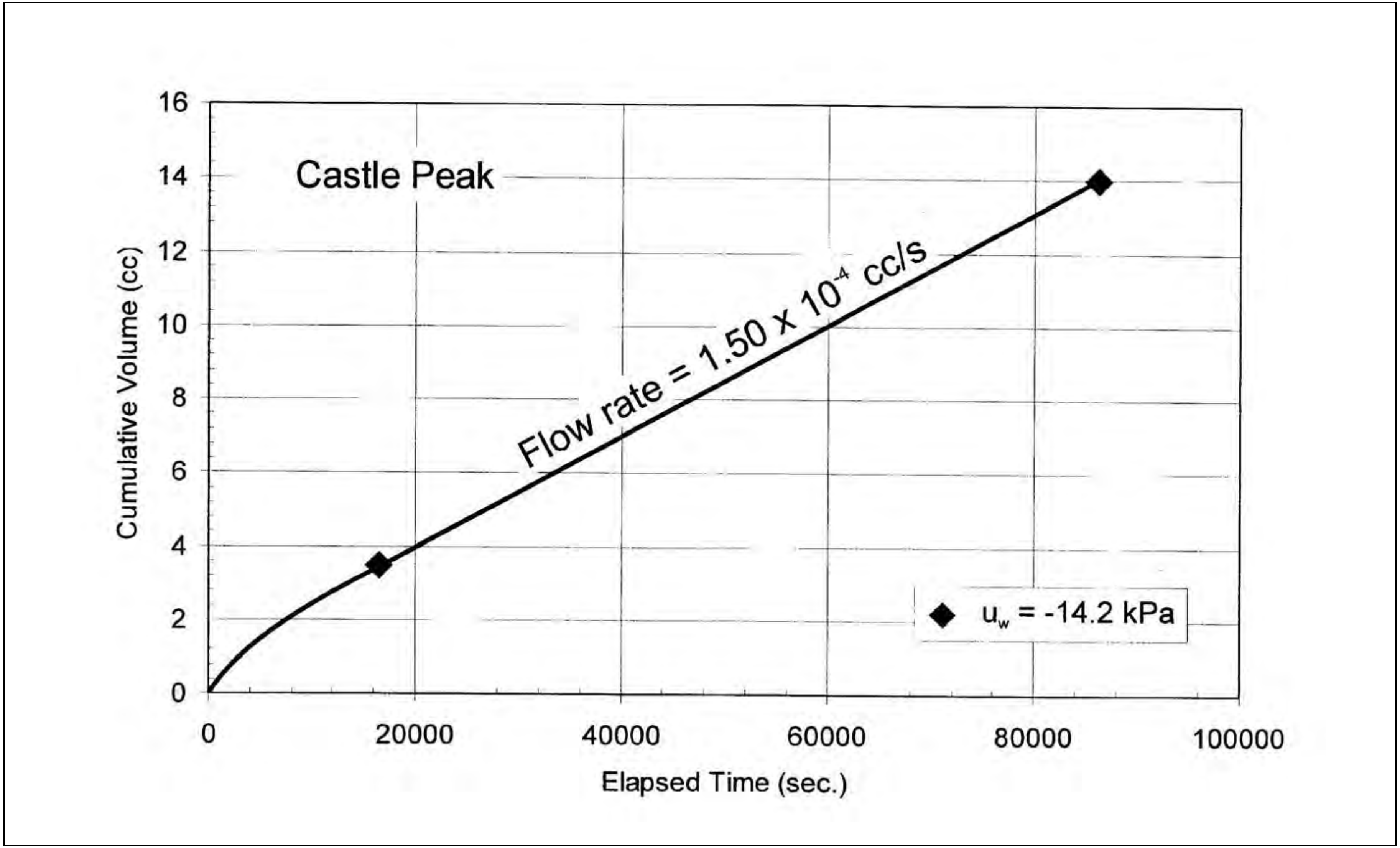

Figure 43 - Water flow rate data for a soil specimen from Castle Peak at a matric suction of 14.2 kPa under a head difference of 150 mm across the specimen

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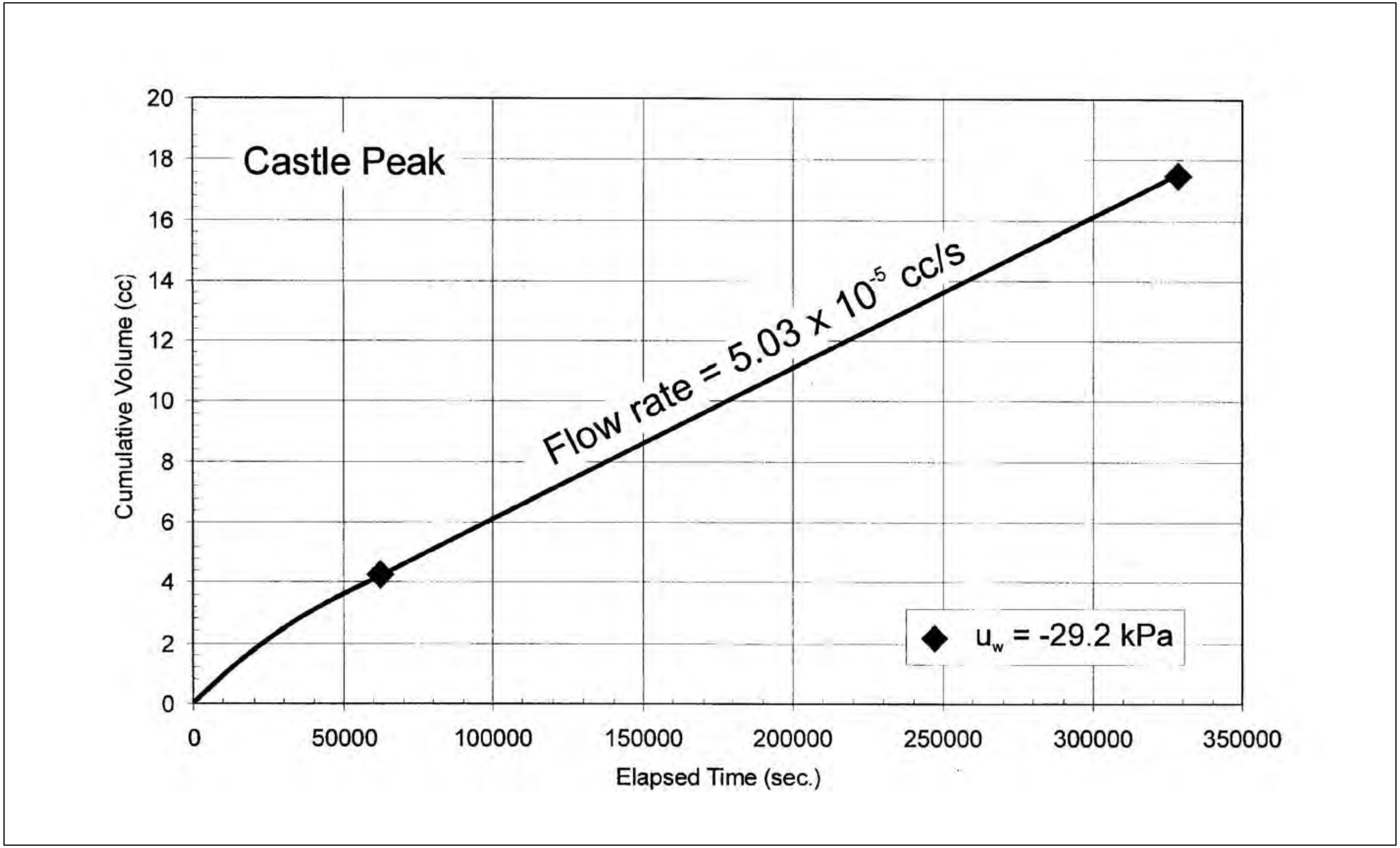

Figure 44 - Water flow rate data for a soil specimen from Castle Peak at a matric suction of 29.2 kPa under a head difference of 150 mm across the specimen

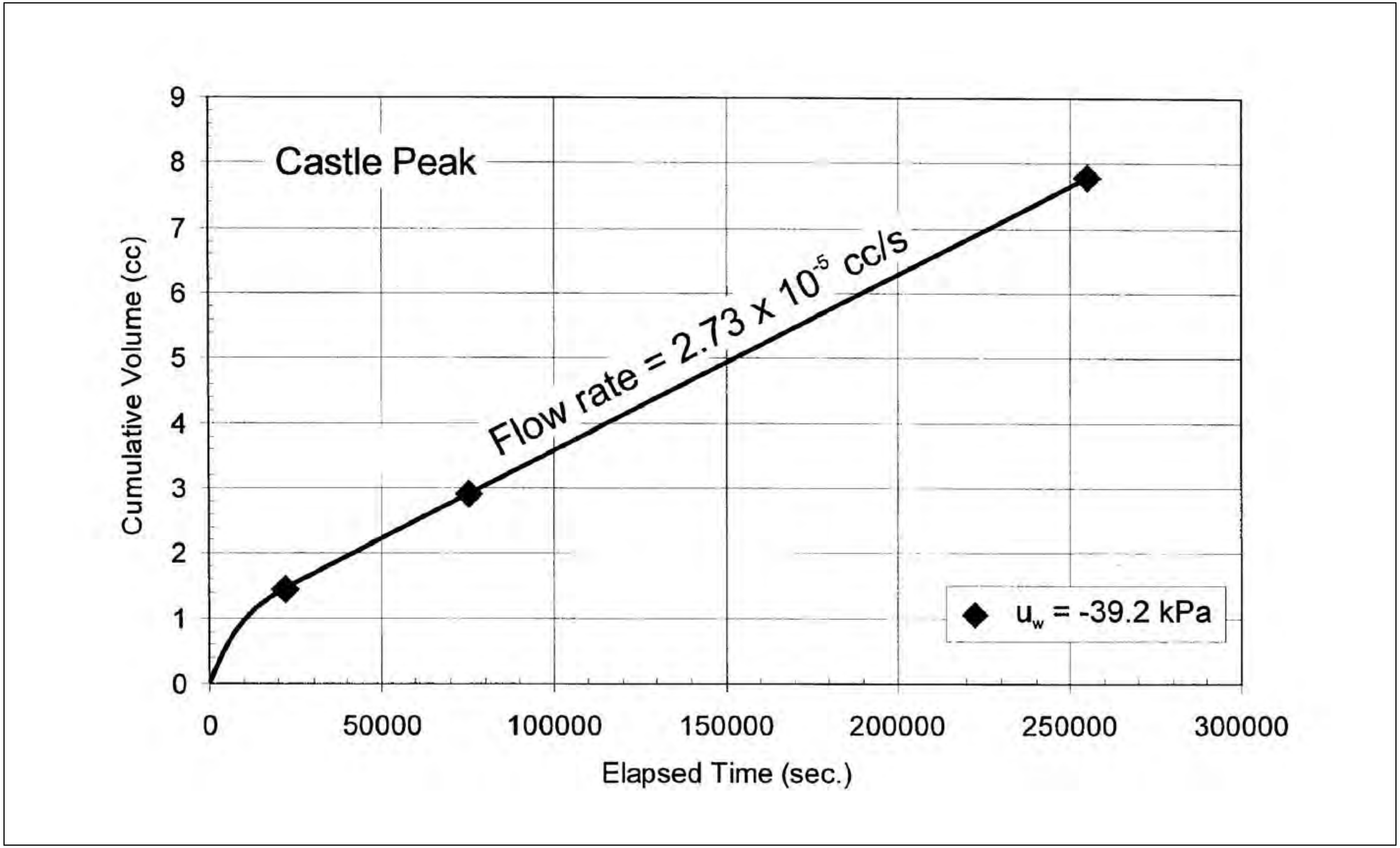

Figure 45 - Water flow rate data for a soil specimen from Castle Peak at a matric suction of 39.2 kPa under a head difference of 150 mm across the specimen

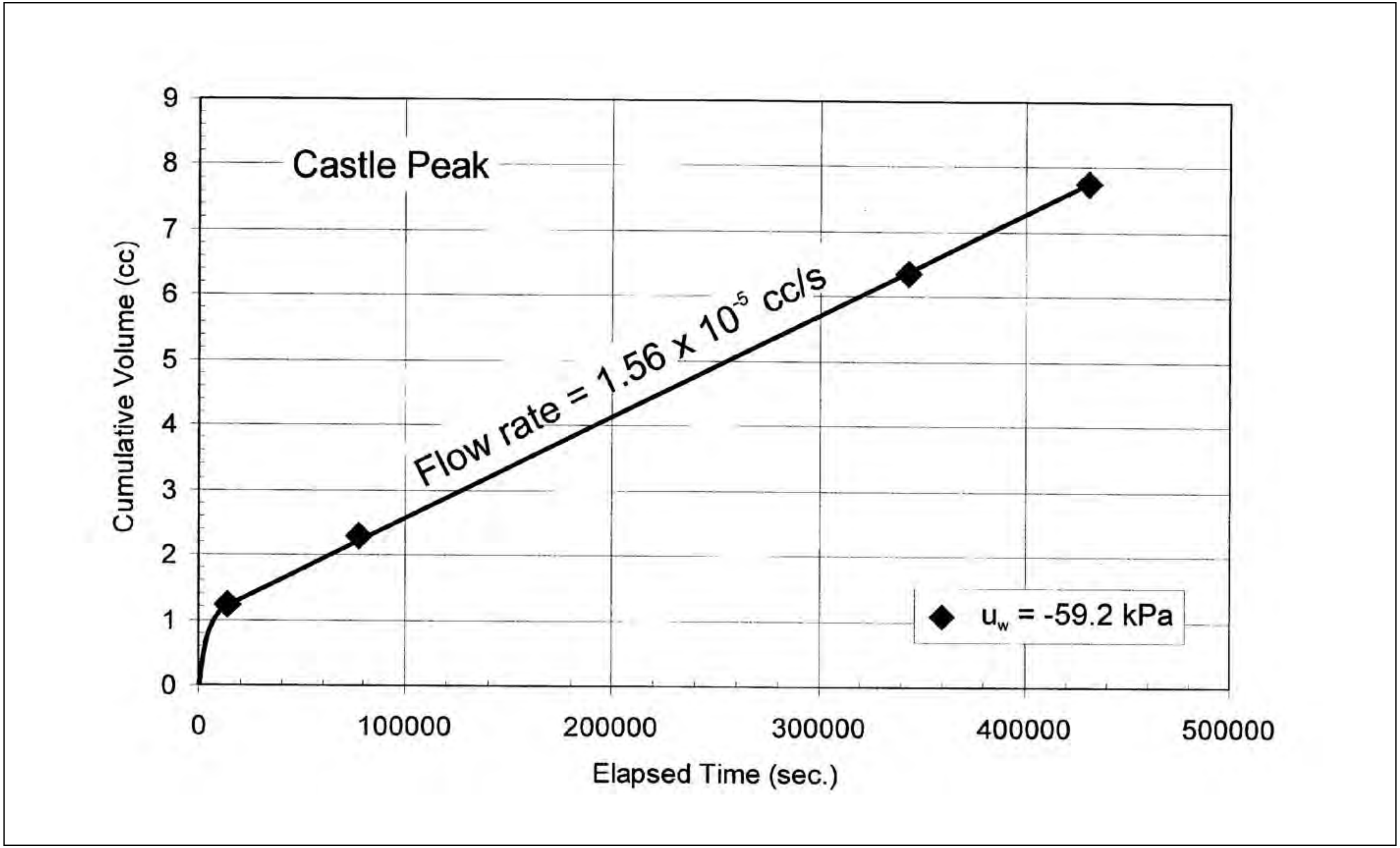

Figure 46 - Water flow rate data for a soil specimen from Castle Peak at a matric suction of 59.2 kPa under a head difference of 150 mm across the specimen

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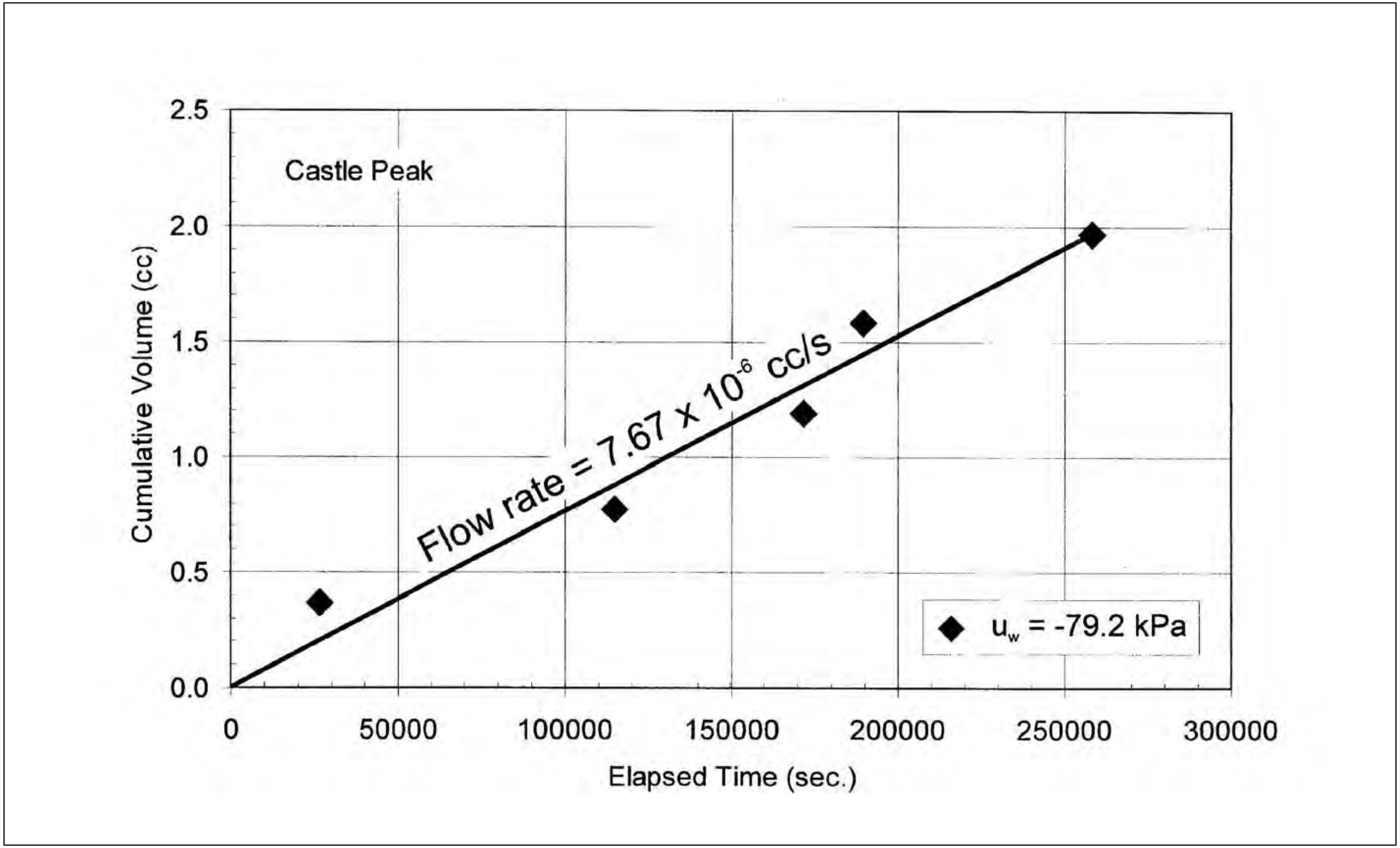

Figure 47 - Water flow rate data for a soil specimen from Castle Peak at a matric suction of 79.2 kPa under a head difference of 150 mm across the specimen

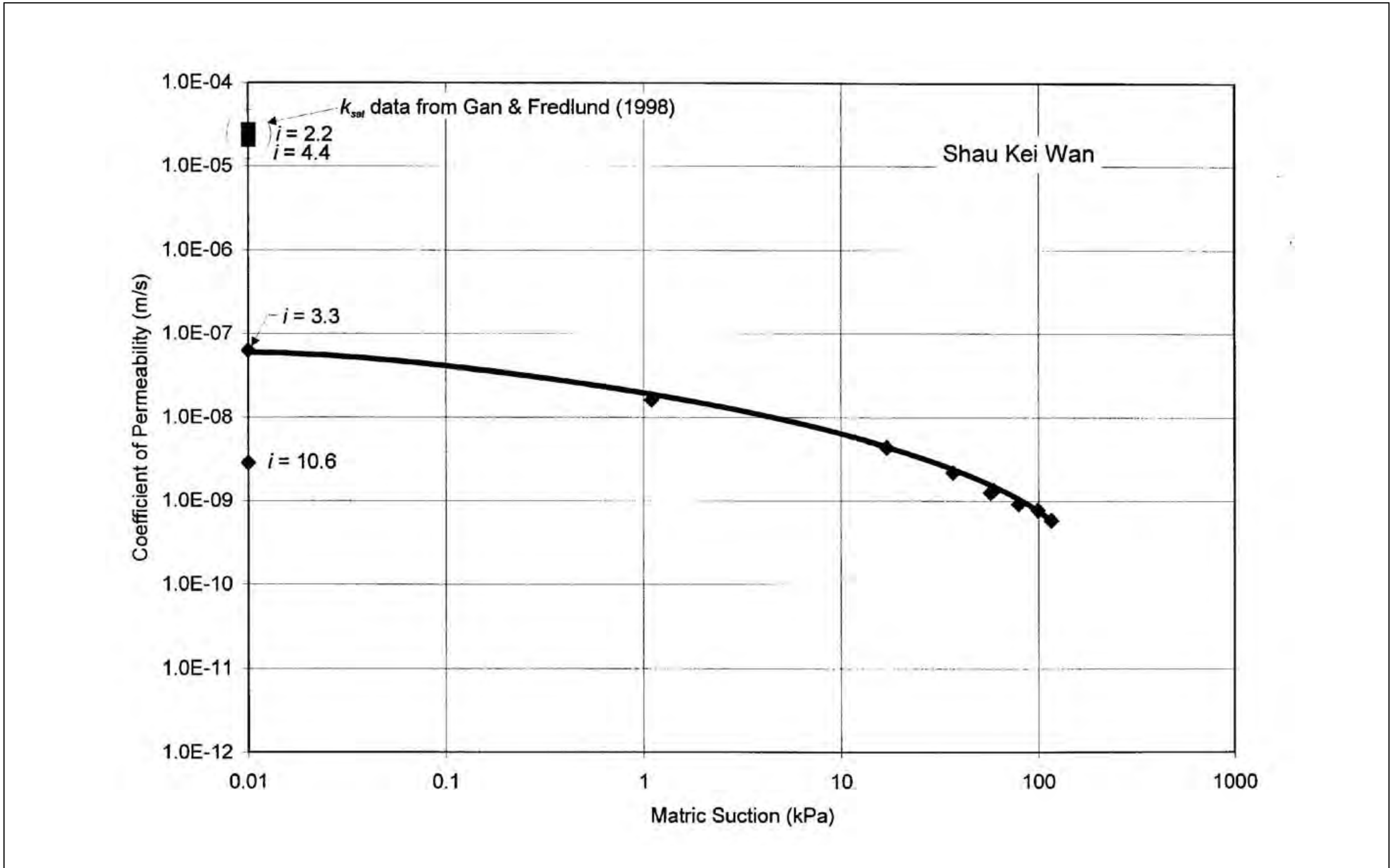

Figure 48 - Coefficient of permeability function for the soil specimen from Shau Kei Wan

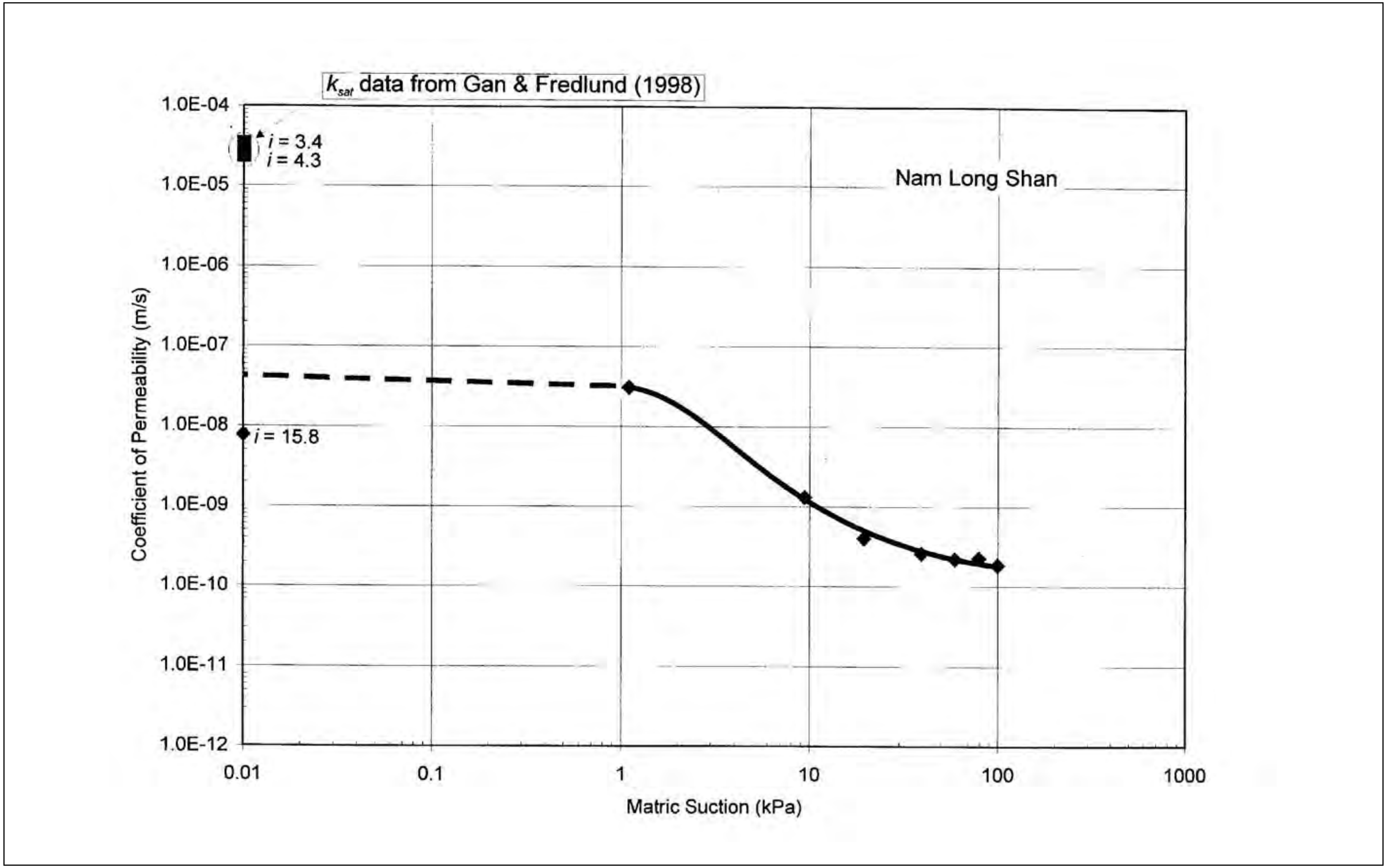

Figure 49 - Coefficient of permeability function for the soil specimen from Nam Long Shan

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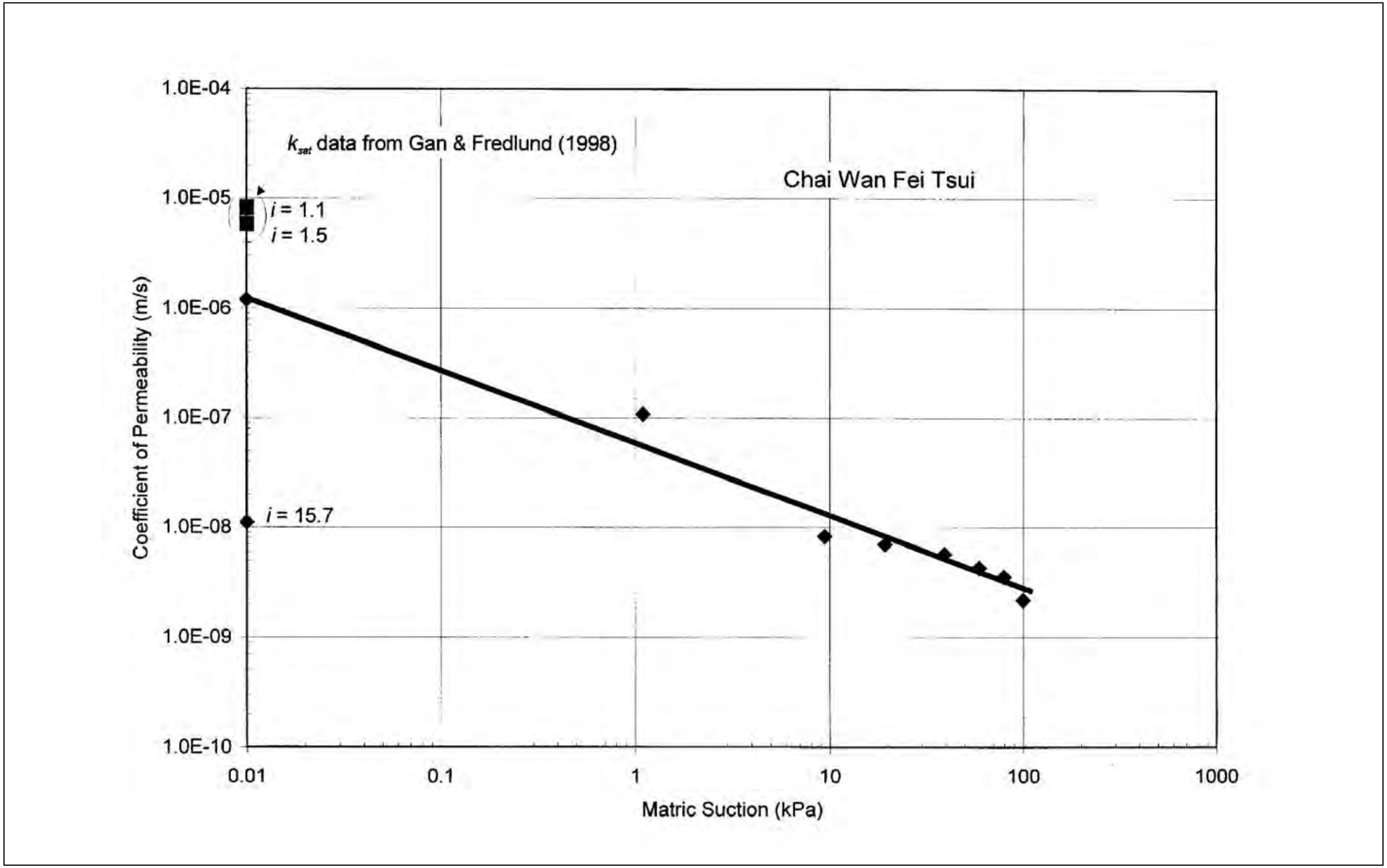

Figure 50 - Coefficient of permeability function for the soil specimen from Chai Wan Fei Tsui

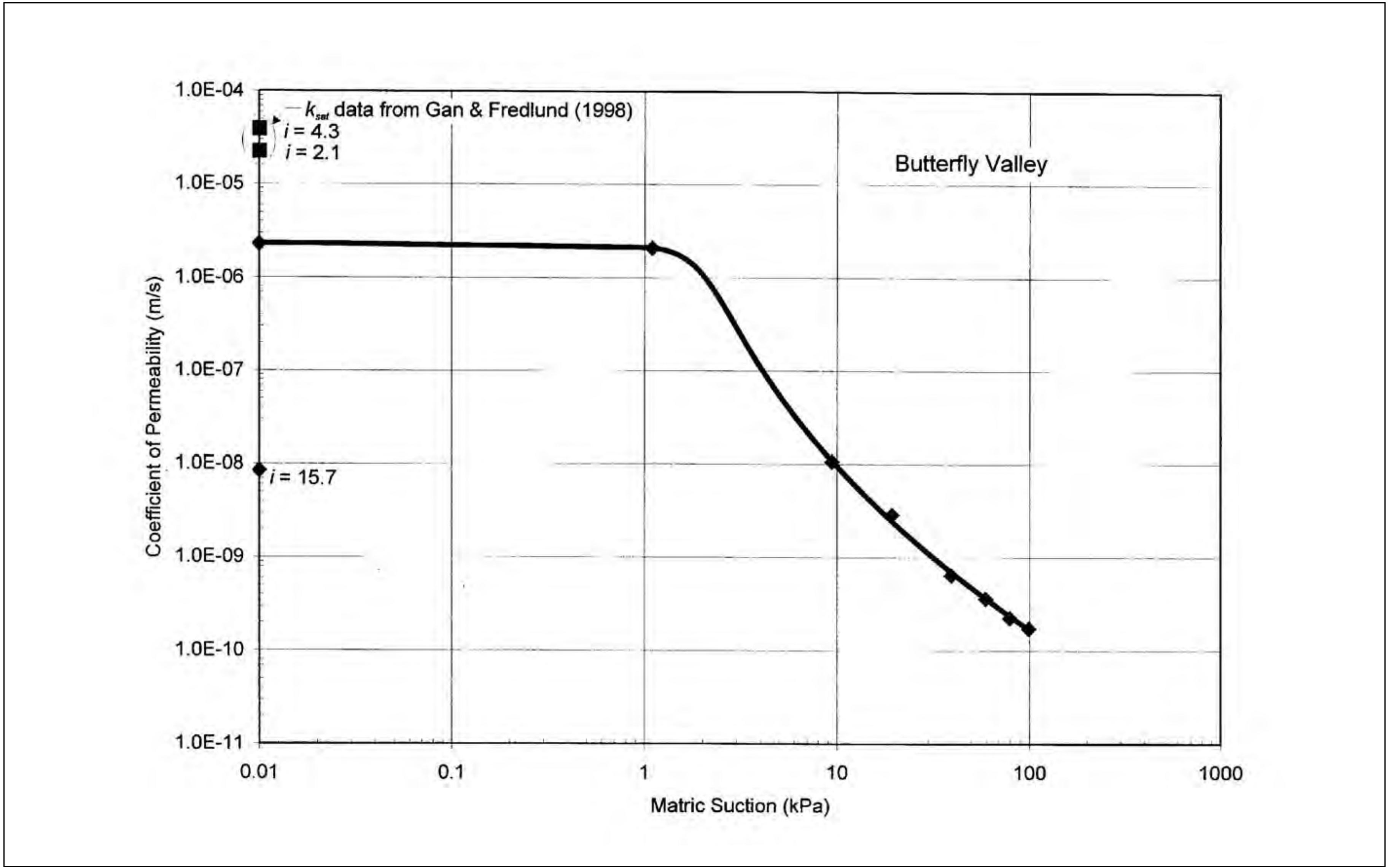

Figure 51 - Coefficient of permeability function for the soil specimen from Butterfly Valley

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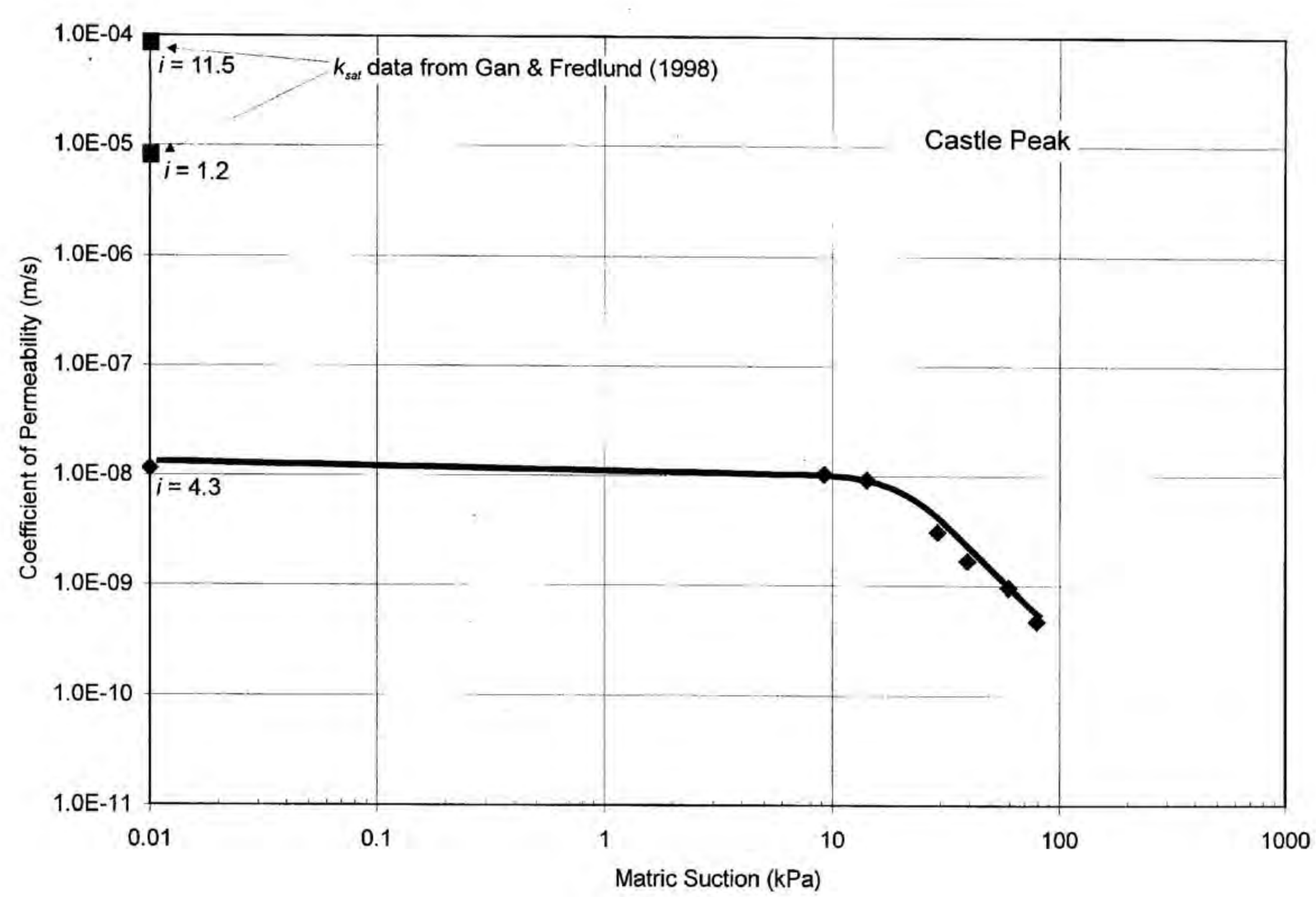

Figure 52 - Coefficient of permeability function for the soil specimen from Castle Peak

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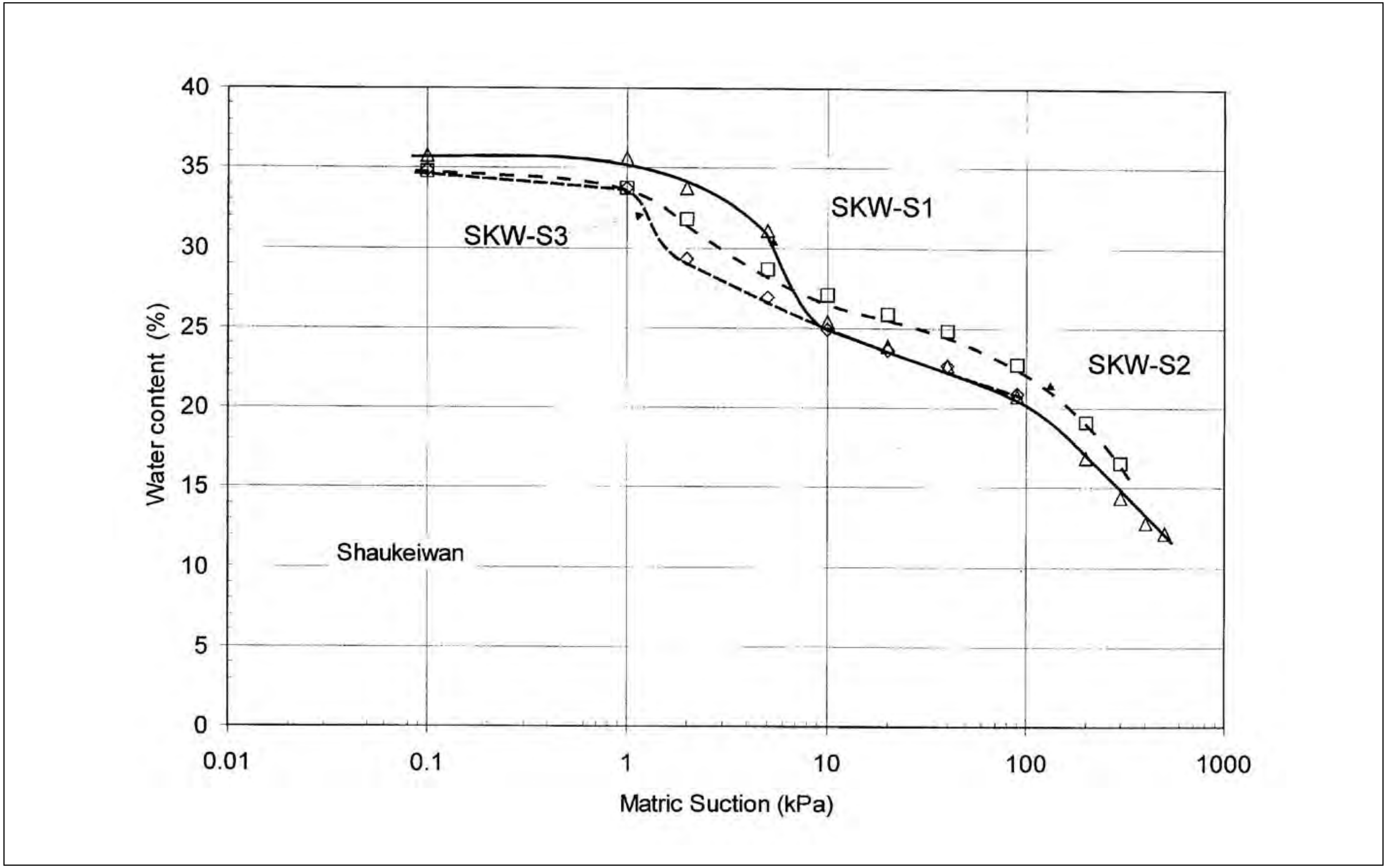

Figure 53 - Soil-water characteristic curves for three soil specimens from Shau Kei Wan (Gan and Fredlund,1998)

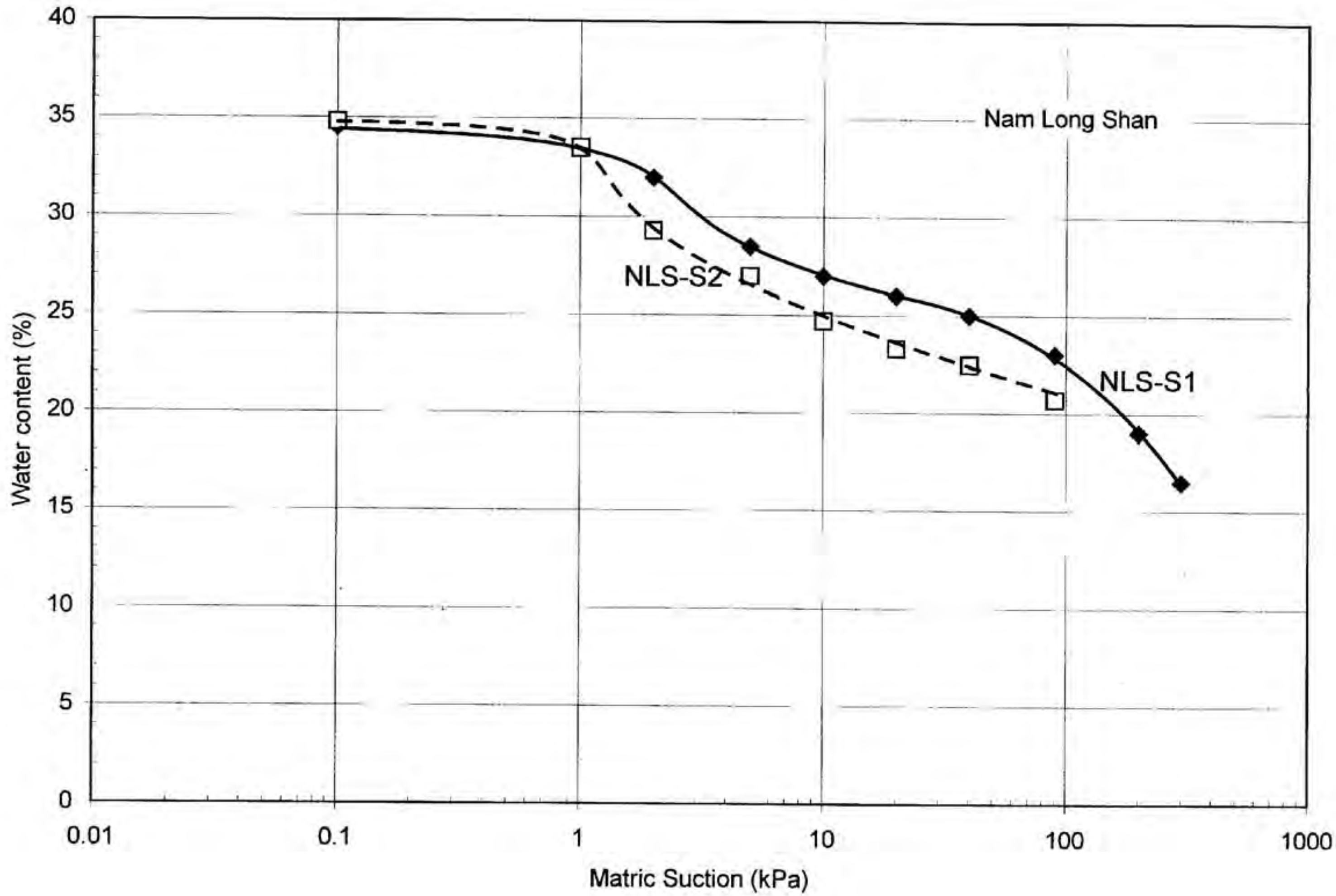

Figure54 - Soil-water characteristic curves for two soil specimens from Nam Long Shan (Gan and Fredlund,1998)

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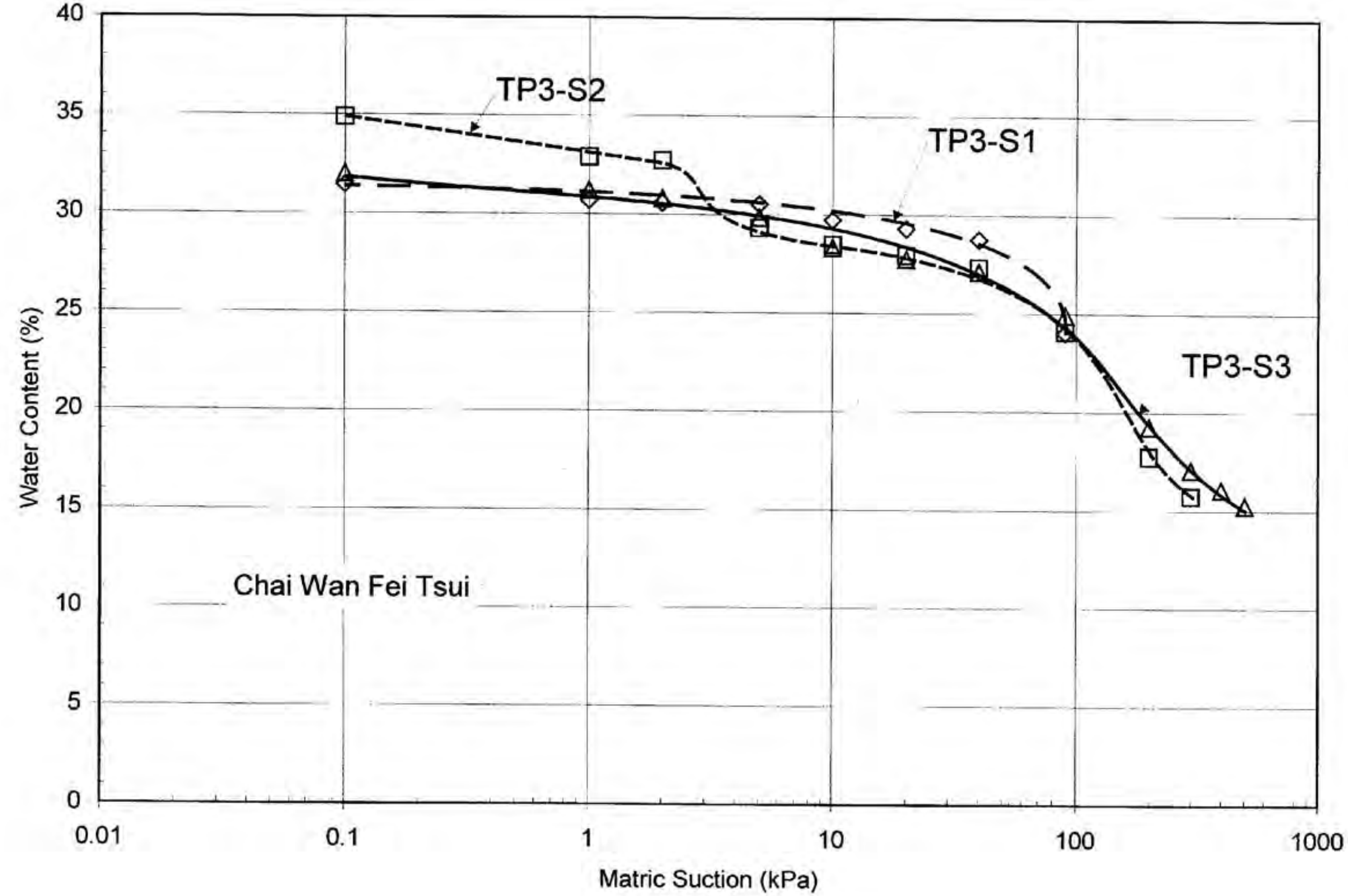

Figure 55 - Soil-water characteristic curves for three soil specimens from Chai Wan Fei Tsui (Gan and Fredlund,1998)

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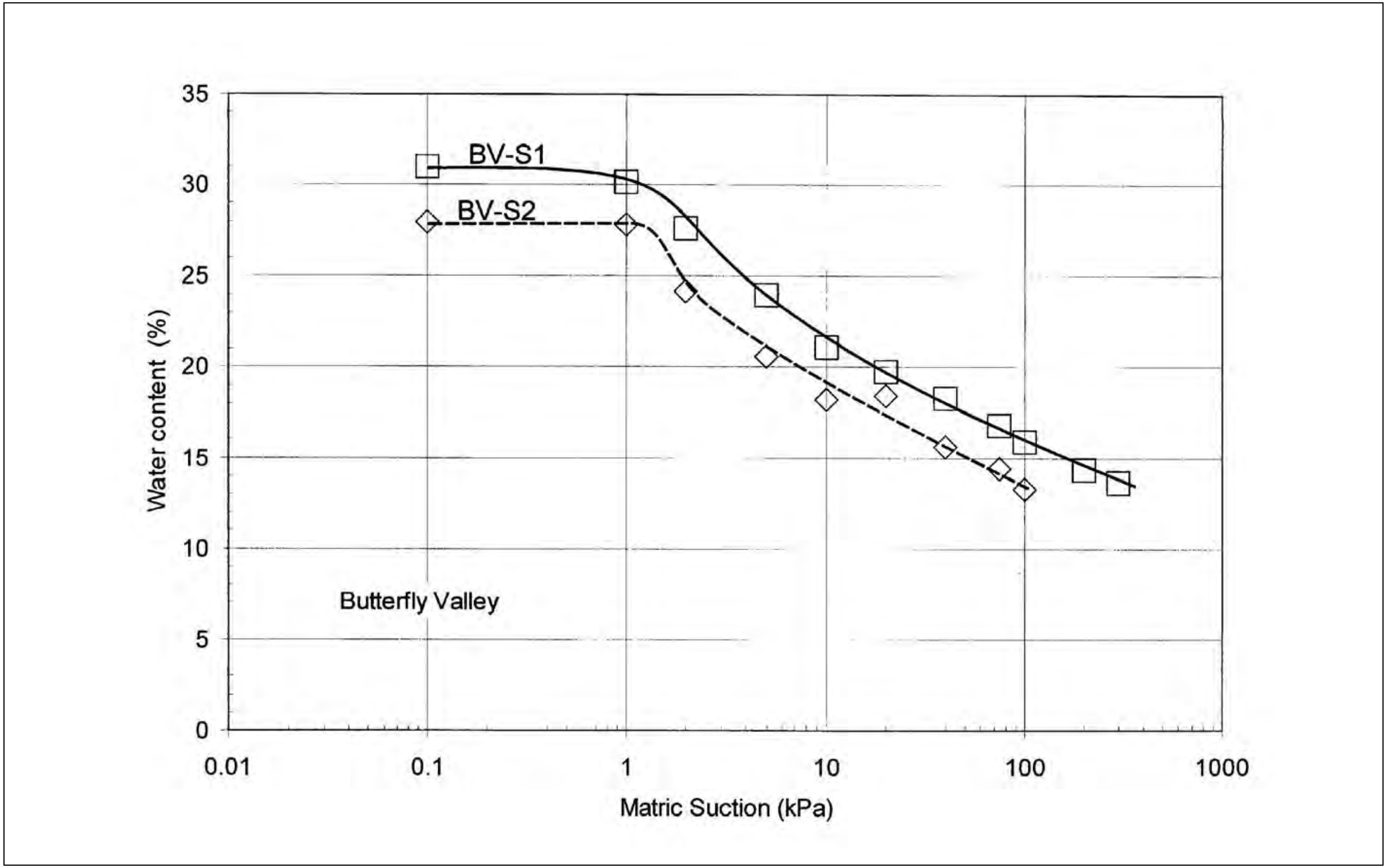

Figure 56 - Soil-water characteristic curves for two soil specimens from Butterfly Valley (Gan and Fredlund,1998)

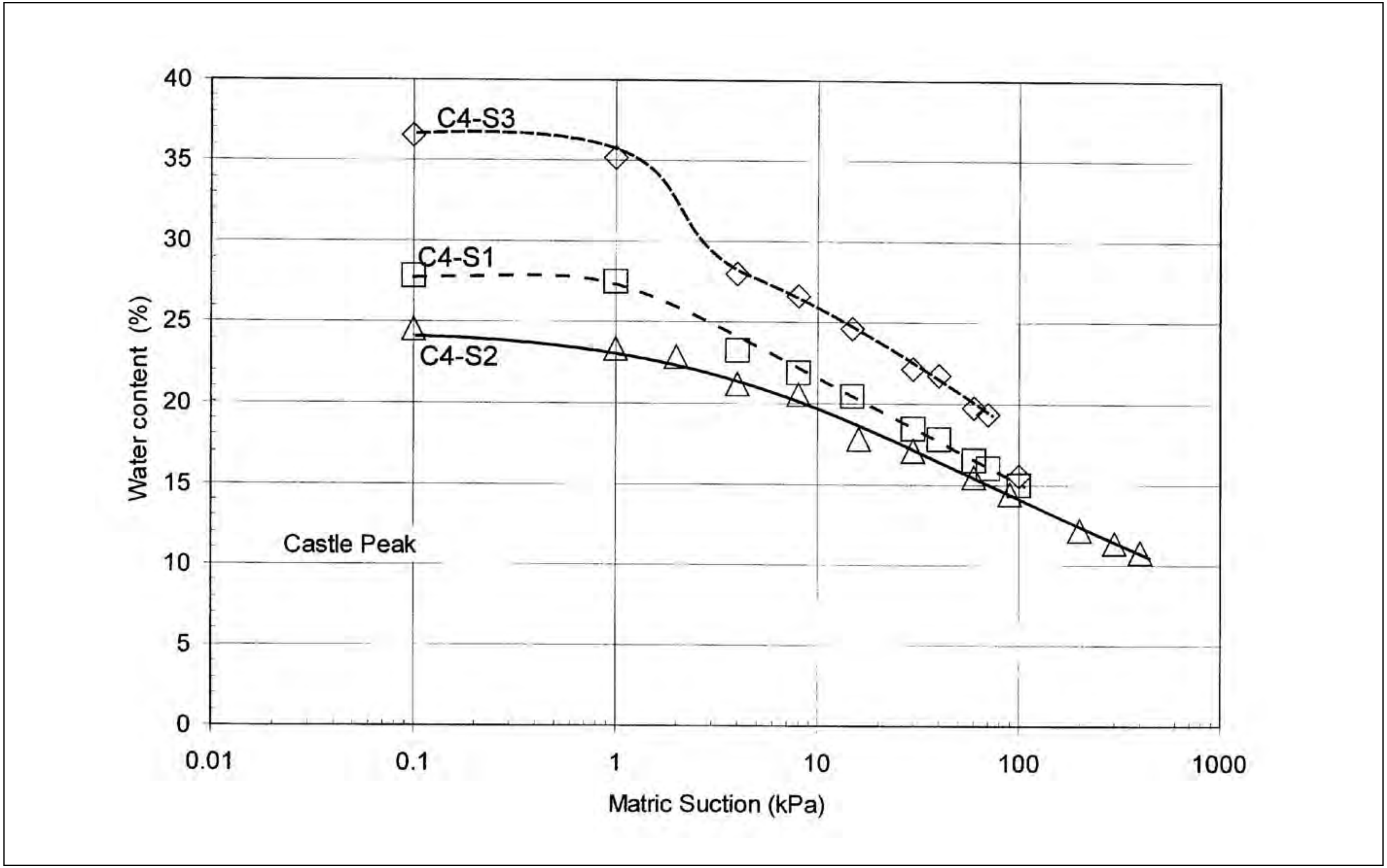

Figure 57 - Soil-water characteristic curves for three soil specimens from Castle Peak (Gan and Fredlund,1998)

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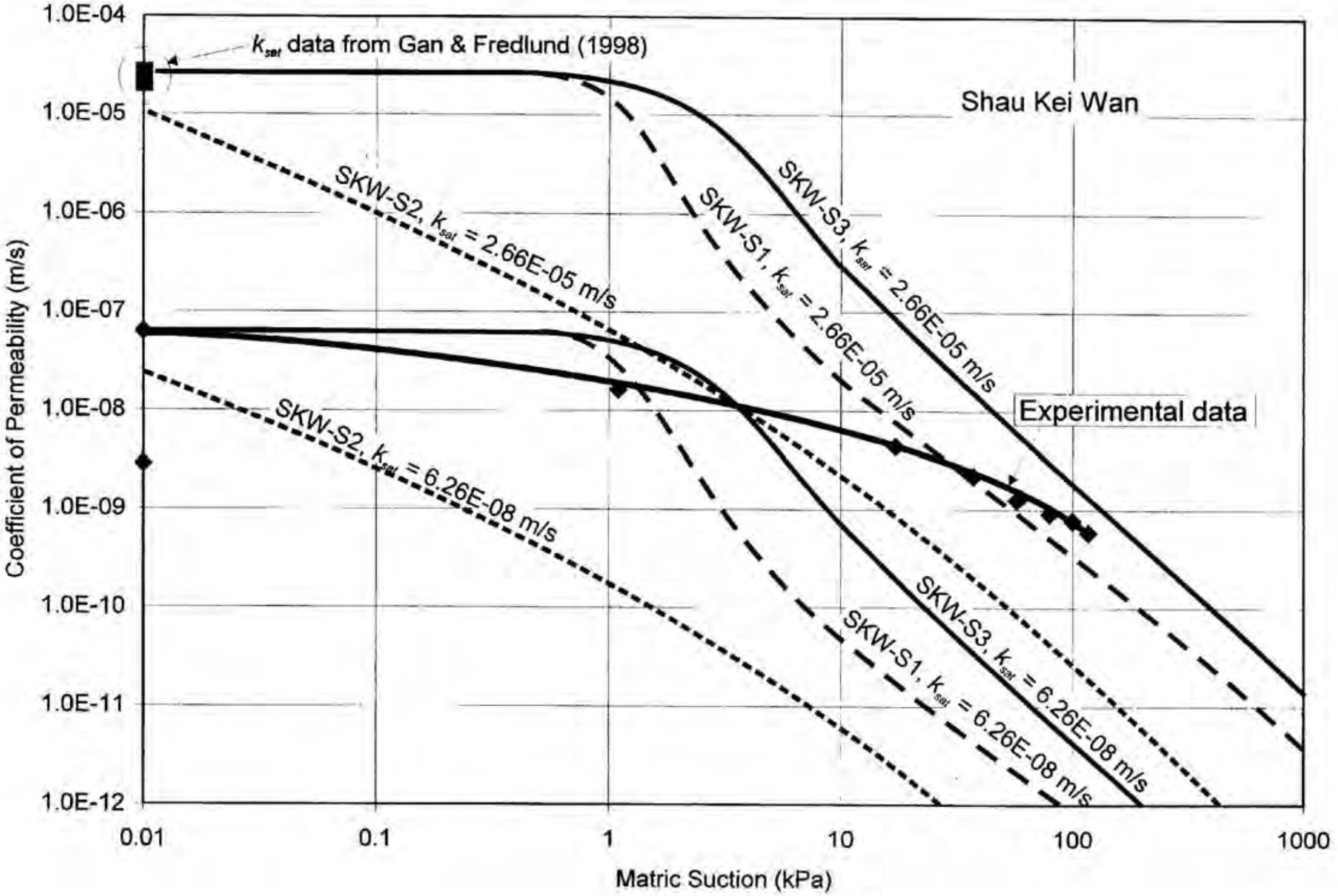

Figure 58 - Comparison of the experimental permeability function with permeability functions generated from soil-water characteristic curves, for soil specimens from Shau Kei Wan

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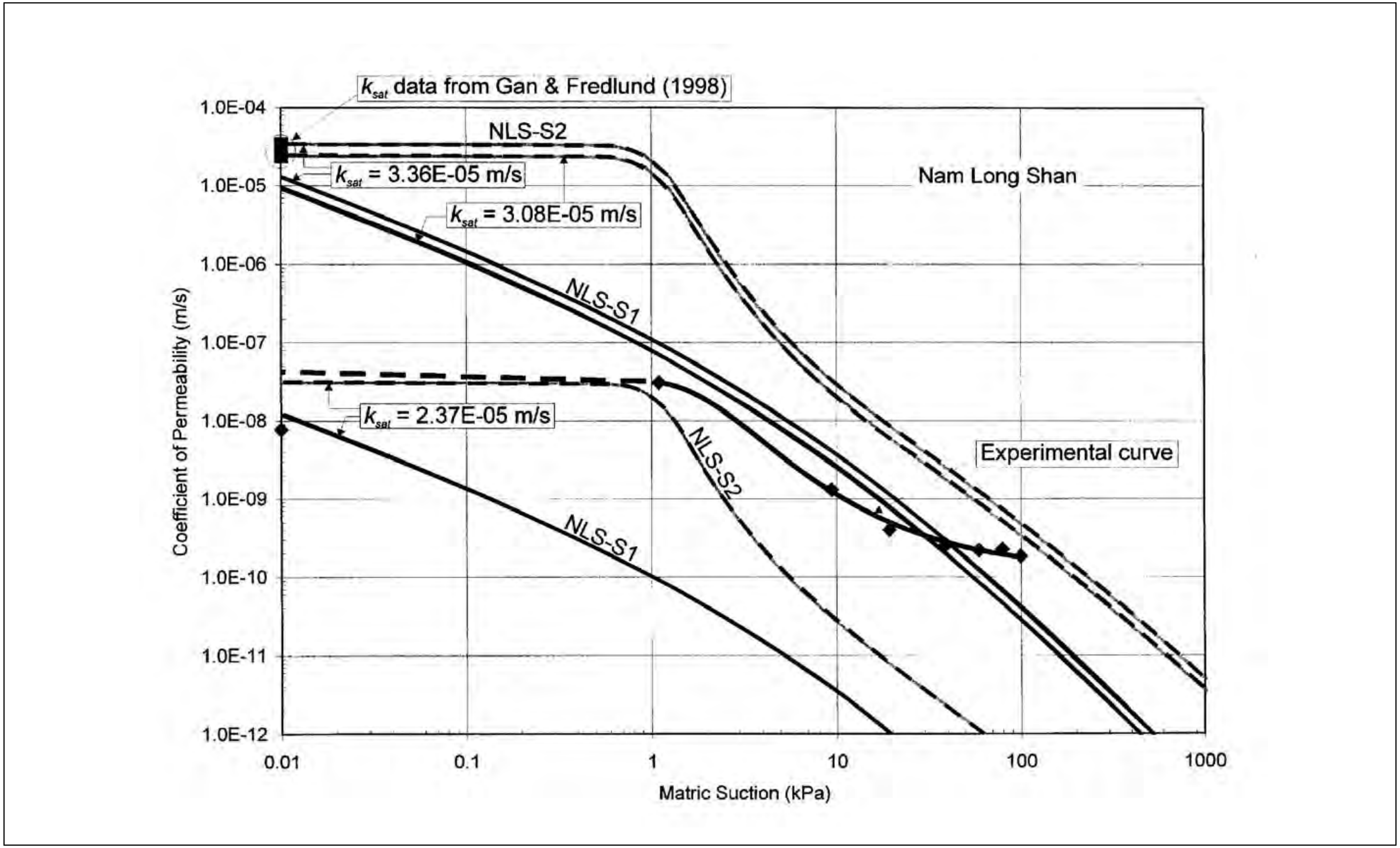

Figure 59 - Comparison of the experimental permeability function with permeability functions generated from soil-water characteristic curves, for soil specimens from Nam Long Shan

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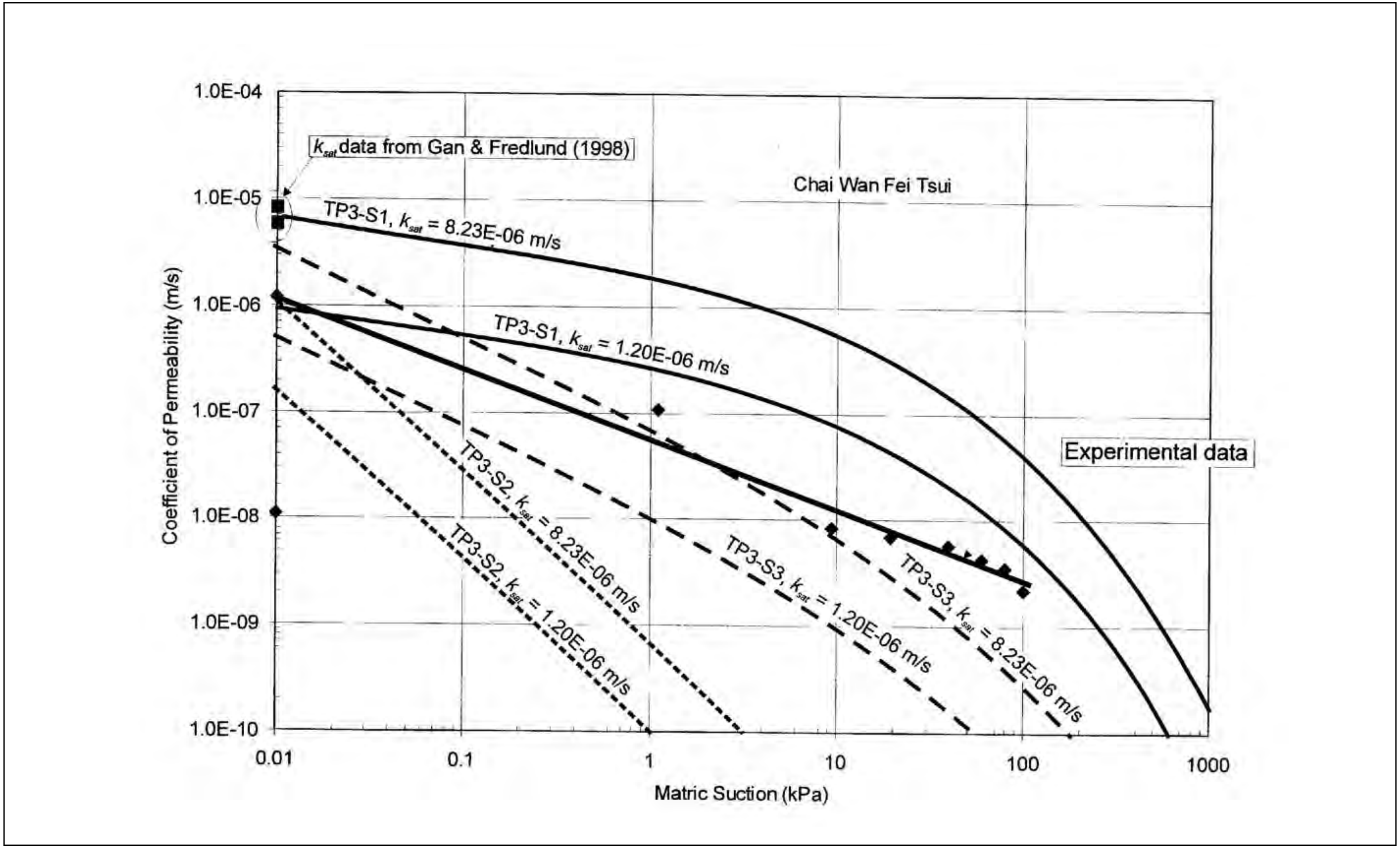

Figure 60 - Comparison of the experimental permeability function with permeability functions generated from soil-water characteristic curves, for soil specimens from Chai Wan Fei Tsui

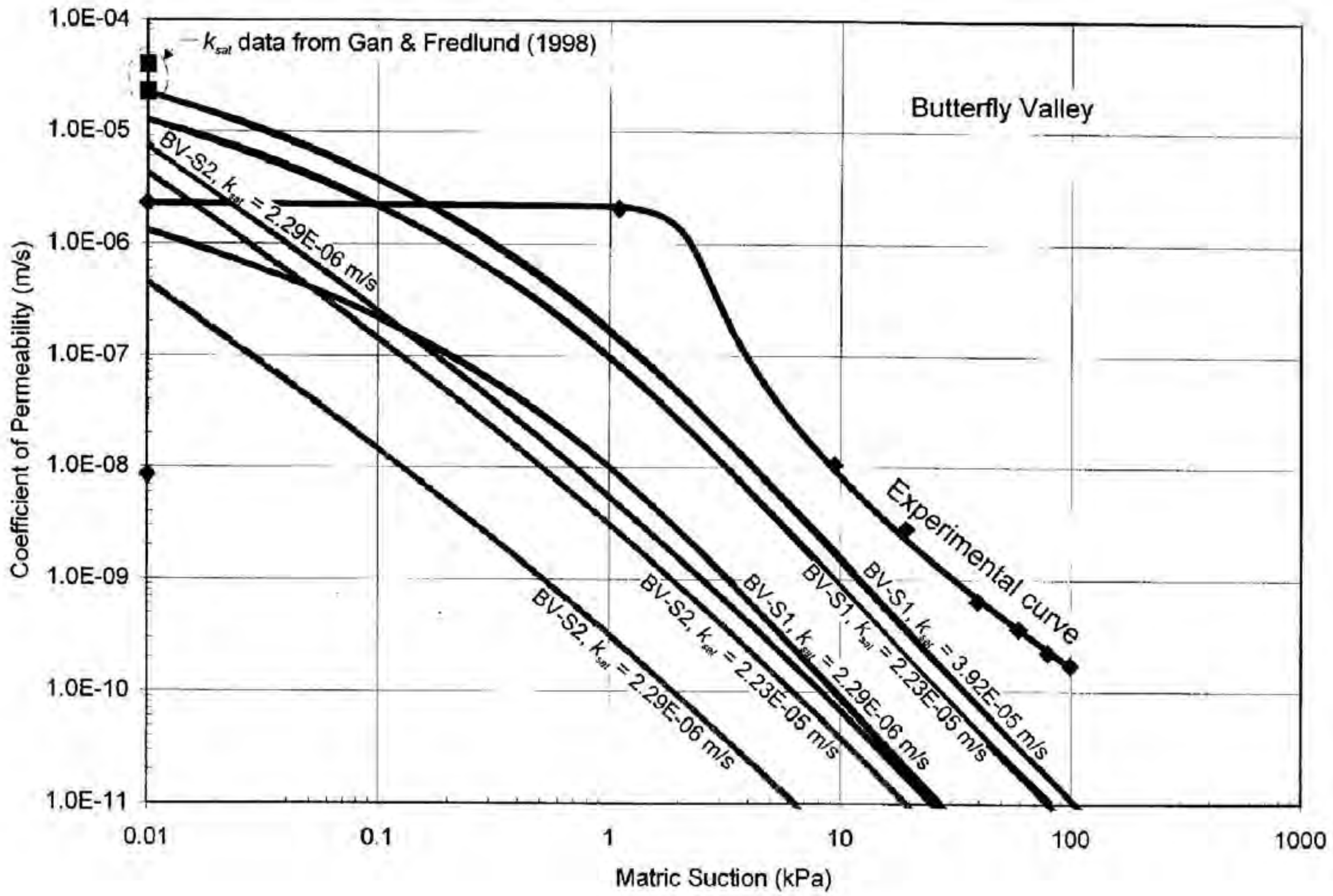

Figure 61 - Comparison of the experimental permeability function with permeability functions generated from soil-water characteristic curves, for soil specimens from Butterfly Valley

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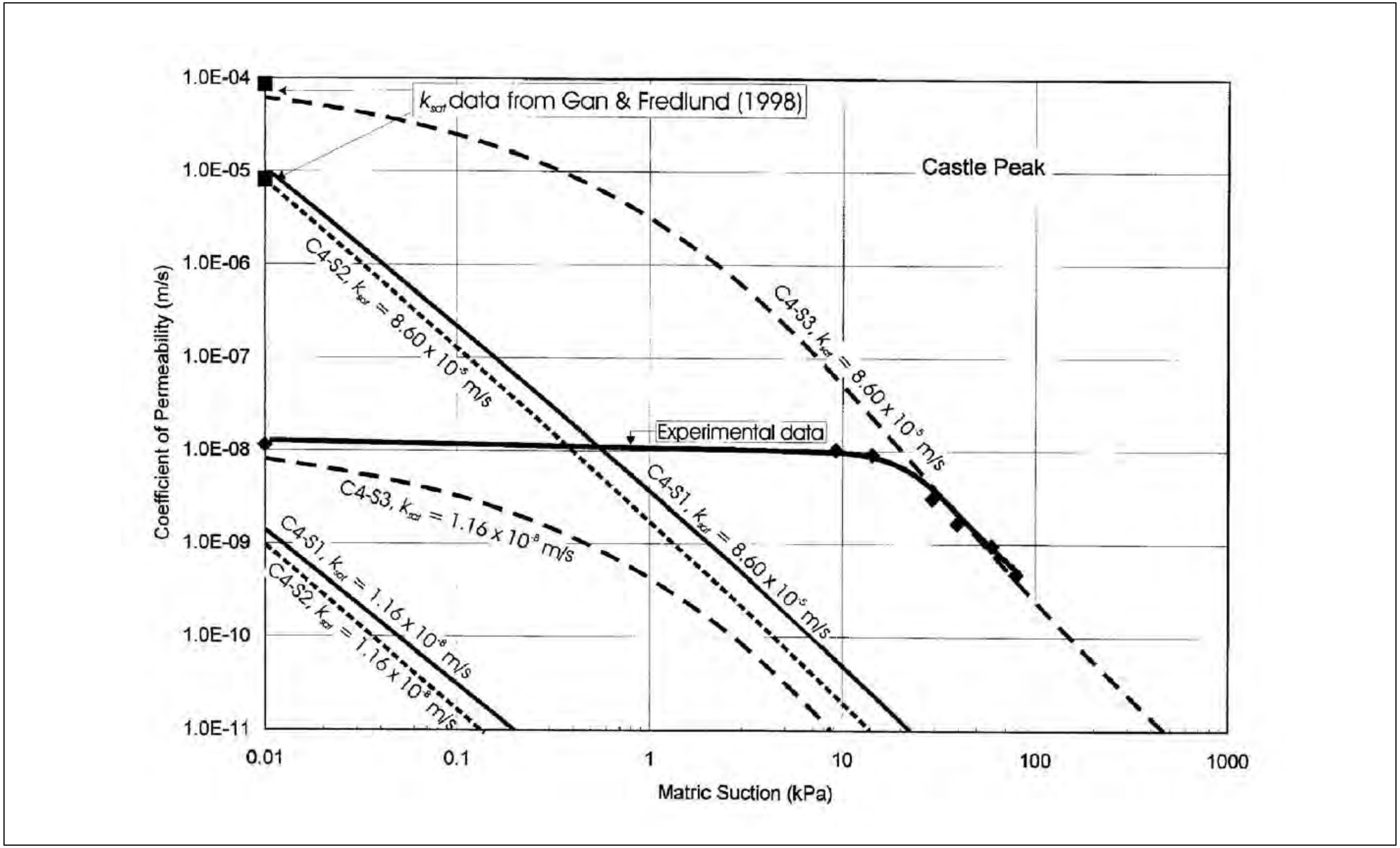

Figure 62 - Comparison of the experimental permeability function with permeability functions generated from soil-water characteristic curves, for soil specimens from Castle Peak

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A selected list of major GEO publications is given in the next page. An up-to-date full list of GEO publications can be found at the CEDD Website http://www.cedd.gov.hk on the Internet under "Publications". Abstracts for the documents can also be found at the same website. Technical Guidance Notes are published on the CEDD Website from time to time to provide updates to GEO publications prior to their next revision.

部份土力工程處的主要刊物目錄刊載於下頁。而詳盡及最新的土力工程處刊物目錄，則登載於土木工程拓展署的互聯網網頁http://www.cedd.gov.hk 的"刊物"版面之內。刊物的摘要及更新刊物內容的工程技術指引，亦可在這個網址找到。

Copies of GEO publications (except maps and other publications which are free of charge) can be purchased either by:

writing to
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or
- Calling the Publications Sales Section of Information Services Department (ISD) at (852) 2537 1910
- Visiting the online Government Bookstore at http://bookstore.esdlife.com
- Downloading the order form from the ISD website at http://www.isd.gov.hk and submit the order online or by fax to (852) 2523 7195
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或
- 致電政府新聞處刊物銷售小組訂購 (電話：(852) 2537 1910)
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1:100 000, 1:20 000 and 1:5 000 maps can be purchased from:

Map Publications Centre/HK,
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Requests for copies of Geological Survey Sheet Reports, publications and maps which are free of charge should be sent to:

For Geological Survey Sheet Reports and maps which are free of charge:
Chief Geotechnical Engineer/Planning,
(Attn: Hong Kong Geological Survey Section)
Geotechnical Engineering Office,
Civil Engineering and Development Department,
Civil Engineering and Development Building,
101 Princess Margaret Road,
Homantin, Kowloon, Hong Kong.
Tel: (852) 2762 5380
Fax: (852) 2714 0247
E-mail: jsewell@cedd.gov.hk

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Civil Engineering and Development Department,
Civil Engineering and Development Building,
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MAJOR GEOTECHNICAL ENGINEERING OFFICE PUBLICATIONS
土力工程處之主要刊物

GEOTECHNICAL MANUALS

Geotechnical Manual for Slopes, 2nd Edition (1984), 300 p. (English Version), (Reprinted, 2000).

斜坡岩土工程手冊(1998)，308頁(1984年英文版的中文譯本)。

Highway Slope Manual (2000), 114 p.

GEOGUIDES

Geoguide 1	Guide to Retaining Wall Design, 2nd Edition (1993), 258 p. (Reprinted, 2000).
Geoguide 2	Guide to Site Investigation (1987), 359 p. (Reprinted, 2000).
Geoguide 3	Guide to Rock and Soil Descriptions (1988), 186 p. (Reprinted, 2000).
Geoguide 4	Guide to Cavern Engineering (1992), 148 p. (Reprinted, 1998).
Geoguide 5	Guide to Slope Maintenance, 3rd Edition (2003), 132 p. (English Version).
岩土指南第五冊	斜坡維修指南，第三版(2003)，120頁(中文版)。
Geoguide 6	Guide to Reinforced Fill Structure and Slope Design (2002), 236 p.

GEOSPECS

Geospec 1	Model Specification for Prestressed Ground Anchors, 2nd Edition (1989), 164 p. (Reprinted, 1997).
Geospec 3	Model Specification for Soil Testing (2001), 340 p.

GEO PUBLICATIONS

GCO Publication No. 1/90	Review of Design Methods for Excavations (1990), 187 p. (Reprinted, 2002).
GEO Publication No. 1/93	Review of Granular and Geotextile Filters (1993), 141 p.
GEO Publication No. 1/2000	Technical Guidelines on Landscape Treatment and Bio-engineering for Man-made Slopes and Retaining Walls (2000), 146 p.
GEO Publication No. 1/2006	Foundation Design and Construction (2006), 376 p.

GEOLOGICAL PUBLICATIONS

The Quaternary Geology of Hong Kong, by J.A. Fyfe, R. Shaw, S.D.G. Campbell, K.W. Lai & P.A. Kirk (2000), 210 p. plus 6 maps.

The Pre-Quaternary Geology of Hong Kong, by R.J. Sewell, S.D.G. Campbell, C.J.N. Fletcher, K.W. Lai & P.A. Kirk (2000), 181 p. plus 4 maps.

TECHNICAL GUIDANCE NOTES

TGN 1	Technical Guidance Documents