COMPARATIVE STUDY OF SOIL SAMPLES FOR QUICK CONSOLIDATION AND NORMAL CONSOLIDATION

RESEARCH REPORT

REPORT NO. RES-3 (2002)

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RIVER RESEARCH INSTITUTE, FARIDPUR

Ministry of Water Resources
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PREFACE

Bangladesh forms a major portions of Bengal basin. The landscape of Bangladesh is mainly monotonous flat plain. From geological point of view, most of Bangladesh is an extremely flat delta which consists of a large alluvial basin floored primarily with quaternary sediments deposited by the Ganges and Brahmaputra rivers and their numerous associated streams and distributaries. The soils of Bangladesh comprised of alluvial deposit varying from gravel to fine grained soil material , the stratified arrangement of soil materials mainly depends on the fluctuation of the stream velocity. Thus in the upper region of Bangladesh the soil is a mixture of coarse and fine grained soils like boulders, gravels, sand and silt and clay and in the lower region is obviously a deposit of fine grained soils like sand, silt and clay. For construction of structure, investigation of soil character is very important. There are various tests for determination of different parameters of soil according to soil types. The settlement characteristics is the one of most important parameter of soil and it is mainly determined by consolidation test. It is very time consuming test. It needs about 8 days to carry out this test. So for reduction of testing time River Research Institute (RRI) takes up a research program to establish quick consolidation method.

The objective of the research program was to find out co-factor of compression index of different soil types of Bangladesh comparing the results obtained in normal and quick consolidation tests.

The research study for quick consolidation test method may assist to calculate settlement characteristics of soil by conducting the quick consolidation test, which may expedite the design works as well as development works of the country like ours.

The services given by RRI staff and officers concerned are gratefully acknowledged. Sincere thanks to all who have helped directly or indirectly in connection with this research project. Special thanks to Bangladesh (BWDB) for supplying soil samples.

27/6/02

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ACKNOWLEDGEMENT

The team members of this applied research project like to express their heartfelt gratitude to Engr. Syed Abdus Sobhan, Derector General, River Research Institute, Faridpur and Md. Hanif Mazumder, Director of Geotechnical Research Directorate, River Research Institute, Faridpur for his valuable advice to perform the quick consolidation test and co-operation and support all the time. The members also thanks to BWDB personnel who were directly involved in the soil sampling. The members would like to gratefully acknowledge all the technician's who were directly engaged for conduct the laboratory consolidation test and its relevant tests.

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CHAPTER ONE

1. INTRODUCTION

1.1 BACKGROUND

Bangladesh is a developing country and so many construction works on going. As a reverine country the extensive flood plain of these rivers and their numerous tributaries and distributaries is the main physiographic phenomena of these alluvial rivers (H.Mazumder et al. 2000).

As a result of devastating flood many water control structures like embankments, regulators, dykes, culverts etc. are destroyed and the phenomena of the bank erosion became a universal process for flooding. Hundreds of thousands of people became homeless and multicast national projects became threatened almost every year due to bank erosion (F.Karim et al. 1998). Therefore it is necessary to undertaken the national projects from reconstruction of the water control structure and same cases new structure is to be constructed for the preventive measurement of flood.

Bangladesh is a densely populated country and all of work place is situated in the urban places. In urban area for accommodation of large number of population in small space ,construction projects of multistoried building has been undertaken.

For the construction works in different types of projects, various engineering parameters of soil are determined of which consolidation parameter of soil is an important factor which have a significant effect on the vertical stress concentration on the column and on the settlement reduction of the foundation soil (Juran and A. Guermaz, 1988).

As consolidation test of soil is so much important for construction works but the testing technique is time consuming so reduction of time consumption of the test, this research project had been undertaken.

2.2 INTRODUCTION

Consolidation behaviour of soil deposits requires knowledge of the field condition as well as the compressibility and permeability characteristics of the material. These characteristics are usually presented in the form of void ratio- effective stress and void ratio- permeability relationships, which are obtained experimentally (Jin-Chun Liu et. al 1991)

Testing techniques and analysis procedure for consolidation characteristics of soil have been discussed. The test is carried out by applying a sequence of some four to eight vertical loads to a laterally confined specimen having a height of about one quarter of its diameter. The vertical compression under each load is observed over a period of time usually up to 24 hours. Since, no lateral deformation is allowed it is a one dimensional test from which the one dimensional consolidation parameters are derived (K H Head, 1982).

The consolidation of a soil deposit can be divided into three (3) stages :

- Initial consolidation
- Primary consolidation
- Secondary consolidation

Initial consolidation : The reduction in volume of the soil just after the application of the load is known as initial consolidation or initial compression. (K.R.Arora, 1992)

Primary consolidation : The reduction in volume due to outflow of water from the soil pores under applied load and is generally refered to as primary consolidation. (A.M. Zohural Islam and P.K. Roy 1991).

Secondary consolidation : The reduction in volume continues at a very slow rate even after the excess hydrostatic pressure developed by the applied pressure is fully dissipated and the primary consolidation is complete. This additional reduction in the volume is called secondary consolidation.

In most inorganic soils, it is generally small. (K.R.Arora, 1992). Secondary compression effects are often disregarded for inorganic clays, in which primary consolidation phase is responsible for the majority of settlement. (K.H. Head, 1982)

Settlements in sands and gravels take place in a short time, usually as construction proceeds and these rarely cause major problems. But in clay soils, because of their low permeability, settlements can take place over much longer periods-months, years, decades, even centuries, after completion of construction. Estimates of the rate of settlement, and of the time within which settlement will be virtually complete, are therefore important factors in foundation design. (K.H.Head, 1982)

The consolidation of the soft soil has a significant effect on the vertical stress concentration on the column and on the settlement reduction of the foundation soil, which are measured by the consolidation test. (Juran and Guermaz,1988).

If the primary stage has clearly been completed by the time 100 min has been reached, it would be feasible to apply a second increment almost immediately instead of having to wait for 24 hours. It may even be possible to complete several increments within one day. (K .H. Head,1982). From this point of view, the time for settlement (deformation) for each load has been considered 100 minutes.

1.3 OBJECTIVE OF THE STUDY

The objective of the study were :

- To conduct quick consolidation test and normal consolidation test of the same undisturbed soil sample (visually same)
- To assume 100 minutes for each load increment in quick consolidation tests for reduction of time consumption
- To compare the test results of quick consolidation with normal consolidation and find out the co-factor of compression index for quick consolidation test.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Geological Background

Bangladesh forms a major portion of Bengal basin. Being located close to one of the world's major subjection fault in the north and a major transform fault in the east, the Bengal basin and its adjacent area from one of the most active tectonic regions of the world. Structural activity Primary faulting has significantly influenced the quaternary geology (Morgan, 1954).

The landscape of Bangladesh is mainly monotonous flat plain. From geological point of view, most of Bangladesh is an extremely flat delta which consists of a large alluvial basin floored primarily with Quaternary sediments deposited by the Ganges and Brahmaputra rivers and theirs numerous associated streams and distributaries (Morgan and McIntire, 1959). The three major physiographic units namely Hill formations of Sylhet in the north-east and of Chittagong Hill tracts in the south-east, uplifted Pleistocene Terraces and recent flood-plain and piedmont alluvium, which occupies roughly seventy percent of the total land area of Bangladesh (Hunt, 1976). The recent floodplain deposits are again differentiated into meander flood-plain deposits, depending on the environmental conditions that existed at the time of deposition.

The quaternary sediments of the country have different characteristics, ranging from piedmont deposits near the northern and eastern borders deposits in southern districts near the southern sea-shore. The major locations of the older alluvial deposits are the north of the Ganges-Padma river system. Barind Tract, Madhupur Tract and Lalmai Hills are the major areas of such deposits. They are not subject to normal seasonal flooding (M, Serajuddin,1998).

The main streams or rivers which still carrying on this process are the Ganges, the Brahmaputra, the Meghna, the Teesta, the Gumti etc. As the soils of Bangladesh comprised of alluvial deposit varying from gravel to fine grained soil material, the stratified arrangement of soil materials mainly depends on the fluctuation of the stream velocity. Thus in the upper region of Bangladesh the soil is a mixture of coarse and fine grained soils like boulders, gravels, sand and silt and clay and in the lower region is obviously a deposit of fine grained soils like sand, silt and clay. In the western region of the country the soils mainly consists of sand, silt and clay deposits (A.M. Zahural Islam and P.K. Roy, 1991).

From engineering point of view, the classification of ingredients of constituents of soil is at utmost importance. Because different types of soil contain different ingredients in varying amount for which its properties varies. (Jahan, 1996)

On the basis of geological formation of soil of Bangladesh, Safiullah, Professor BUET described the soils of Bangladesh with their general characteristics which are given below.

Characteristics of Bangladeshi Soil (Safiullah, 1994)

Soil Type	General characteristics
Hill Soils	Variable soil types which are function of underlying geology. Frequently sandy clays and clays grade into disintegrated rock at shallow depths.
Raised alluvial terrace deposits	Comprises relatively homogeneous clay known as Modhupur clay and Barind clay. (LL=30-40%; Ip= 12-50%). Variable depth underlain by fine to medium uniformly graded sand.
Himalayan piedmont deposits	Mainly sandy silt in higher areas and silty clays in basin areas but often underlying fine sands at shallow depth
Alluvial flood plain deposits	Locally variable but in general silts and silty clays. Silt size predominant. (LL=20-50%, Ip= 4-30%). Fine sands abound at depths and close to rivers. Contain mica.
Depression deposits	In the south alternating organic clay deposits overlying clay at depth. Elsewhere, predominantly silty clays and clays, (LL=30-40%, Ip=10-16%).
Estuarine and flood plain deposits	Generally silt and silty clays. Acid sulfate soils found near coast. Organic soils close to surface in some places. Widely varies in consistency and water content.

Where, LL= Liquid limit, Ip= Plasticity Index (H, Mazumder et al. 2000).

2.2 Physical properties of Bangladeshi soils

Colors of the soils usually range from light grey to dark grey and (often) black, from light brown to brown or tan, or reddish and occasionally a combination of them. Light grey to dark grey soils are more frequently obtained than those of other colors. Soils with bluish and greenish colors were also encountered sometimes (M. Serajuddin, 1998).

2.3 Some engineering properties of soils relate to consolidation parameter

The compression index is related to its index properties, especially the liquid limit. Terzaghi and Peck gave the following empirical relationship for clays of low to medium sensitivity ($S_t \leq 4$)

$$C_c = 0.009\,(w_L - 10) \text{ ----- For undisturbed soils}$$

$$C_c = 0.007\,(w_L - 10) \text{ ----- For remolded soils}$$

Where, w_L = Liquid limit (%)

The compression index is also related to the in situ void ratio e_0 or water content w_o,

$$C_c = 0.54(e_0 - 0.35)$$

$$C_c = 0.0054(2.6w_0 - 35)$$

(K.R.Arora, 1992)

The compression index (C_c) of compressible clays and silts has some empirical relations with liquid limit (w_L) , initial void ratio (e_0) and natural water content (w_N). Serajuddin and Ahmed (1967) connected C_c with w_L and e_0 of a large number of undisterbed plastic silt and clay soil samples of different areas of Bangladesh and obtained the following empirical equations :

$$C_c = 0.0078(w_L - 14\%)$$

$$C_c = 0.44(e_0 - 0.30)$$

A general survey by Serajuddin (1964 and 1969) of the engineering aspects of soils of Bangladesh coastal embankment area has suggested the following two relationships for Cc with e_0 and w_N for fine grained soil of the project area:

$$C_c = 0.50(e_0 - 0.50)$$

$$C_c = 0.0135(w_N - 20\%)$$

Another correlation study (Serajuddin and Ahmed, 1982) with additional test data from cohesive fine grained soils occurring within about 7m from the ground surface of the different areas of the country suggested the relationship :

$$C_c = 0.047(e_0 - 0.46)$$

with a correlation coefficient of a 0.72 (M. Serajuddin)

The usual range of values of the co-efficient of consolidation (C_v) obtained from laboratory consolidation tests is indicated in Table-1, together with values of compression index (C_c).

Table-1 : Typical range of values of co-efficient of consolidation and compression index for inorganic soils

Soil type	Plasticity index (range)	Coefficient of consolidation $C_v(m^2 / year)$		Compression index C_c
		undisturbed	remolded	
Clays-montmorillonite high plasticity	greater than 25	0.1-1	About 25-50% of undisturbed values	upto 2.6
medium plasticity	25-5	1-10		
low plasticity	15 or less	10-100		
Silts		above 100		

(K.H.Head, 1982)

CHAPTER THREE

3. METHODOLOGY

3.1 Soil Specimen Test

For determination of C_c value ,quick consolidation test and normal consolidation test has been performed for same undisturbed soil samples (visually same) of different location of Bangladesh.The undisturbed soil samples were received from Bangladesh Water Development Board (BWDB) collected in connection with different project of BWDB.

The sample is trimmed to fit a cylindrical container and is loaded up to 24 hours interval for each load increment for laboratory normal consolidation test and loaded up to 100 minutes in case of quick consolidation test for each load increment. For a given load increment, deformation reading has been taken from the respective dial gauge for different time intervals.

3.2 Method of Data Analysis

Dial reading vs. log time has been plotted for each load increments and find the deformation (D_0, D_{100}, D_{50}) and the corresponding t_{50} which has been shown in Fig-1 (for clay soil). In case of silt samples, as it is difficult to evaluate the D_0 point from the log-time plot, so the settlement is plotted against square root of time in minutes which has been shown in Fig-2.

Consolidation parameters like void ratio, natural moisture content, liquid limit, plastic limit, specific gravity has been determined which has been shown in the tabular form in Table-3. Void ratio and co-efficient of consolidation (C_v) versus log pressure for the loading and unloading stages for both quick and normal consolidation has been shown in Fig–3 to Fig-11.

The compression index C_C is determined from the tangent of the slope at the void ratio versus log- pressure curve by using following equation,

Where,

$$C_c = - e / \log p/p_0 = e / \log \overline{\sigma}/\overline{\sigma_0}$$

Where,

$\overline{\sigma_0}$= initial effective stress

$\overline{\sigma}$= final effective stress

Δe= change in void ratio

By determining the value of C_c for both quick and normal consolidation test, a co-factor has been find out for quick consolidation test . The parameter related to consolidation tests and concerned parameter ranges have been shown in Table-2 and Table-3 respectively. The comparison of C_c and C_v values for different soil types obtained in quick consolidation and normal consolidation test has been shown graphically in Fig- 13.

CHAPTER FOUR

4. DISCUSSIONS OF RESULTS

The undisturbed soil sample, which has been tested in the laboratory by two methods namely, normal consolidation test and quick consolidation test. After conducting the test it has been observed that ingredients of soil are not homogeneous which has been shown in Table –2. According to ingredients of tested samples the soil has been classified in four categories. These are as follows :

- Very soft to medium stiff CLAY mixed with varying amount of fine sand and plasticity varies from medium plastic to high plastic.
- Very soft to soft CLAY mixed with trace to little organic and fine sand and plasticity is high plastic.
- Very soft ORGANIC CLAY mixed with trace fine sand and plasticity is medium to high plastic.
- Soft SILT mixed with trace fine sand and compressibility is medium compress.

The four categories soil samples and the range of consolidation parameters has been shown in the tabular form in Table-3 and compression index versus soil types for both normal and quick consolidation test has been shown in bar graph in Fig-12.

From graphical presentation of time settlement curve, it has been found that primary consolidation of soil for quick consolidation reach as a sequence as normal consolidation test which has been shown in fig-1 & 2. Only for time reduction of load increment, the deformation reading has been varied from normal consolidation test as well as void ratio and compression index. As a result the value of compression index has been changed from normal consolidation test results.

It has been found from Fig-13 that the co-factor of compression index Cc has slightly varied and it is due to soil types, stiffness and for ingredients of soil. Natural moisture content and plasticity of soil are also responsible for the variation of compression index and it is due to field condition i,e ground water level.

Table-2 : Soil type and test results of natural moisture content, liquid limit, plasticity index, specific gravity and compression index

Soil type	Av. N.M.C in %	LL in %	PI in %	Sp. Gr.	Nomal consolidation test		Quick consolidation test	
					Initial .N.M.C in %	C_c	Initial N.M.C in %	C_c
Soft CLAY trace org. trace fine sand H.P	54.54	60	30	2.668	54.53	0.496	54.46	0.440
Ver soft CLAY trace org. trace fine sand H.P	59.61	61	31	2.667	56.91	0.423	58.19	0.447
Soft CLAY trace org. trace fine sand H.P	43.24	56	29	2.672	43.70	0.337	43.63	0.314
Soft CLAY trace fine sand H.P	43.47	58	29	2.678	43.06	0.395	42.70	0.375
Very soft CLAY trace organic trace fine sand H.P	53.12	60	30	2.669	54.08	0.515	54.47	0.495
-Do_	52.56	55	28	2.671	48.8	.352	46.8	0.312
Soft CLAY trace fine sand H.P	50.82	56	29	2.676	47.60	0.354	44.50	0.313
-Do-	46.71	63	33	2.682	47.44	0.356	48.34	0.372
Very soft CLAY trace fine sand M.P	40.54	45	20	2.678	44.98	0.346	40.66	0.422
Very soft CLAY little organic little fine sand H.P	46.11	59	31	2.5616	52.8	0.544	44.39	0.348
Very soft CLAY little organic trace fine sand H.P	56.11	64	30	2.569	71.91	0.484	54.36	0.686
Very soft ORGANIC CLAY trace fine sand M. to H.P	46.36	86	45	2.556	61.13	0.619	62.60	0.590
Soft CLAY trace organic trace fine sand H.P	46.72	55	27	2.644	40.99	0.330	37.26	0.280
Soft CLAY trace fine sand H.P	61.02	64	32	2.609	55.5	0.520	56.65	0.547
Very soft ORGANIC CLAY trace fine sand M. to H.P	80.48	85	42	2.531	66.91	0.563	79.31	0.697
Very soft ORGANIC CLAY trace fine sand M. to H.P	65.23	77	40	2.557	51.07	0.375	57.53	0.365
Very soft CLAY trace fine sand H.P	51.97	58	29	2.585	50.55	0.300	51.89	0.295
-Do-	51.53	59	29	2.578		0.508	51.58	0.401
Soft SILT trace fine sand M.C	43.42	42	16	2.674	38.12	0.260	38.86	0.25
-Do-	23.45	40	13	2.671	37.40	0.235	36.50	0.245
Very soft CLAY trace fine sand H.P	47.2	69	31	2.6332	45.52	0.394	47.53	0.337
Soft CLAY trace fine sand H.P	44.56	55	29	2.5616	46.09	0.390	47.64	0.402
Soft CLAY some fine sand M.P	34.42	43	21	2.6435	30.79	0.261	32.71	0.257
Medium stiff FINE SAND AND CLAY M.P	26.37	40	19	2.6378	37.61	0.385	36.85	0.384
Soft CLAY trace fine sand H.P	41.53	54	28	2.5665	25.76	0.160	25.91	0.130
Soft CLAY some fine sand M.P	44.81	45	22	2.5608	42	0.425	43.92	0.395

Notations used in the Table-2

N.M.C = Natural moisture content
LL = Liquid limit
PI = Plasticity index
Sp.Gr. = Specific gravity
C_c = Compression index
H.P. =High plastic
M. to H. P = Medium to high plasticity
M.C. = Medium compress
M..P = Medium plasticity

Table-3 : **Range of consolidation parameters and co-factor according to soil types**

Soil type	Sp.Gr.	Av. M.C in %	LL in %	PI in %	Normal Test			Quick Test			Co-factor C_f
					N.M.C in %	initial void ratio	Cc	N.M.C in %	initial void ratio	Cc	
Very soft to medium stiff CLAY mixed with trace fine sand and plasticity varies from medium to high plastic	2.5608-2.682	26-55	40-64	19-32	26-52	0.8935-1.4514	0.16-0.520	26-57	0.6316-1.6961	0.13-0.547	0.819-1.231
Very soft to soft CLAY mixed with trace to little organic and fine sand and plasticity is high plastic	2.561-2.672	39-63	55-64	27-31	41-72	0.6832-2.0057	0.330-0.544	37-54	1.0064-1.4925	0.280-0.686	0.820-1.563
Very soft to soft ORGANIC CLAY mixed with trace fine sand and plasticity is medium to high plastic	2.531-2.557	55-73	77-86	40-45	51-67	1.3294-1.7071	0.563-0.619	58-79	1.0600-2.1370	0.590-0.697	0.808-1.049
Soft SILT mixed wtih trace fine sand and compressibility is medium compress	2.671-2.674	37-39	40-42	13-16	37-38	1.0661-1.1.48	0.235-0.26	37-39	1.076	0.245-0.25	0.959-1.04

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

- The ingredients of soil greatly influence the soil parameter as well as consolidation parameter.
- The quick consolidation prediction method may be used to calculate settlement at various sites of construction by determining the compression index Cc from quick consolidation test multiplied by co-factor (obtained from this study), which may expedite the design works as well as development works of the country.
- Naturally soil strata and ingredient is not homogeneous. So, further study is recommended for remolded soil samples.

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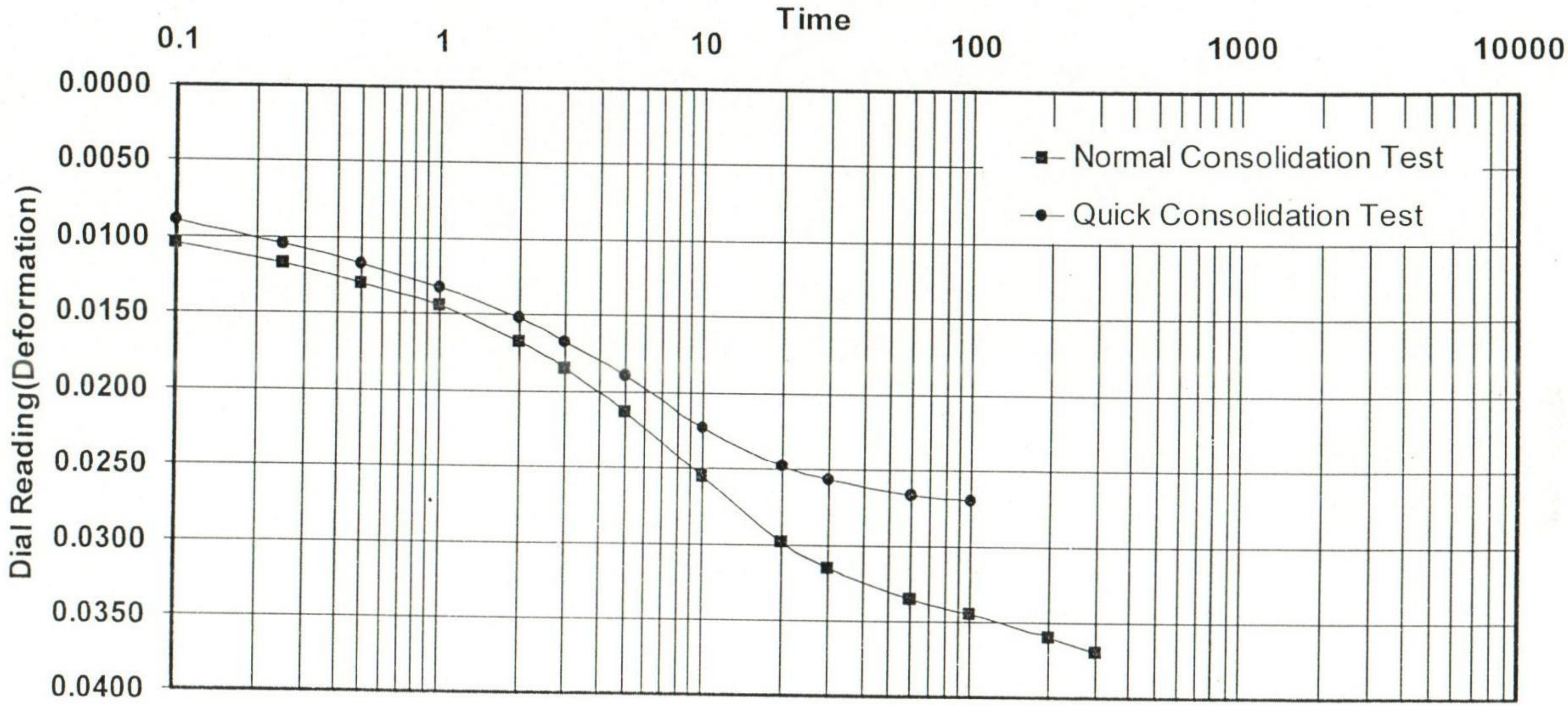

Fig.: 1 Time-Deformation Curve (Clay Soil)

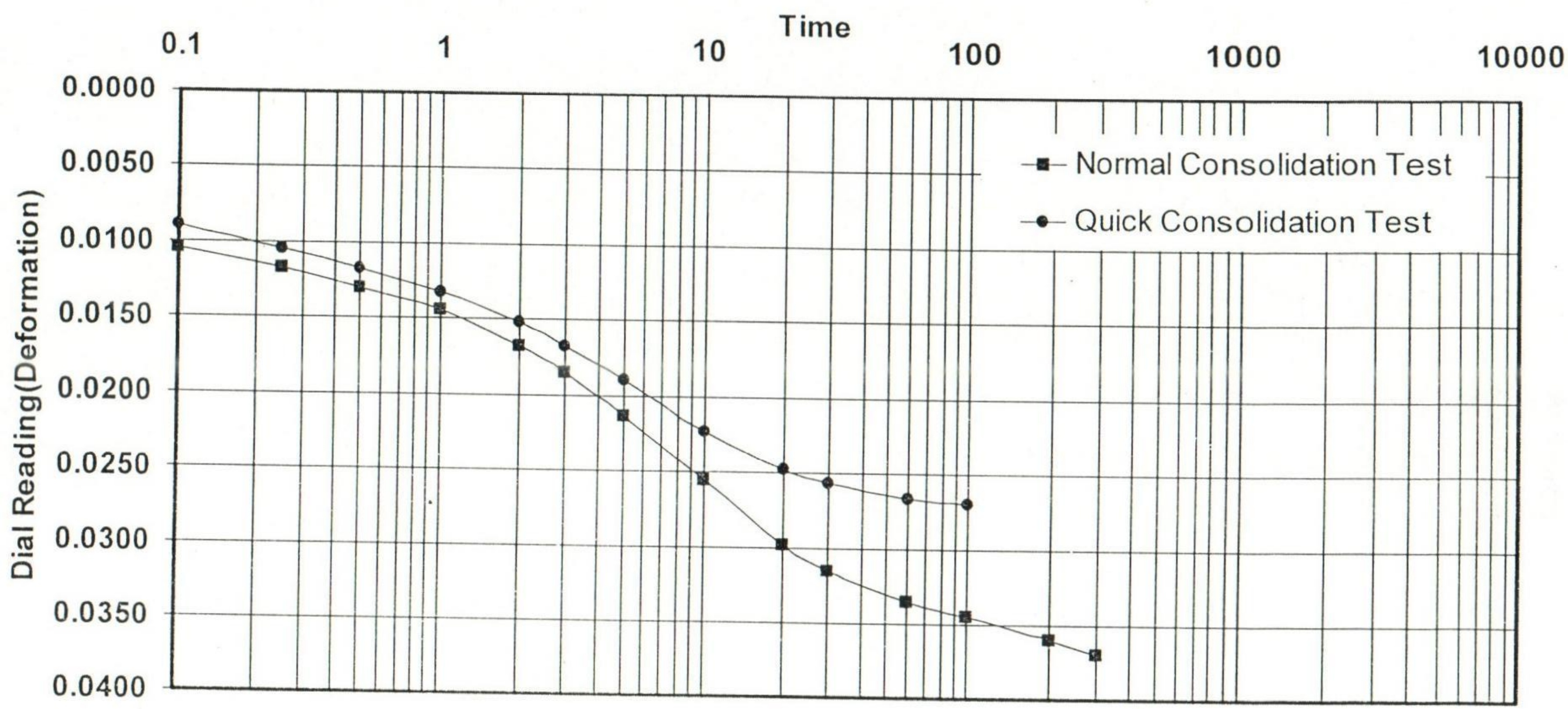

Fig.: 1 Time-Deformation Curve (Clay Soil)

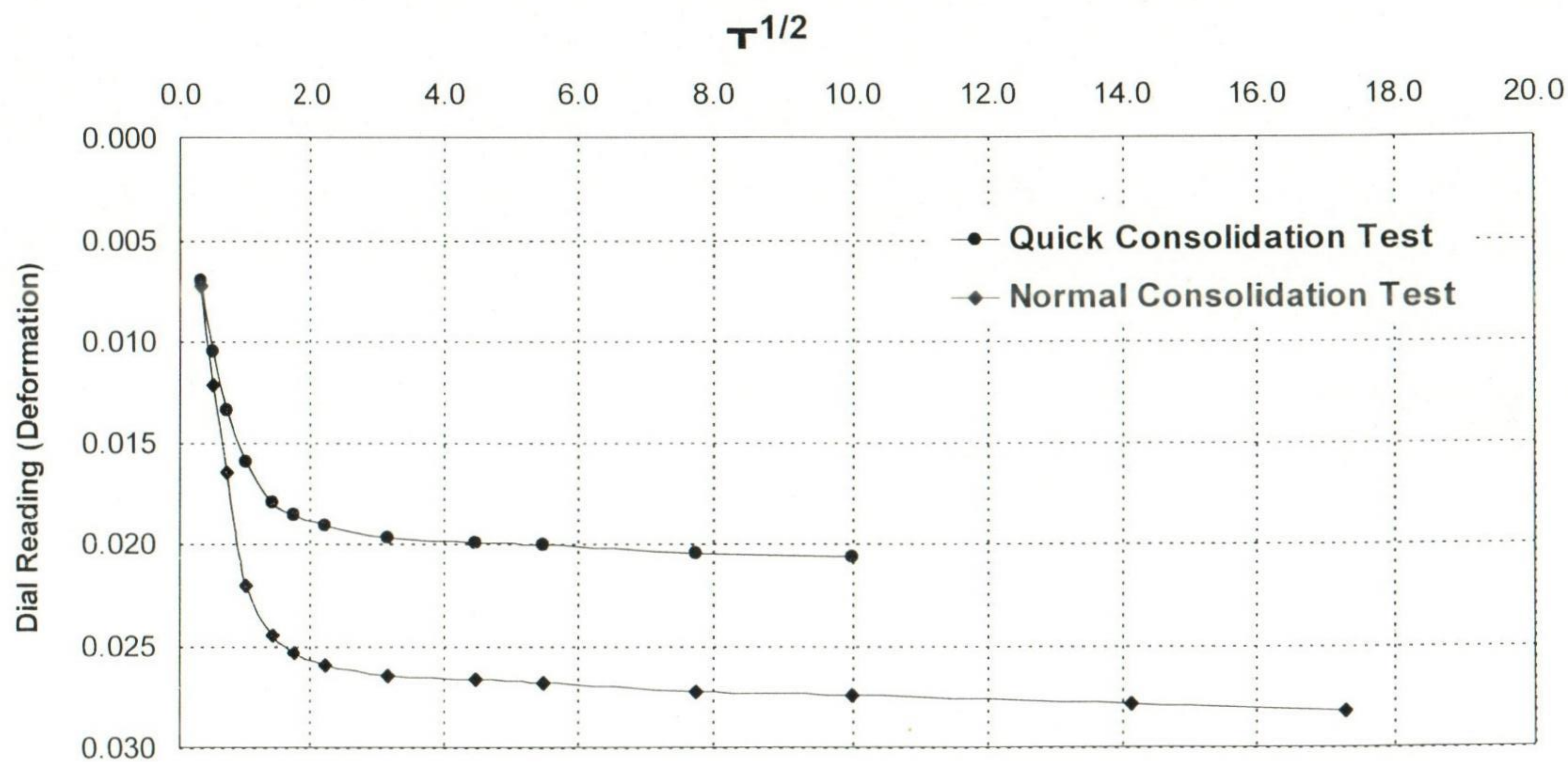

Fig.: 2 Square root time VS Deformation Curve (Silty Soil)

CONSOLIDATION TEST

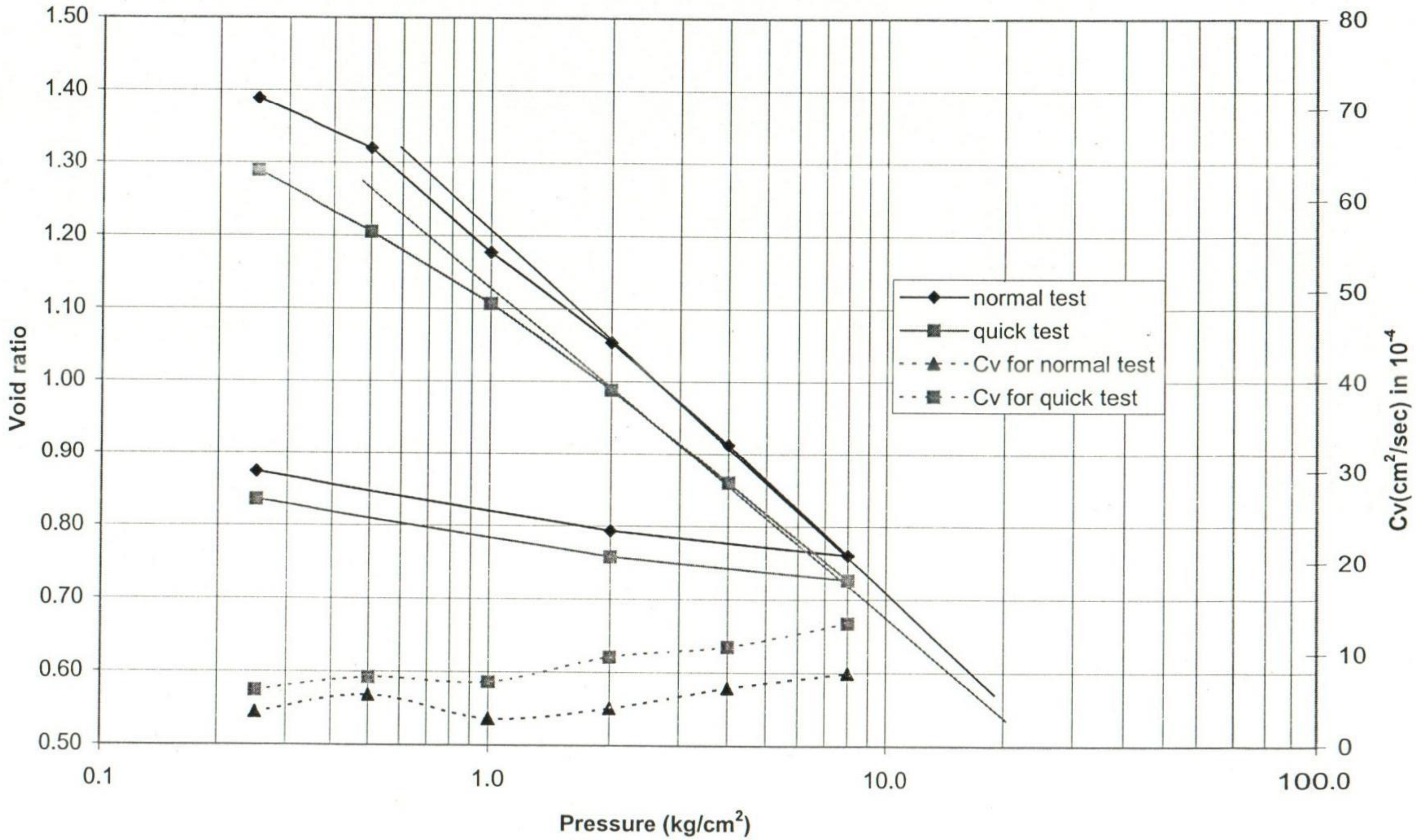

Fig. No. 3.1 : Void Ratio and Cv-Log Pressure curve of Hole No. : 1, Depth : 20' - 22' under Project : Matamuhuri Irrigation, Location : Pekua Rubberdam.

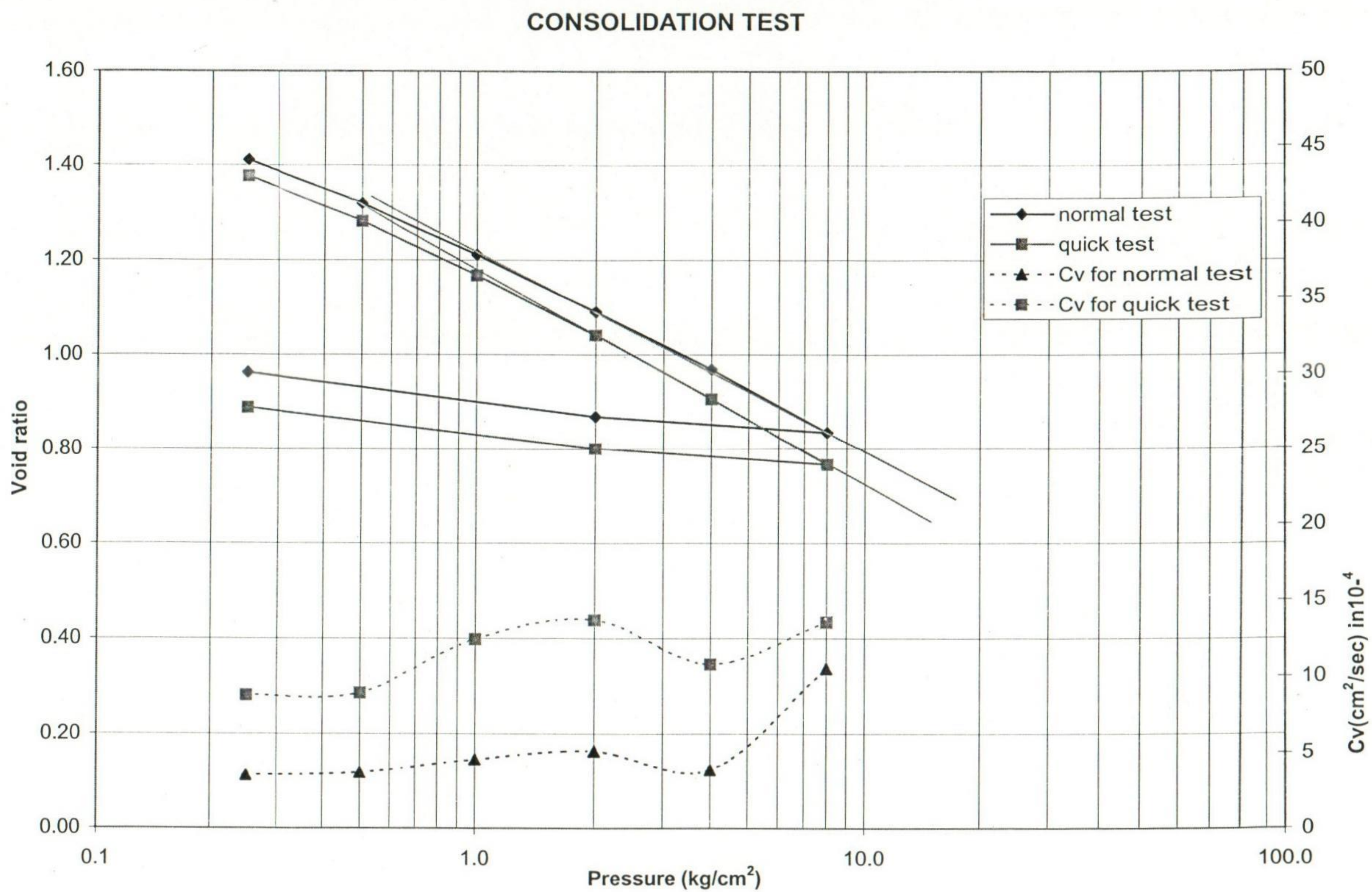

Fig. No. 3.2 : Void Ratio and Cv-Log Pressure curve of Hole No. : 2, Depth : 25' - 27' under Project : Matamuhuri Irrigation, Location : Pekua Rubberdam.

CONSOLIDATION TEST

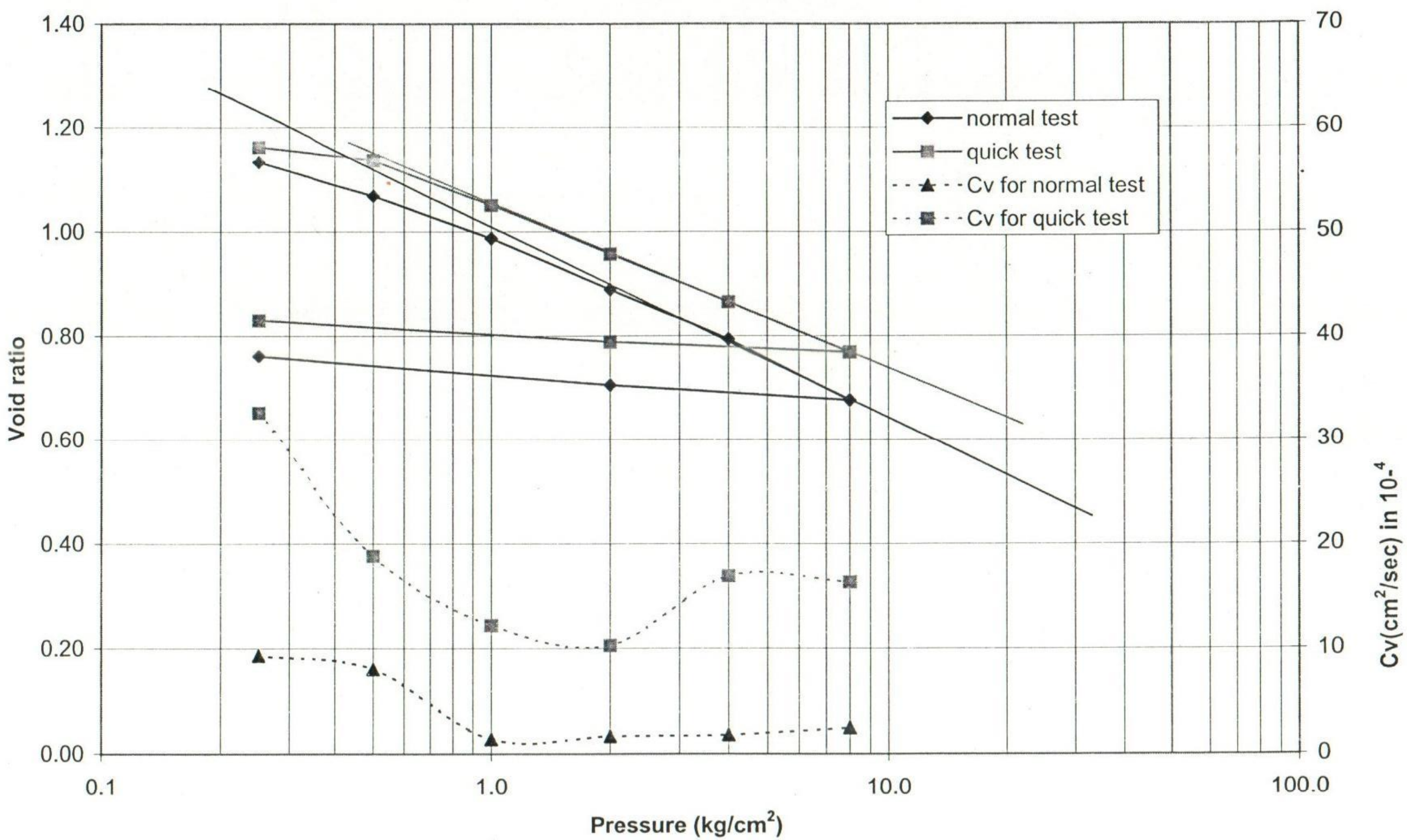

Fig. No. 3.3 : Void Ratio and Cv-Log Pressure curve of Hole No. : 5, Depth : 25' - 27' under Project : Matamuhuri Irrigation, Location : Pekua Rubberdam.

CONSOLIDATION TEST

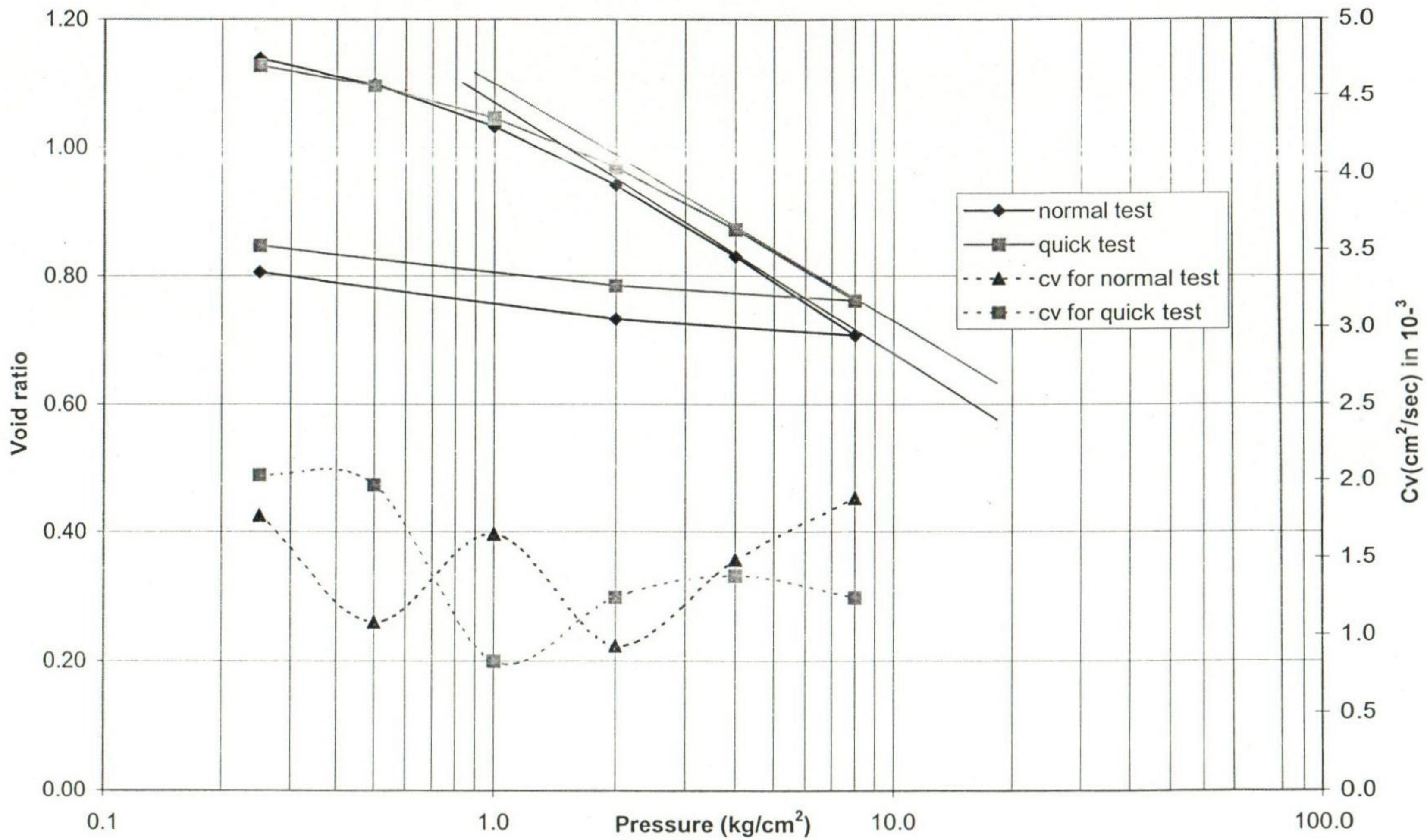

Fig. No.3.4 : Void Ratio and Cv-Log Pressure curve of Hole No. : 6, Depth : 15' - 17' under Project : Matamuhuri Irrigation, Location : Pekua Rubberdam.

CONSOLIDATION TEST

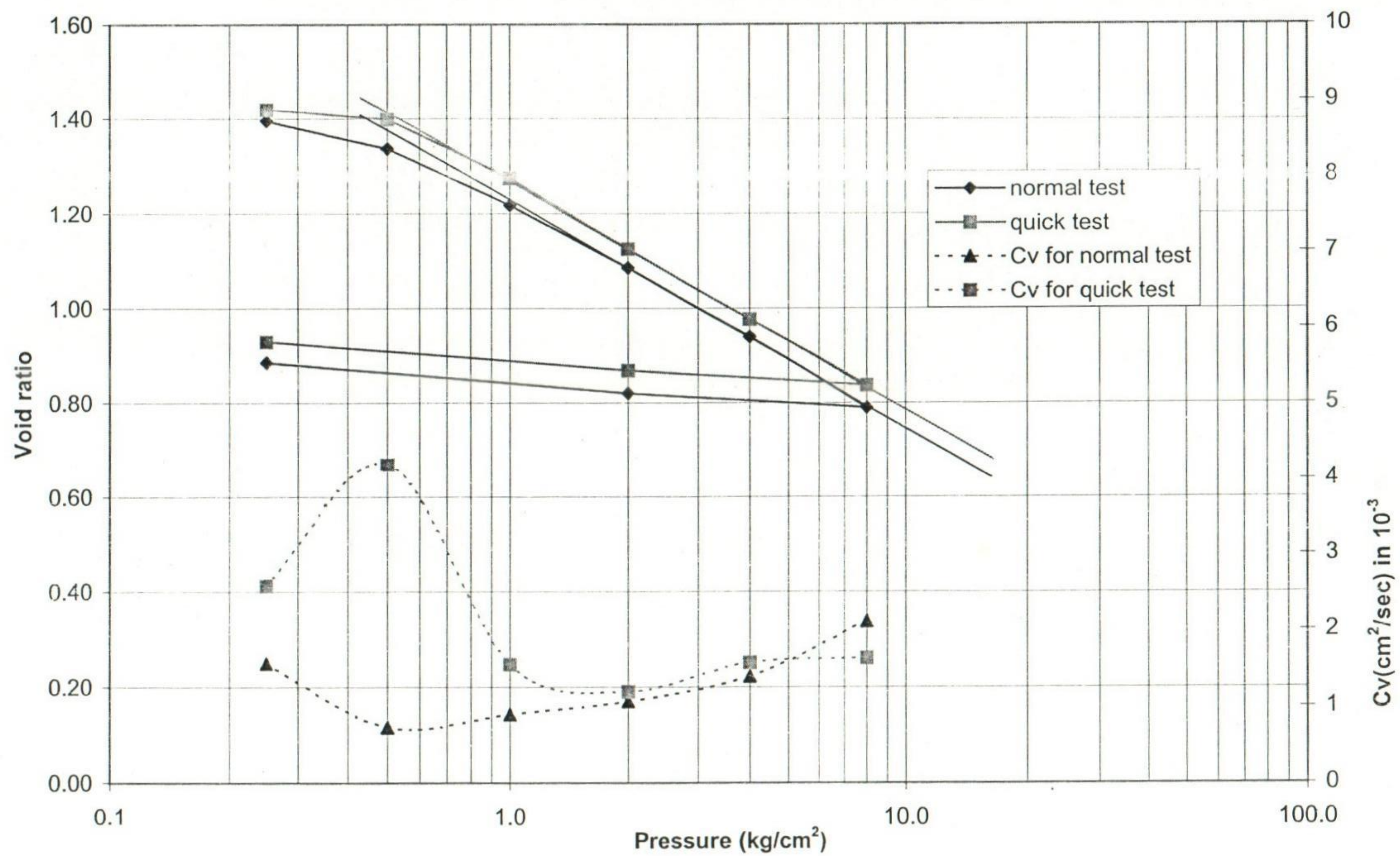

Fig. No. 3.5 : Void Ratio and Cv-Log Pressure curve of Hole No. : 7, Depth : 30' - 32' under Project : Matamuhuri Irrigation, Location : Pekua Rubberdam.

CONSOLIDATION TEST

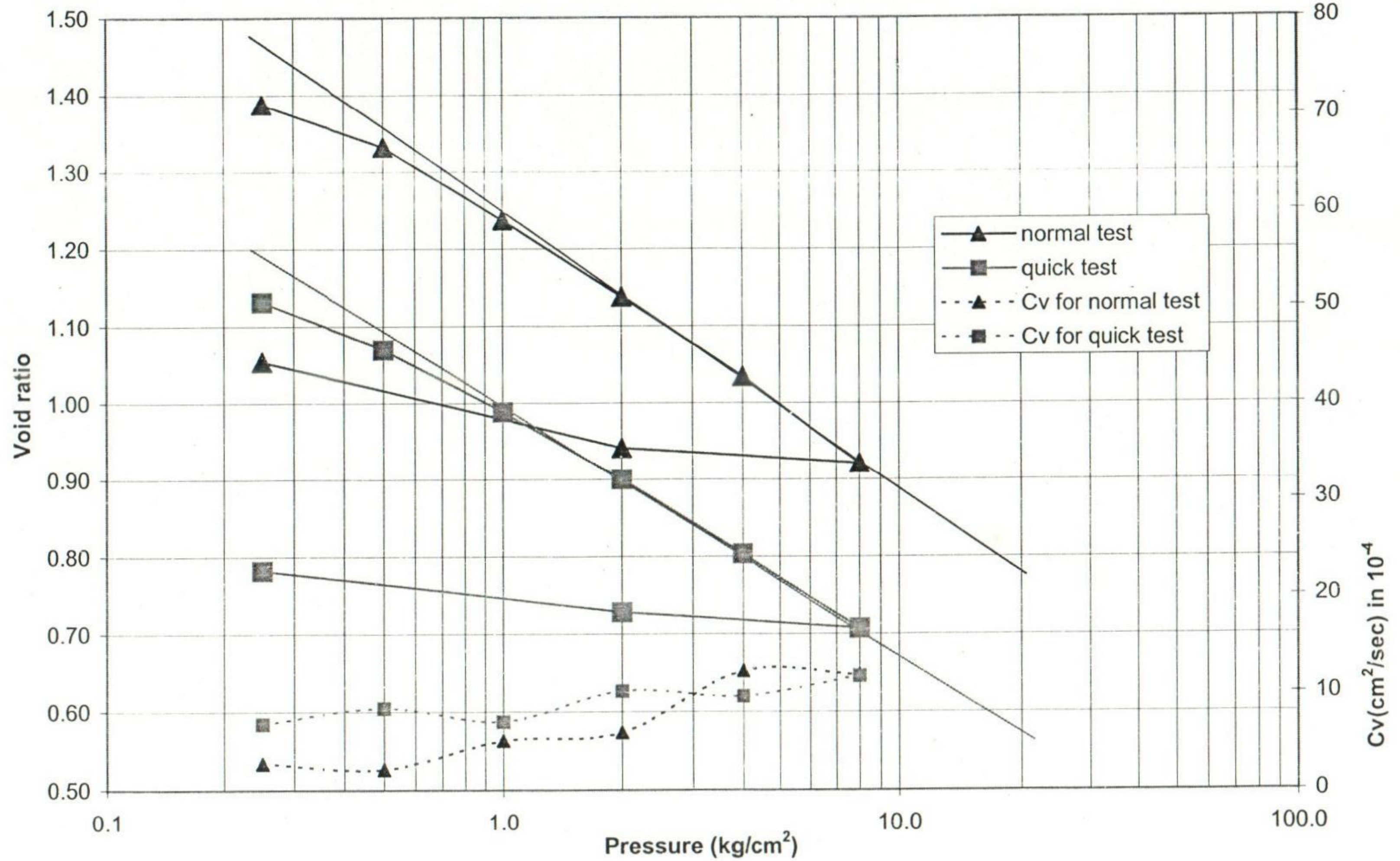

Fig. No. 3.6 : Void Ratio and Cv-Log Pressure curve of Hole No. : 9, Depth : 20' - 22' under Project : Matamuhuri Irrigation, Location : Pekua Rubberdam.

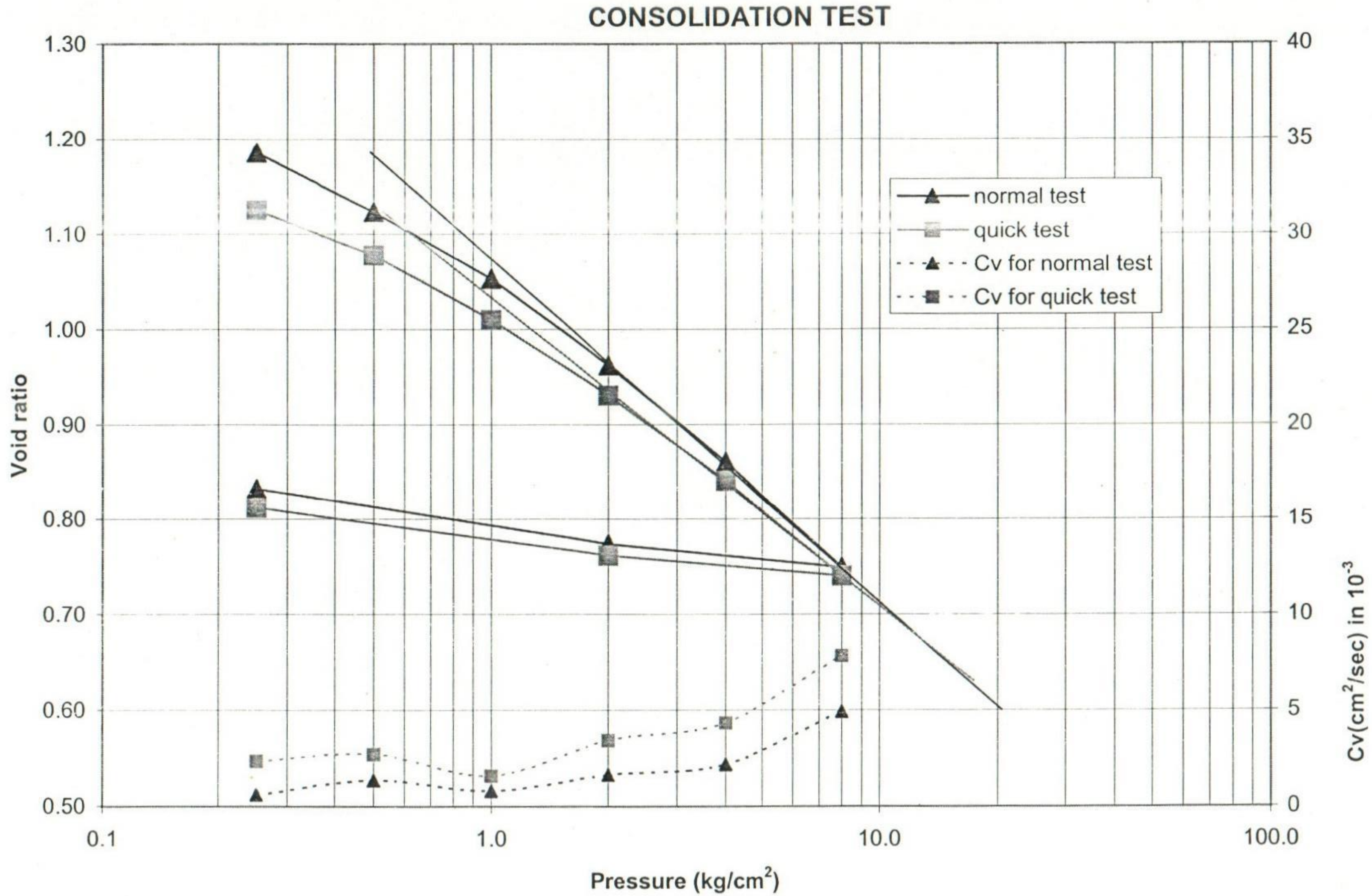

Fig. No. 3.7 : Void Ratio and Cv-Log Pressure curve of Hole No. : 10, Depth :10' - 12' under Project : Matamuhuri Irrigation, Location : Pekua Rubberdam.

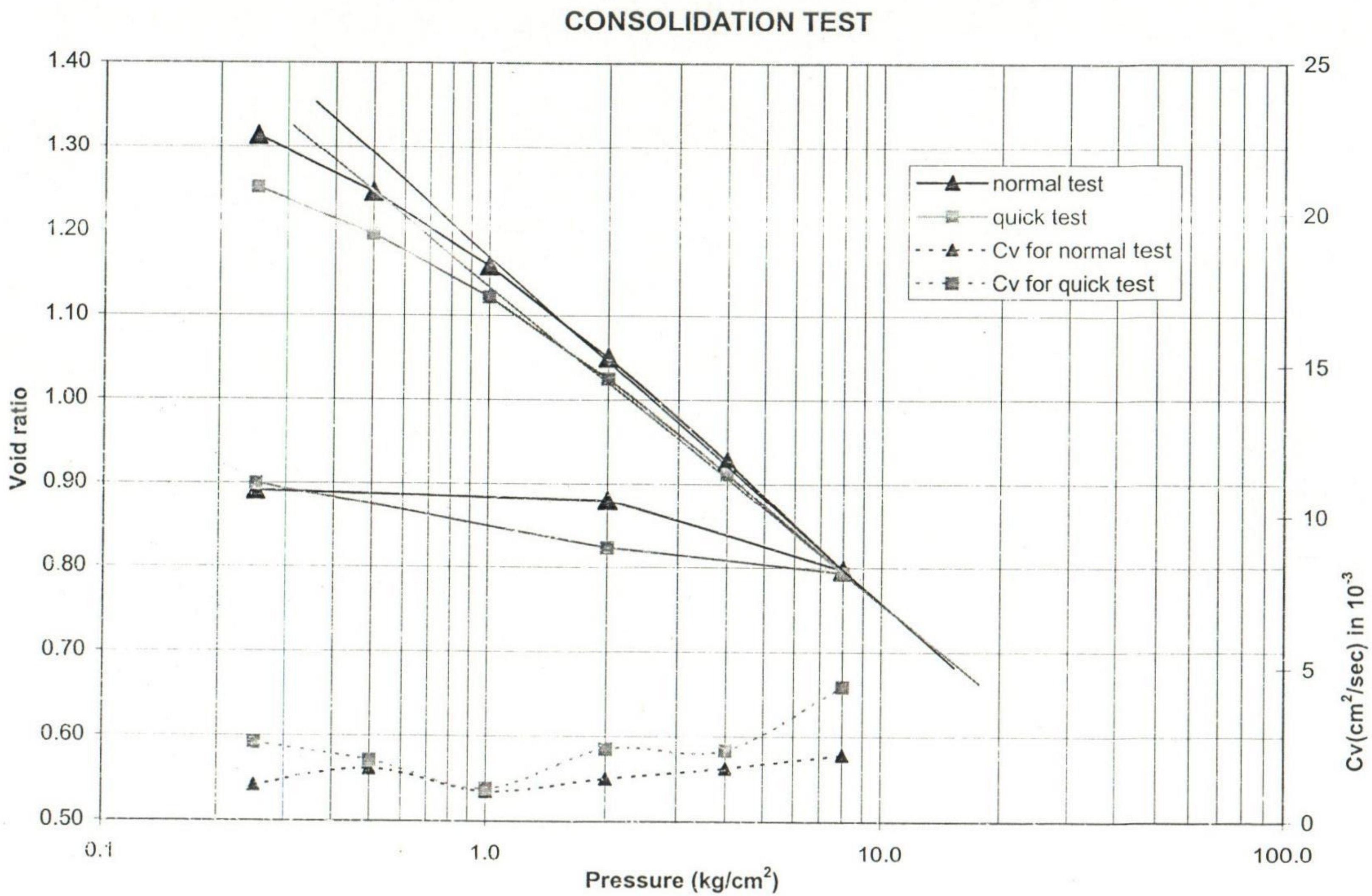

Fig. No. 3.8 : Void Ratio and Cv-Log Pressure curve of Hole No. : 13, Depth : 35'-37' under Project : Matamuhuri Irrigation, Location : Pekua Rubberdam.

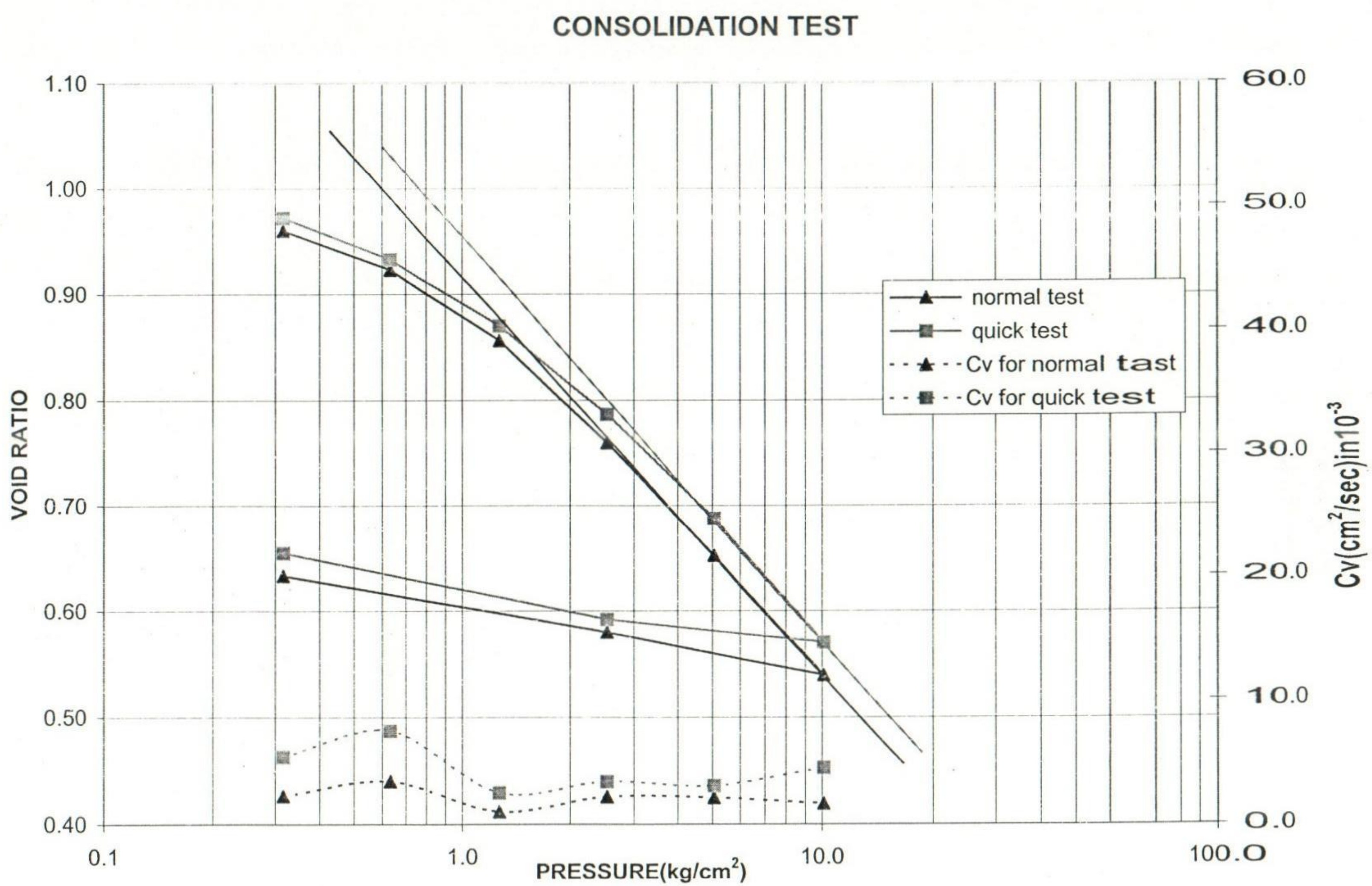

Fig. No. 4.1 : Void Ratio and Cv-Log Pressure curve of HOLE NO. : 1, DEPTH : 20'-22' under Project : Matamuhuri Irrigation, Location : North Mehermama.

CONSOLIDATION TEST

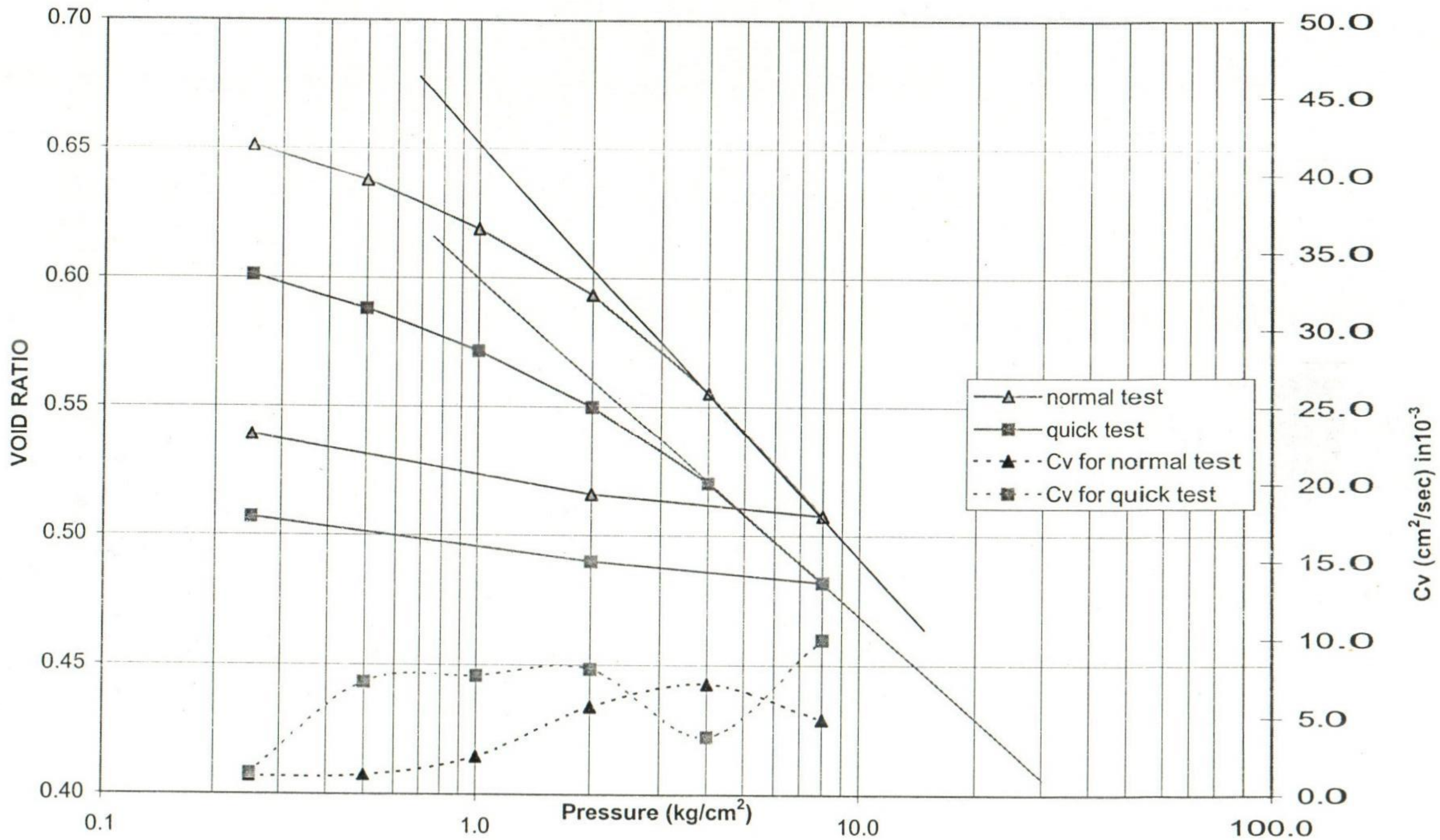

Fig. No. 4.2 : Void Ratio and Cv-Log Pressure curve of Hole No. : 2, Depth : 15'-17' under Project : Matamuhuri Irrigation, Location : North Mehermama.

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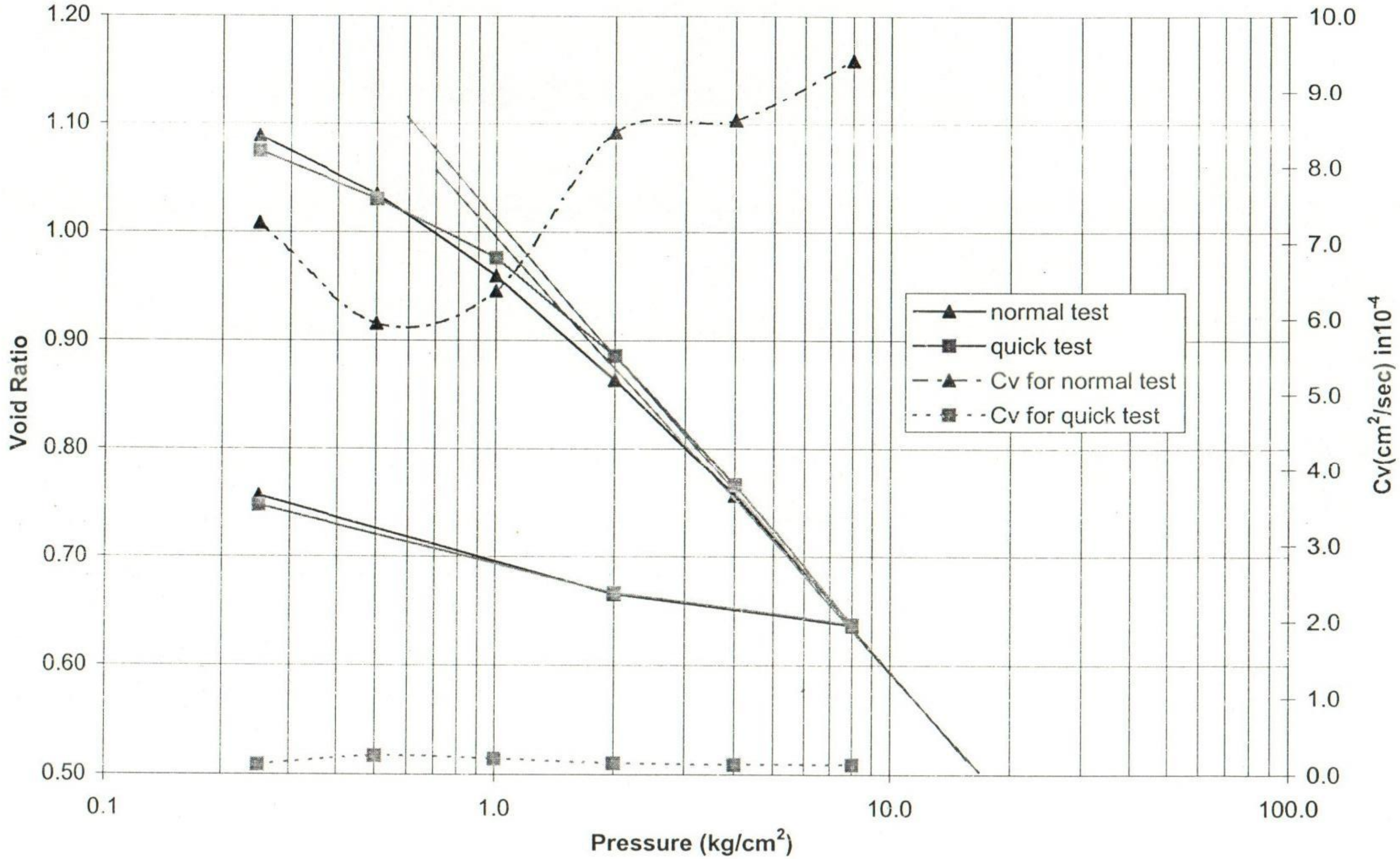

Fig. No. 4.3 : Void Ratio and Cv-Log Pressure curve of Hole No. : 4, Depth : 25-27' under Project : Matamuhuri Irrigation, Location : North Mehermama.

CONSOLIDATION TEST

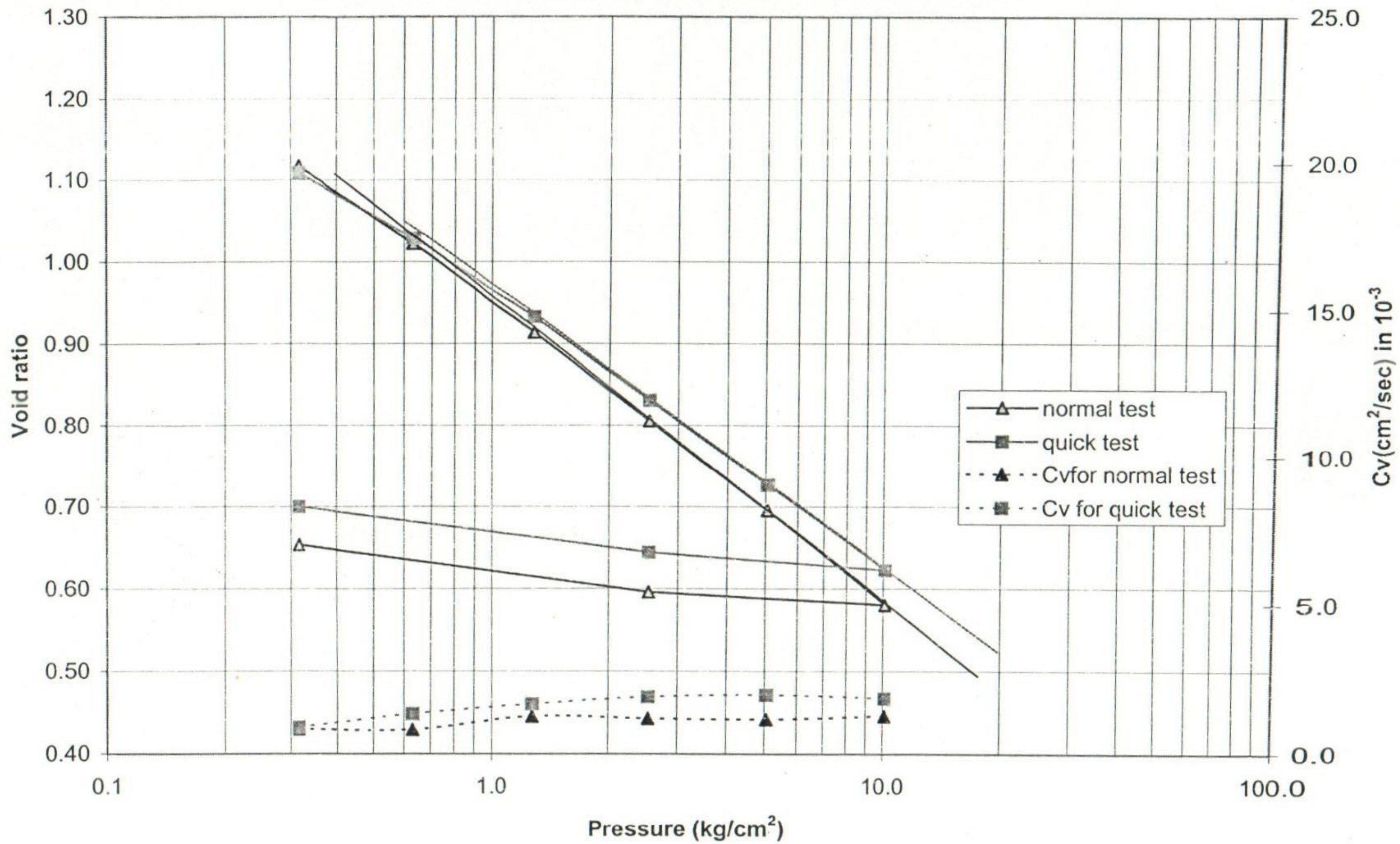

Fig. No. 5.1 : Void Ratio and Cv-Log Pressure curve of Hole No. -1 Depth- 15-17' under Project : Matamuhuri Irrigation, Location : East Guakhali.

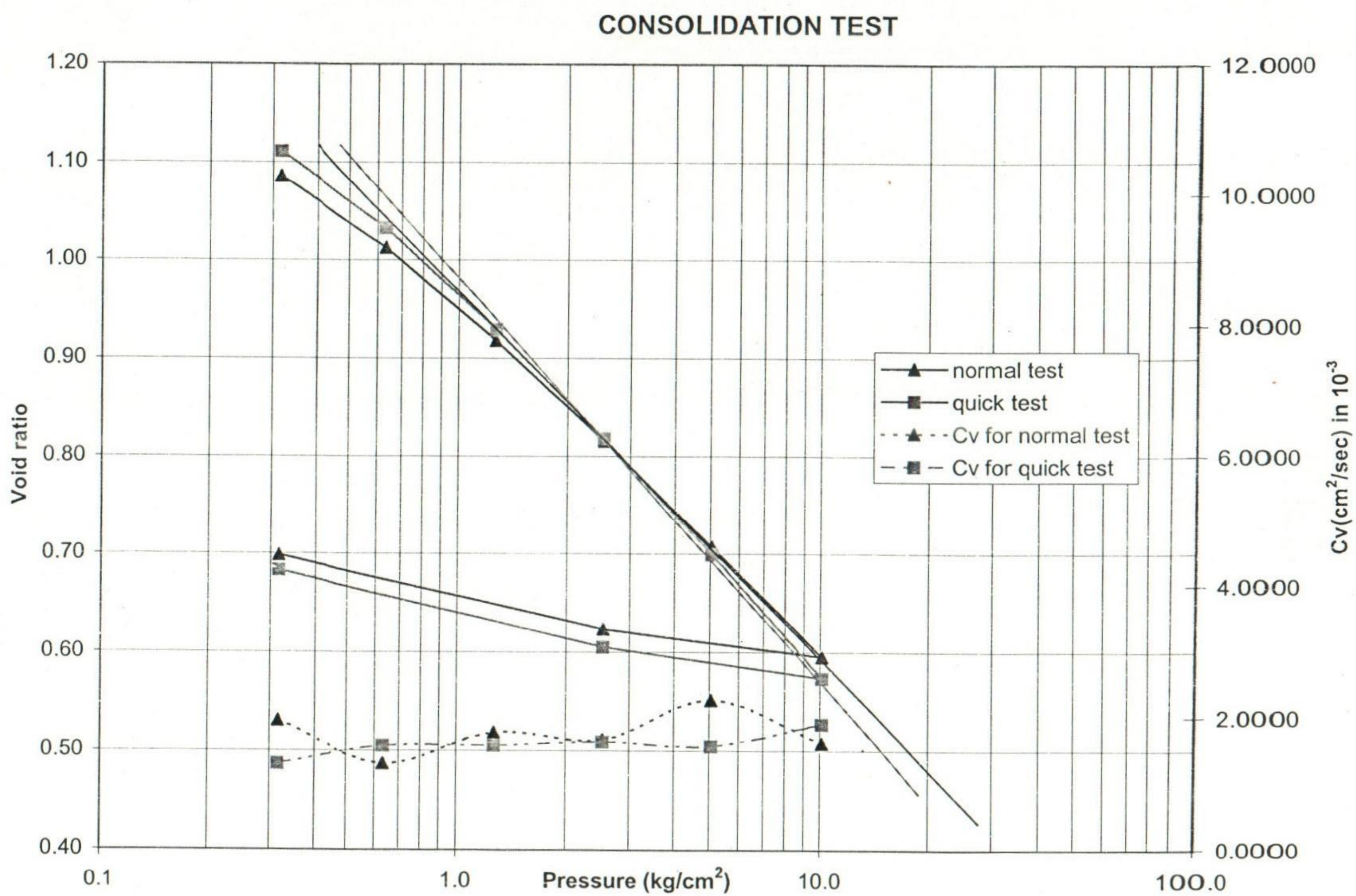

Fig. No. 5.2 : Void Ratio and Cv-Log Pressure curve of Hole-2, Depth- 20-22' under Project : Matamuhuri Irrigation, Location : East Guakhali.

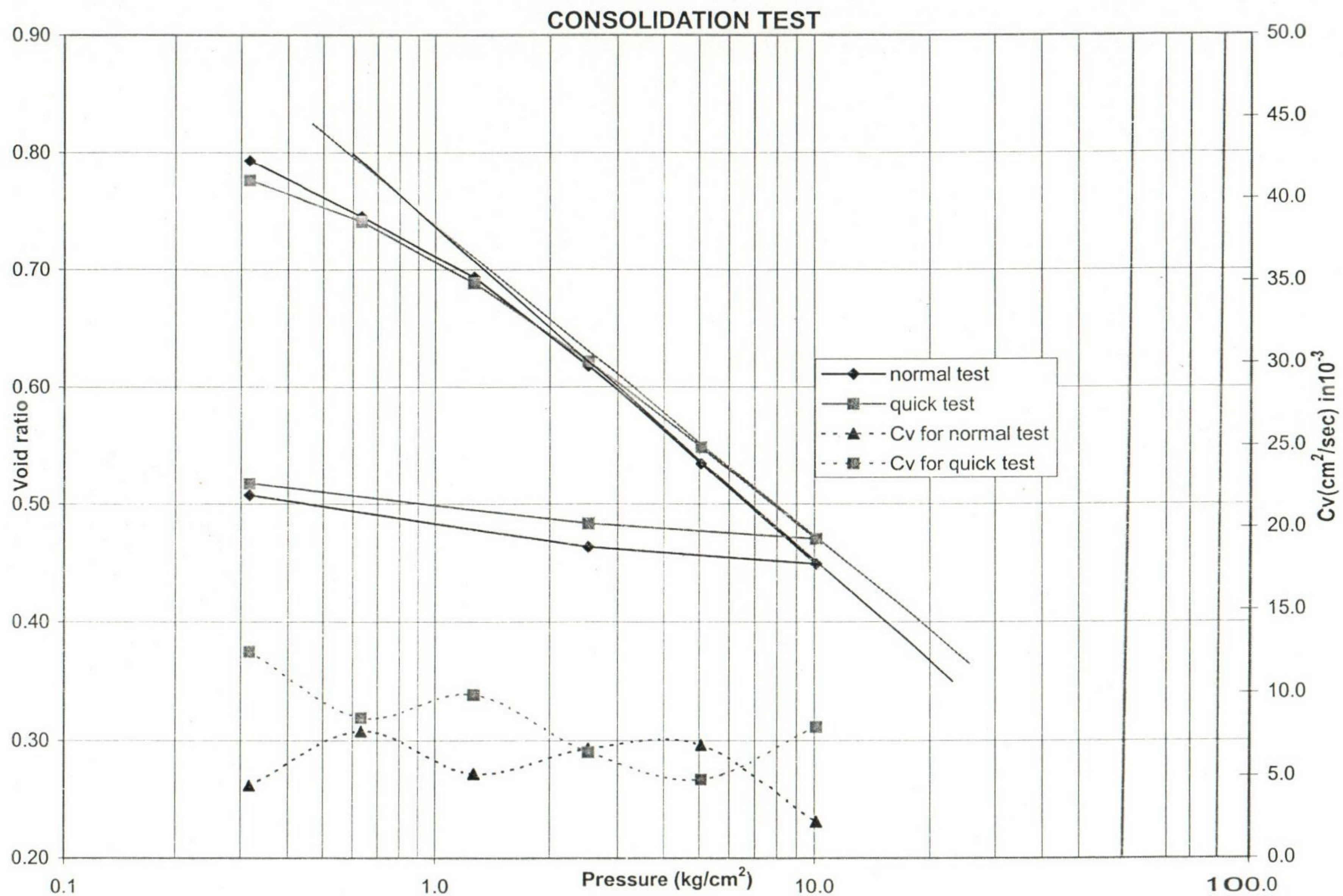

Fig. No. 5.3 : Void Ratio and Cv-Log Pressure curve of Hole No.: 4, Depth : 30-32' under Project : Matamuhuri Irrigation, Location : East Guakhali.

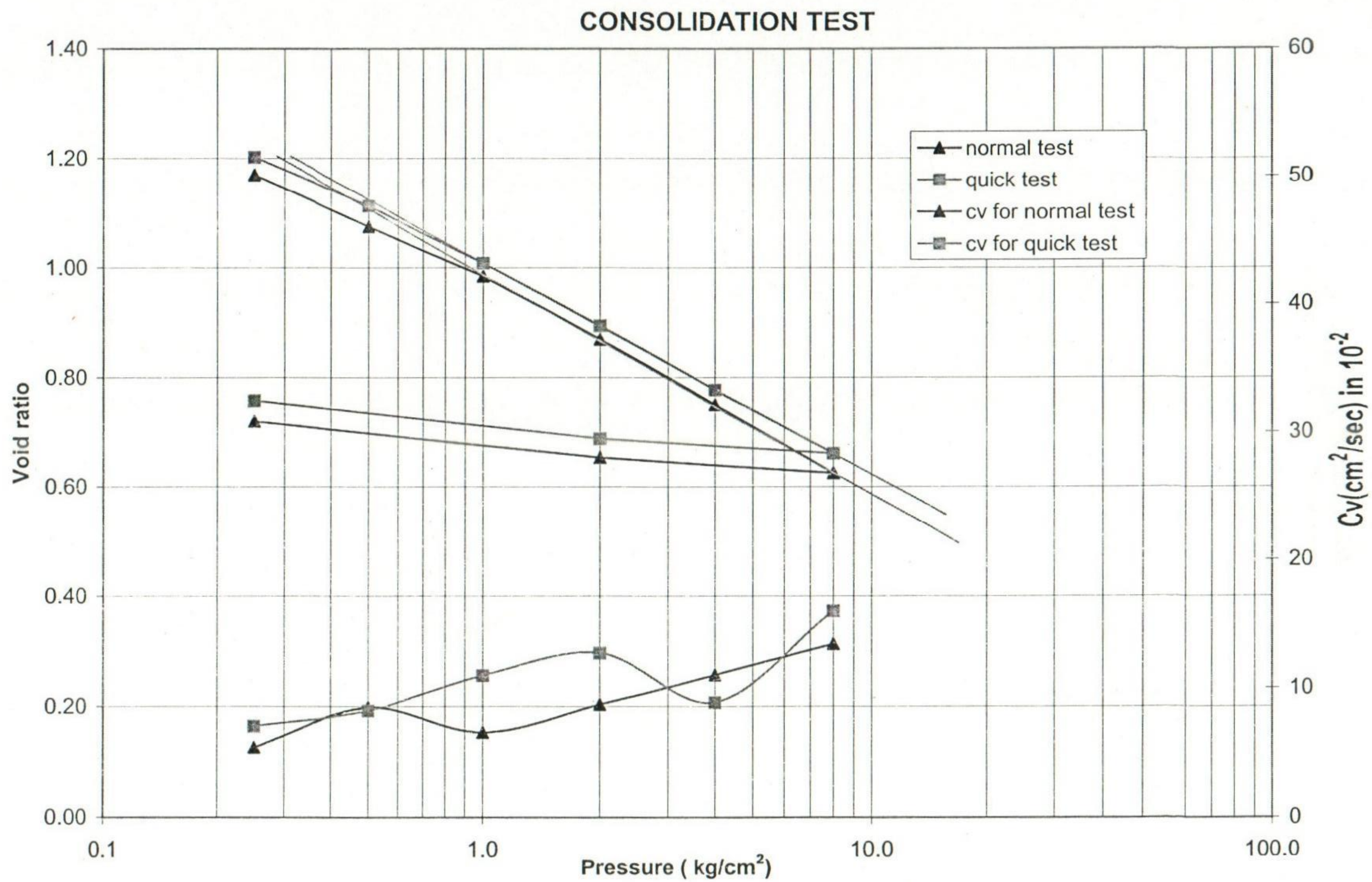

Fig. No.6 : Void Ratio and Cv-Log Pressure curve of Hole No. : 2, Depth : 15-17' under Project : Matamuhuri Irrigation, Location : Chowar Fari.

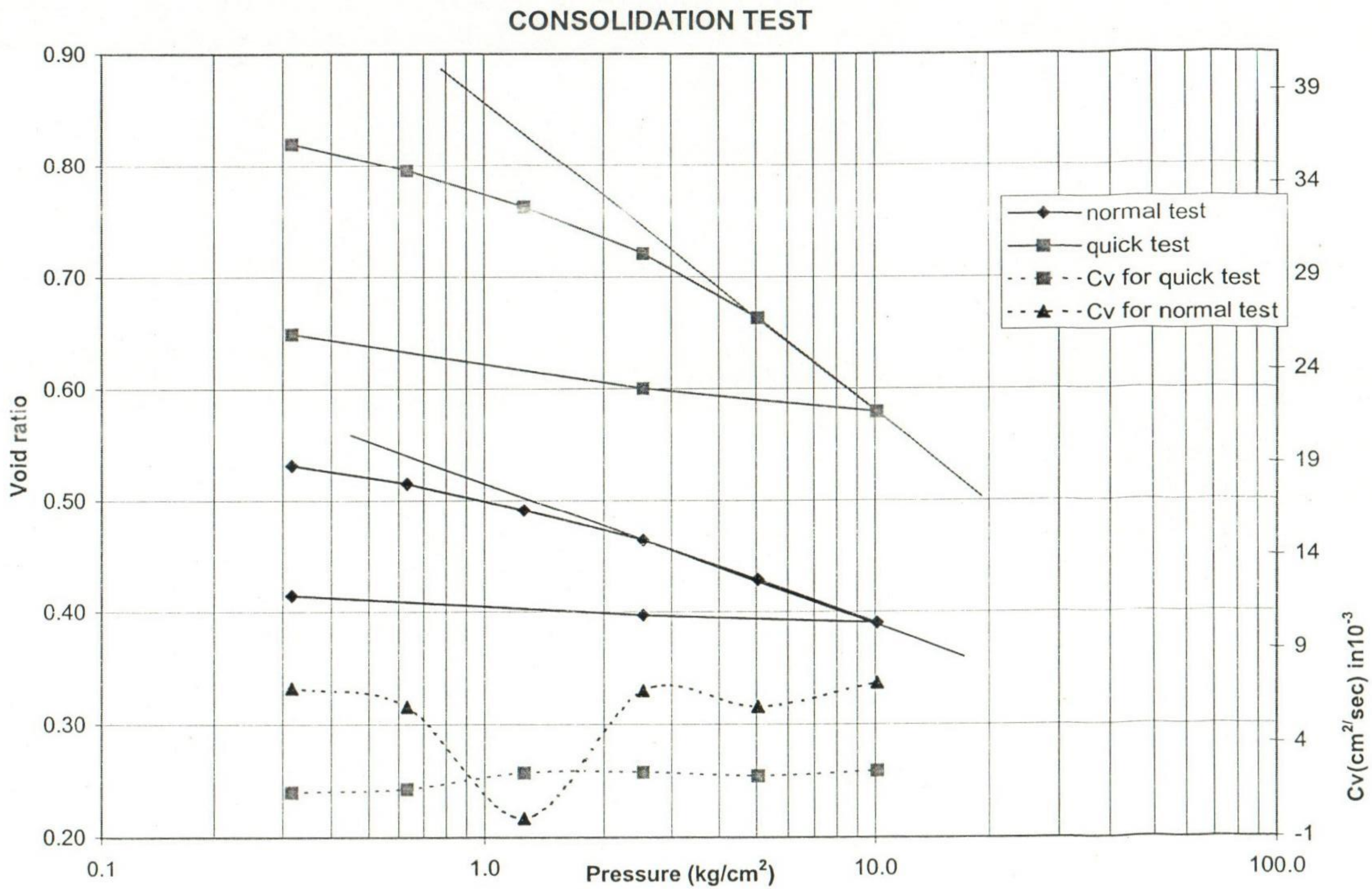

Fig. No. 7 : Void Ratio and Cv-Log Pressure curve of Hole No. : 1, Depth :10-12' under Project : Madhobpur FCDI, Hobigonj, Location- Bahara Madhobpur Structure.

CONSOLIDATION TEST

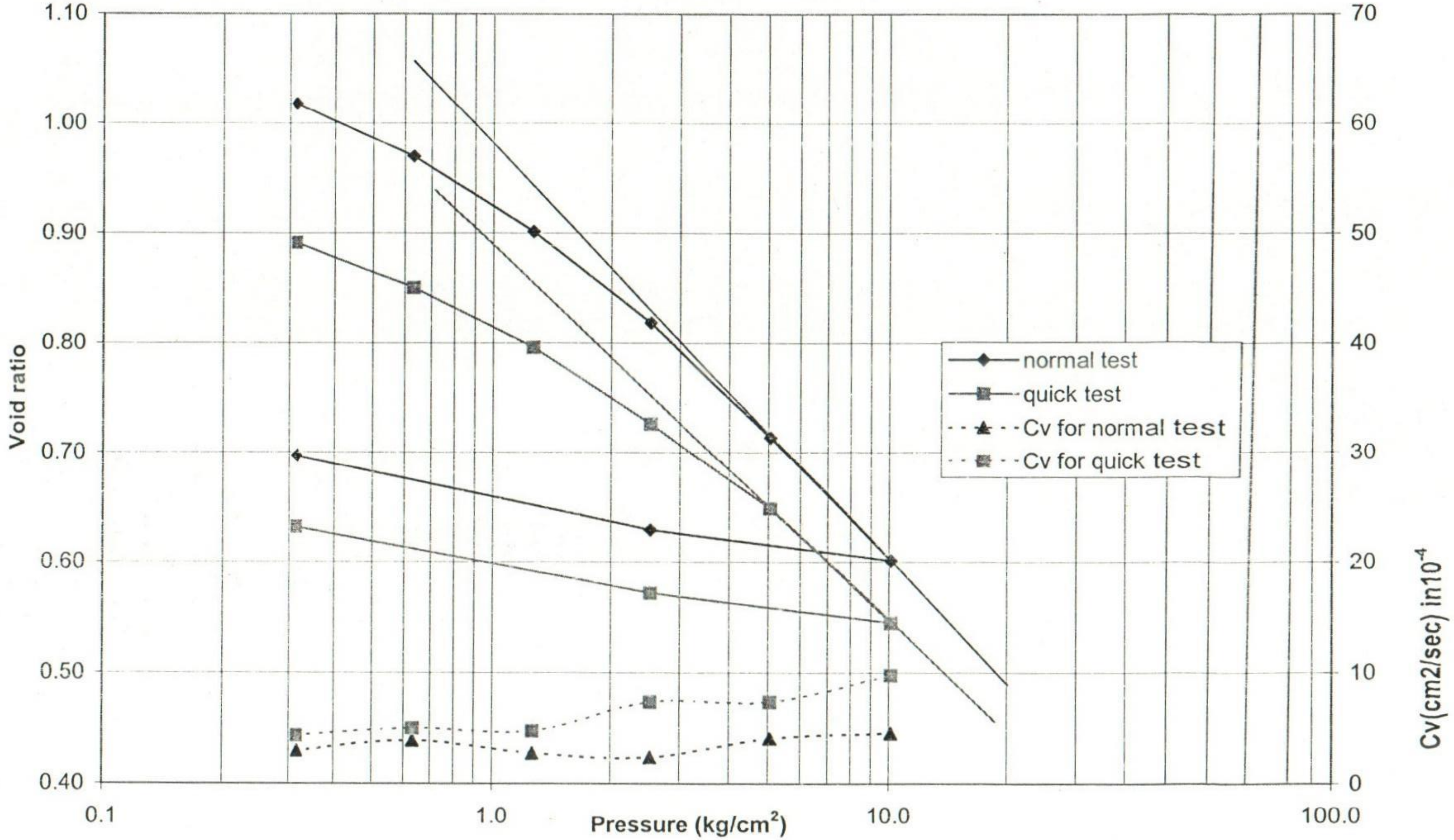

Fig. No. 8 : Void Ratio and Cv-Log Pressure curve of Hole No. : 3, Depth : 25-27' under Project : Madhobpur FCDI, Hobigonj, Location-Bahara water Control Structure,

CONSOLIDATION TEST

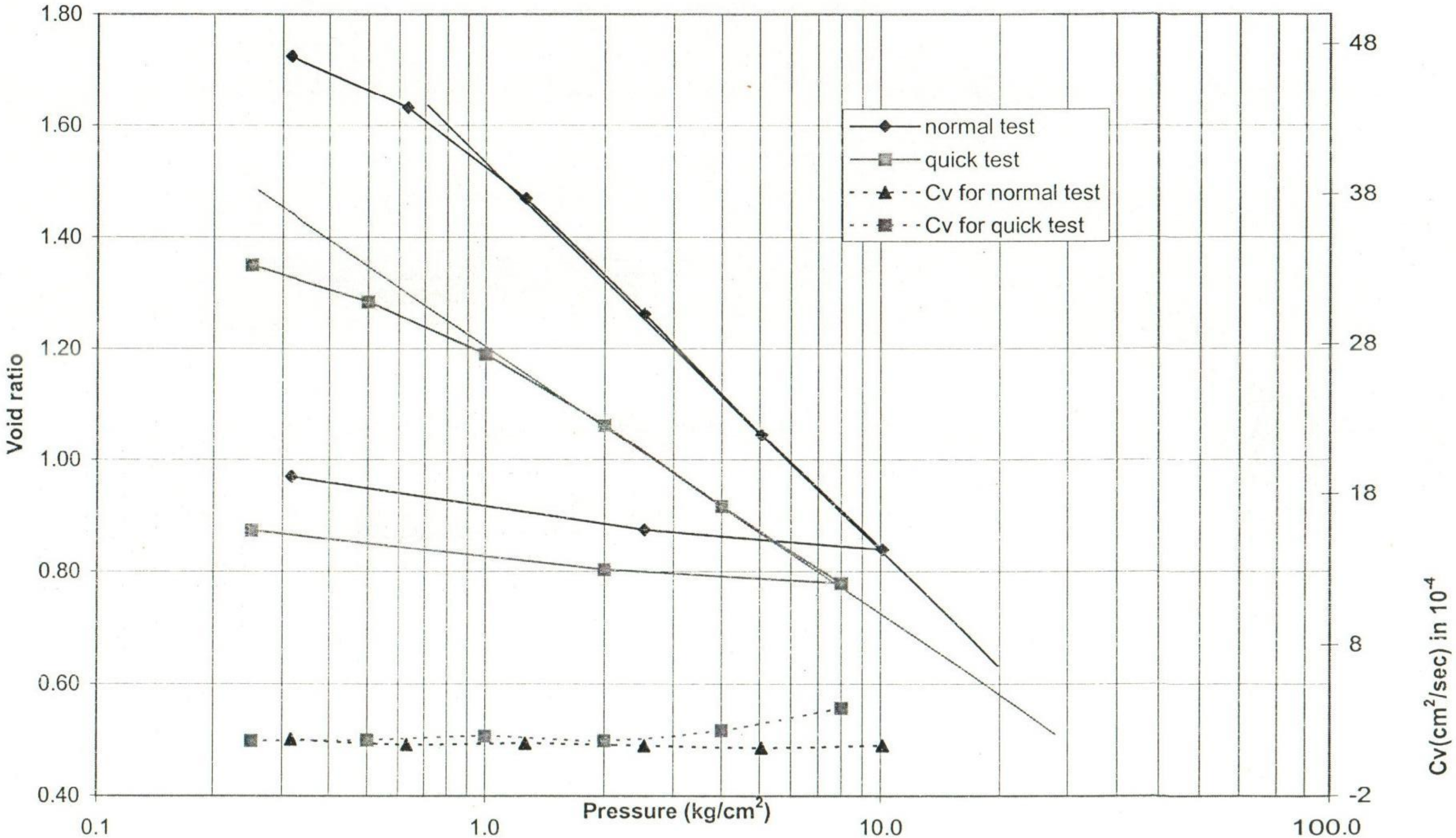

Fig. No. 9.1 : Void Ratio and Cv-Log Pressure curve of Hole No. : 1, Depth : 10-12 under Project : DCP, Location- Goranchatbari Bousa Bill.

CONSOLIDATION TEST

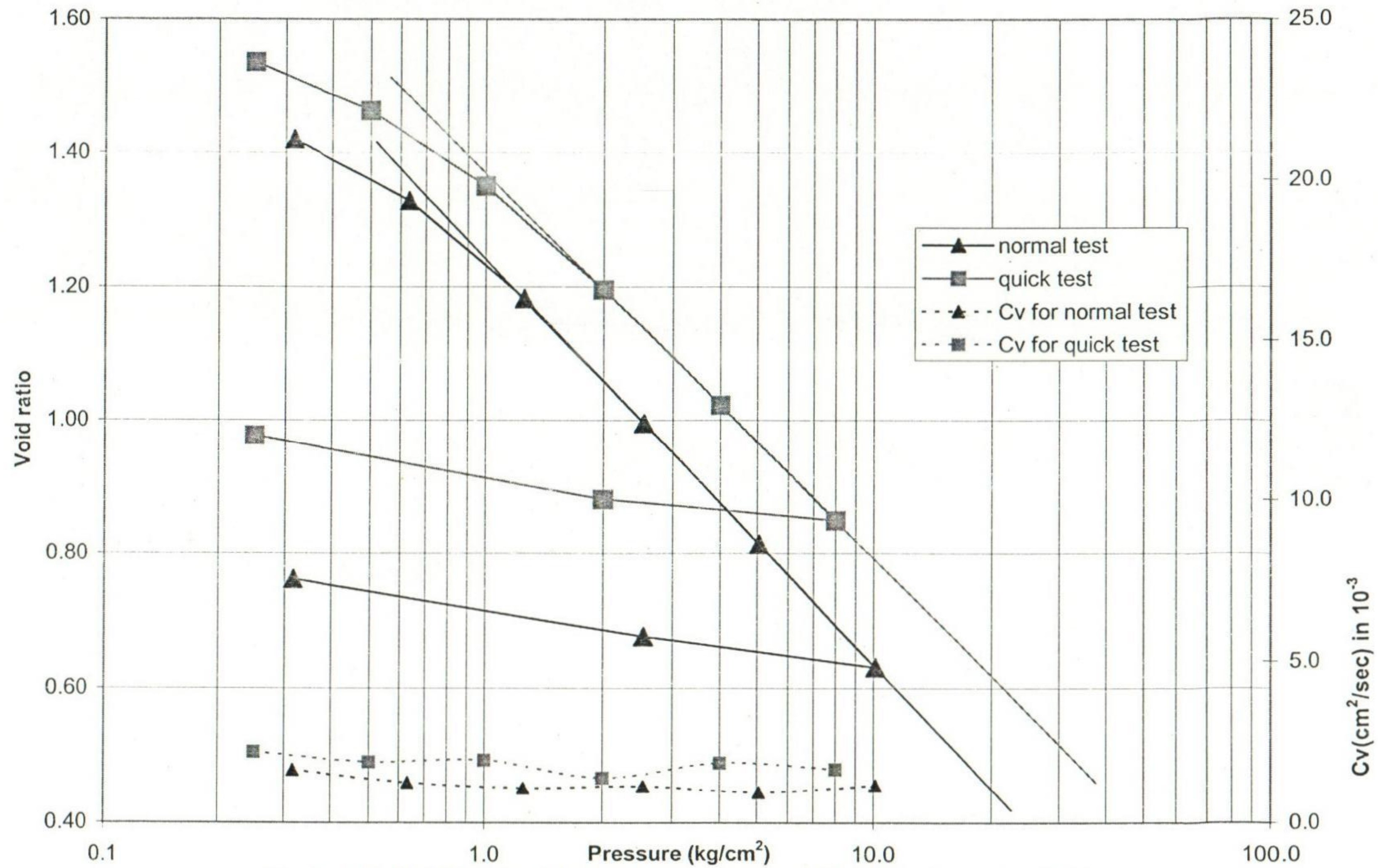

Fig. No. 9.2 : Void Ratio and Cv-Log Pressure curve of Hole No. : 3, Depth : 15-17' under Project : Project-DCFP, Location- Goranghatbari Bousa Bill.

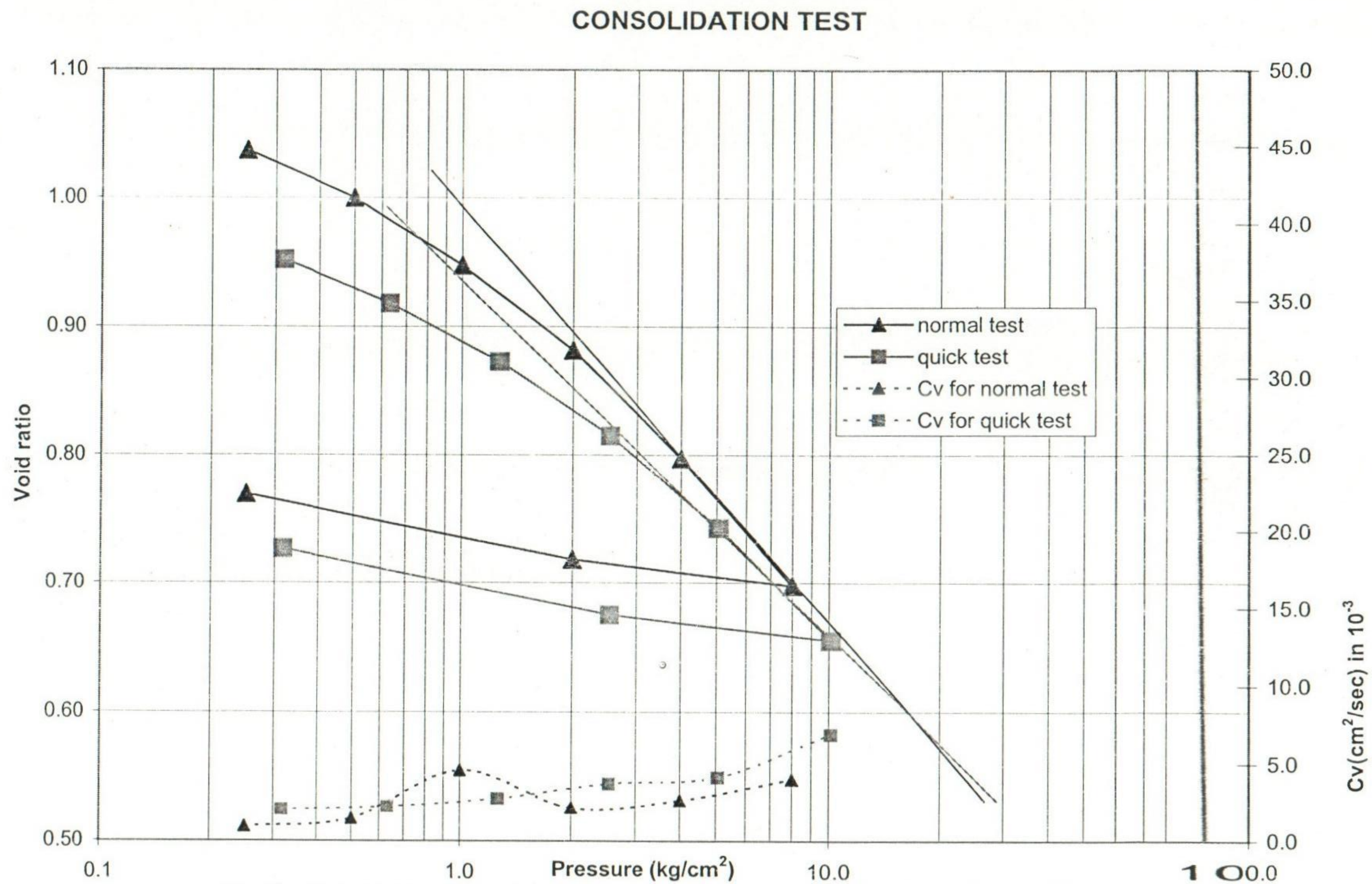

Fig. No. 10.1 : Void Ratio and Cv-Log Pressure curve of Hole No. : 2, Depth : 20-22' under Project : DCFP, Location-Goranchatbari Maijlar Bill.

CONSOLIDATION TEST

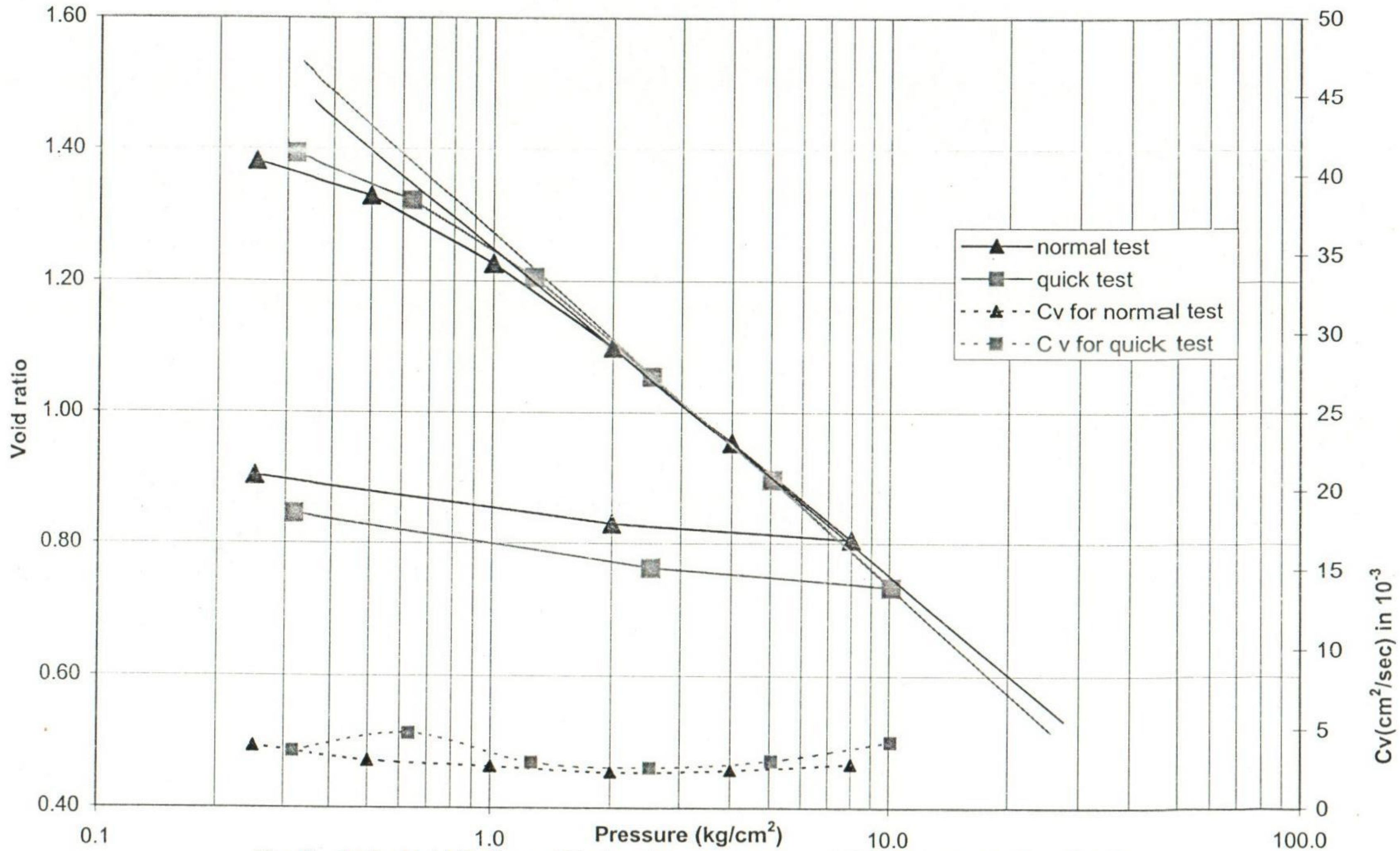

Fig. No. 10.2 : Void Ratio and Cv-Log Pressure curve of Hole No. : 3, Depth : 25-27' under Project : DCPF, Location- Goranchatbari Maijar Bill.

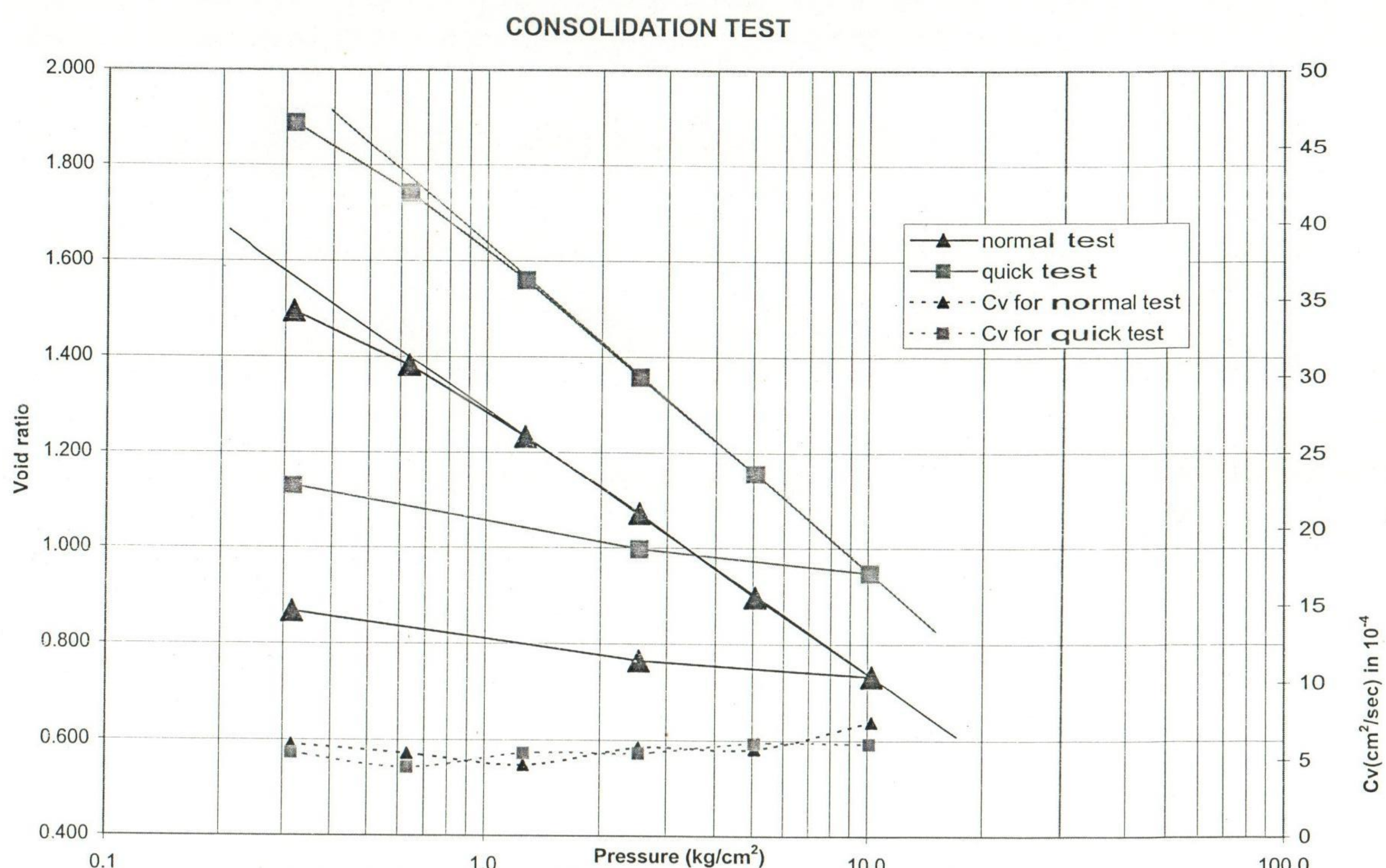

Fig. No. 10.3 : Void Ratio and Cv-Log Pressure curve of Hole No. : 4, Depth : 15'-17' under Project : DCPF, Location : Goranchatbari Maijar Bill.

CONSOLIDATION TEST

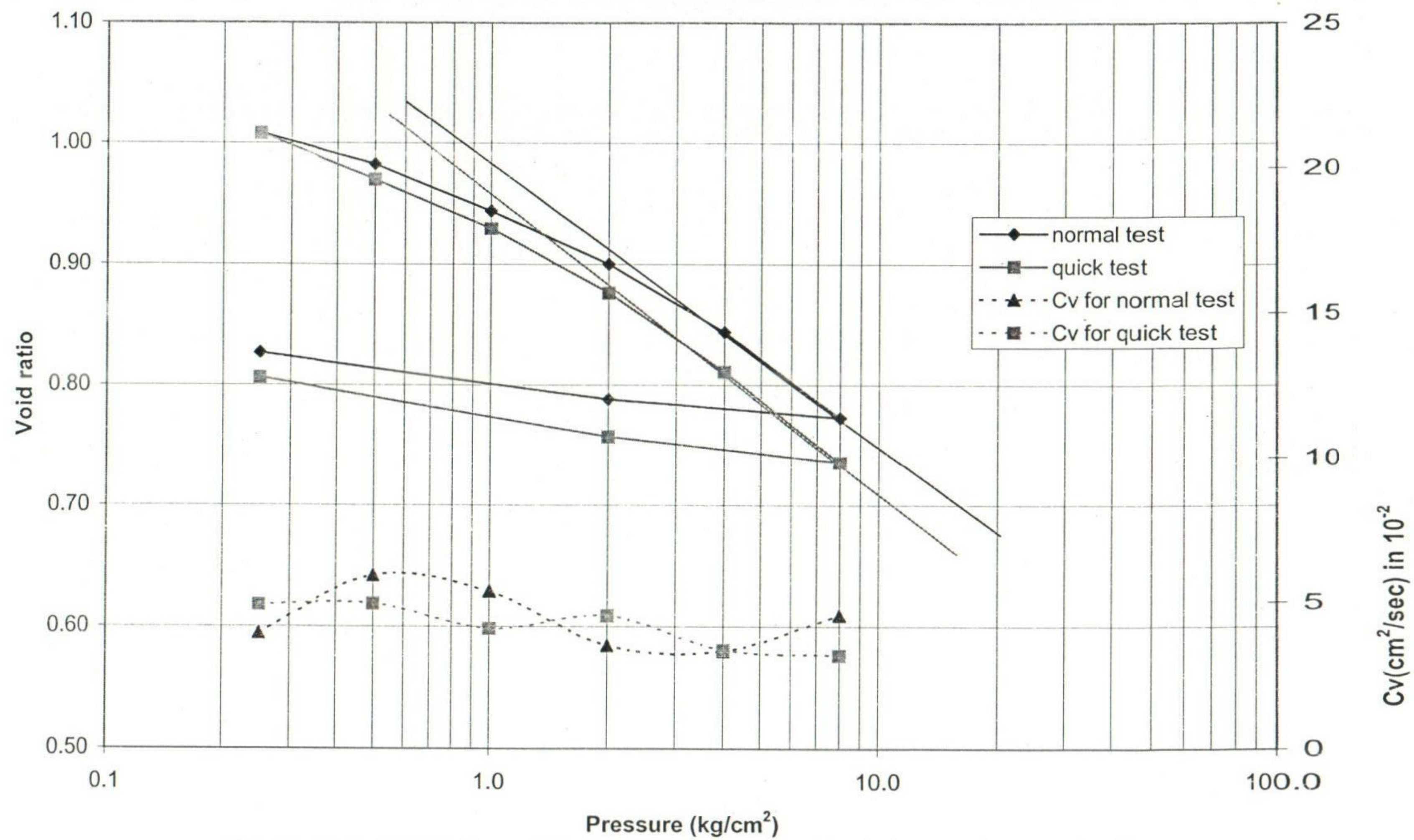

Fig. No. 11.1 : Void Ratio and Cv-Log Pressure curve of Hole No. : 4, Depth : 20' - 22' under Project : Coastal Embankment, Patuakhali, Location : Hajirhat.

CONSOLIDATIONB TEST

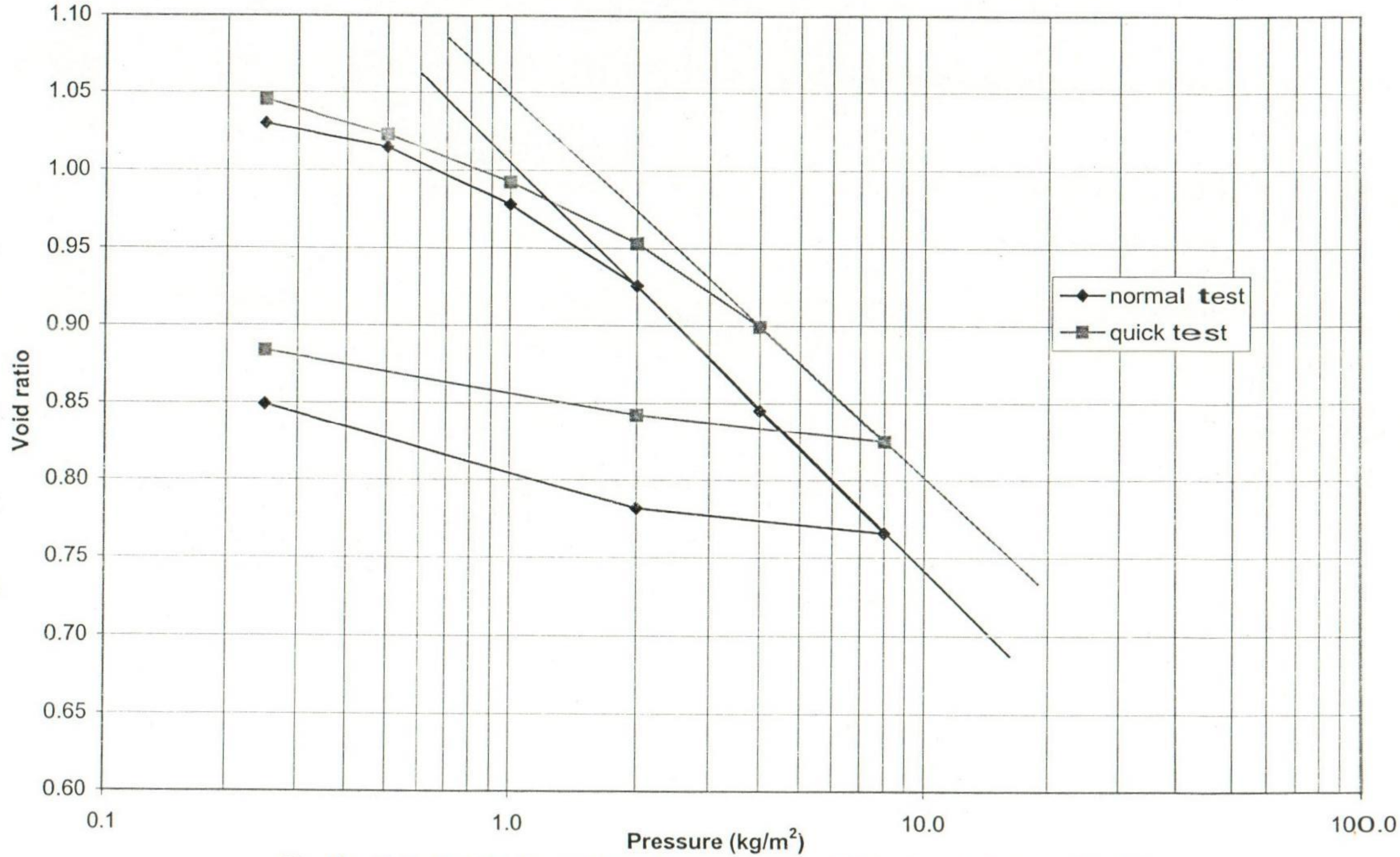

Fig. No. 11.2 : Void Ratio and Log Pressure curve of Hole No. : 2, Depth : 20' - 22' under Project : Coastal Embankment, Patuakhali Location : Hajirhat.

CONSOLIDATION TEST

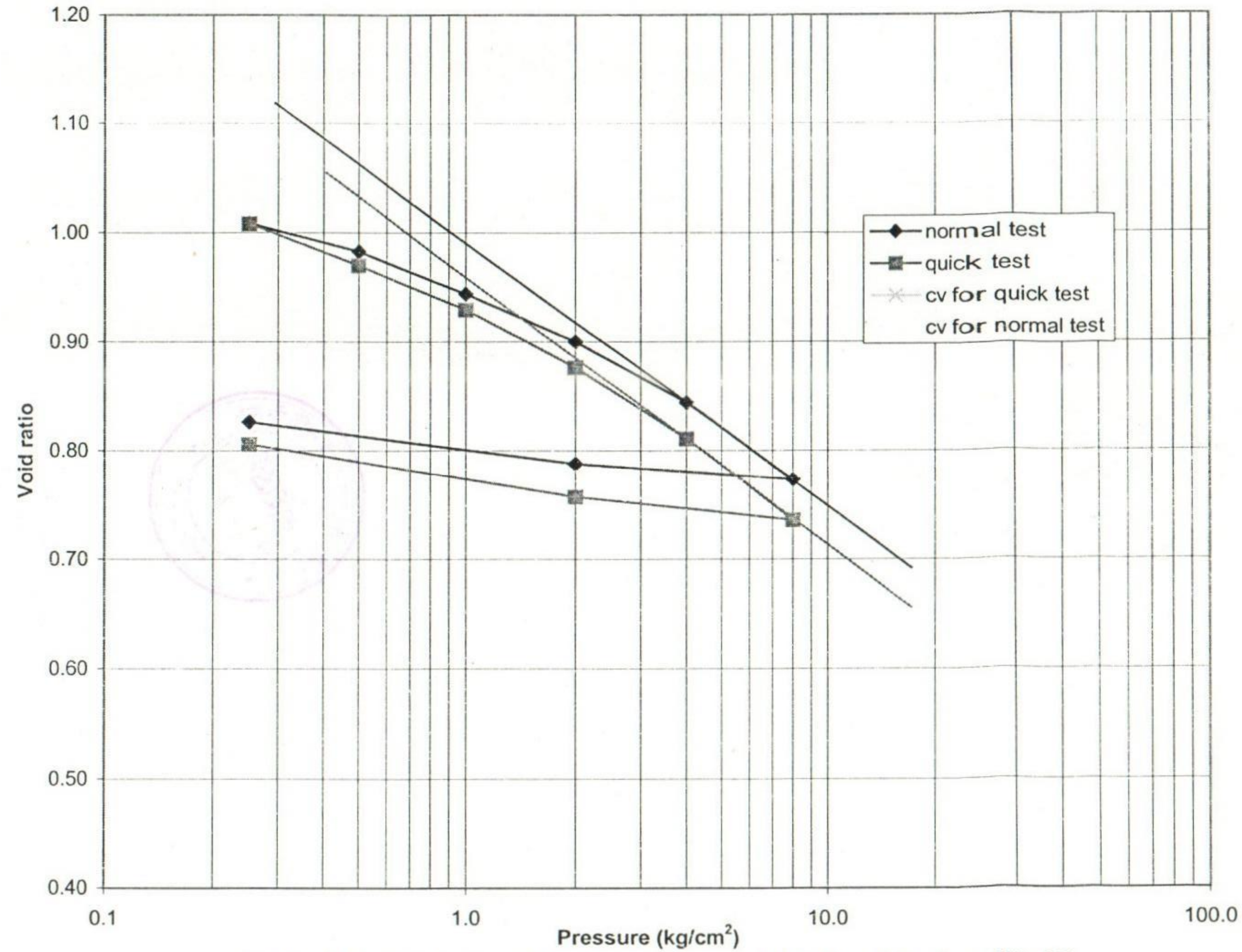

Fig. No. 11.3 : Void Ratio and Log Pressure curve of Hole No. : 4, Depth : 20' - 22' under Project : Coastal Embankment, Patuakhali, Location : Hajirhat.

Soil Type VS Cc Value

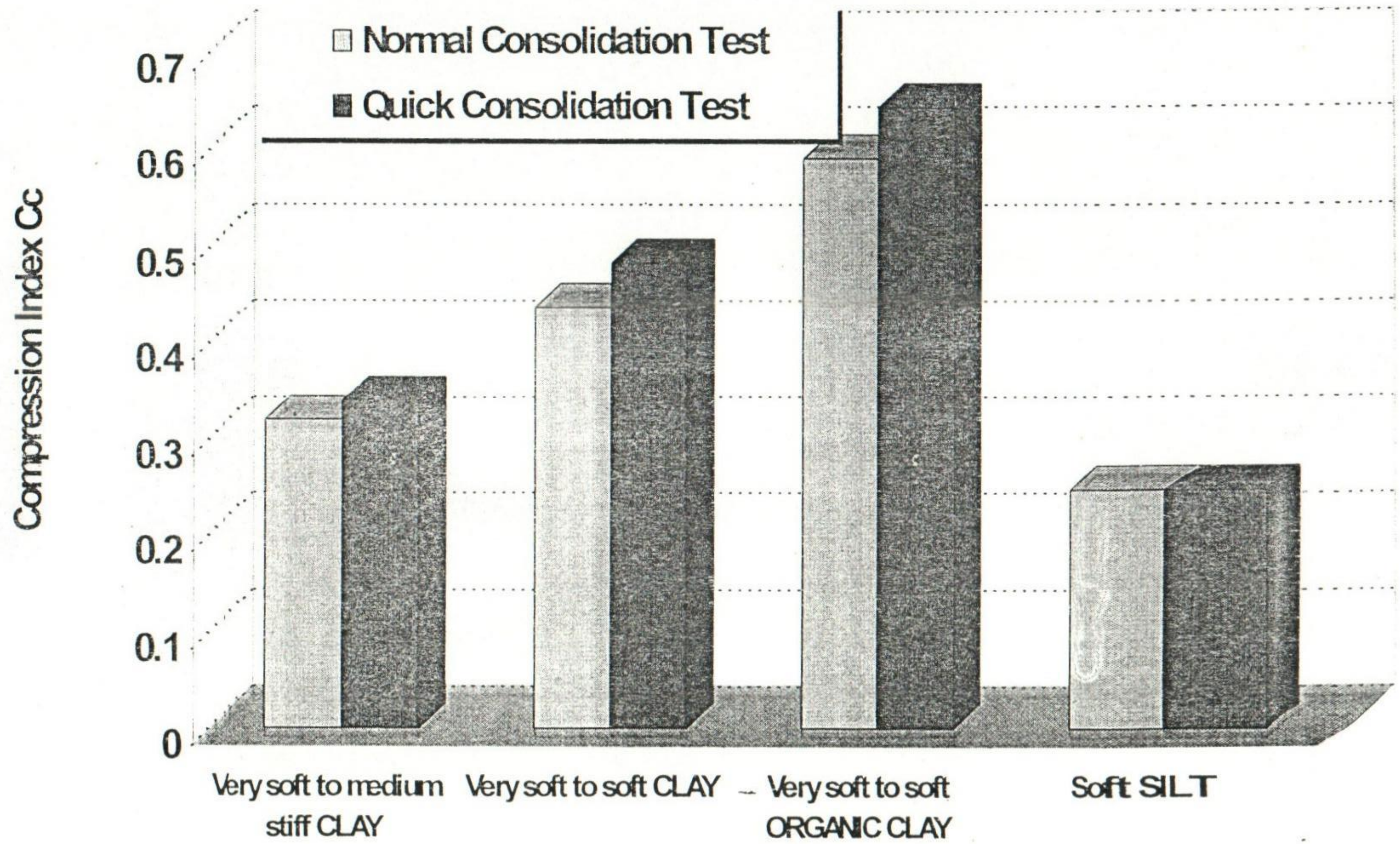

Fig: Soil Type Vs Cc Value for Different types of Soil

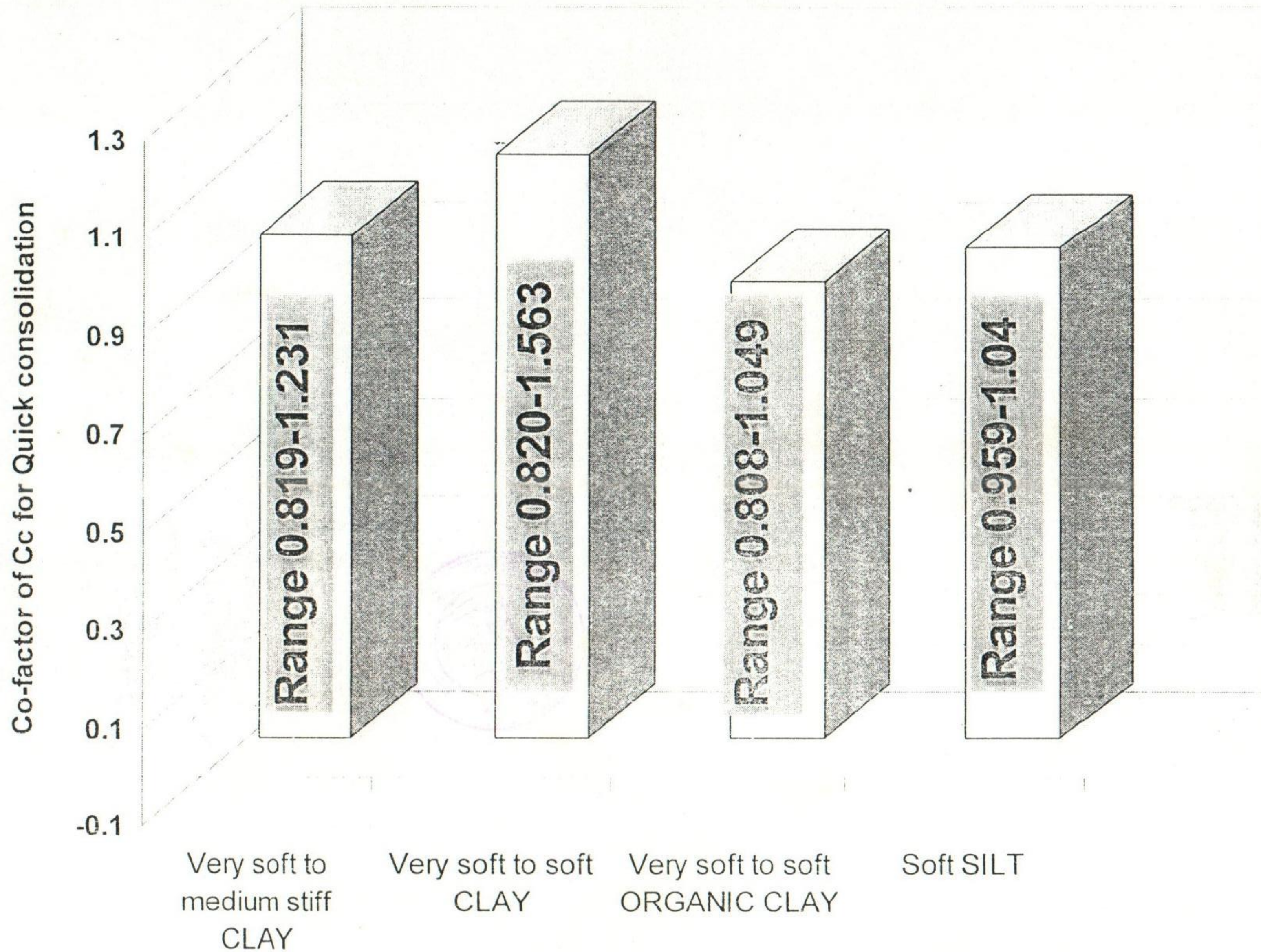

Fig.13 Range of Co-factor of Cc for quick consolodation for different types of soil