International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 13, Issue 2 [February. 2024] PP: 145-150

Characterization of Shear Zone by the Pressuremeter Test

Noor Shahid[1], Gupta M[2], Chitra R[3], Singh Amardeep[4], Harendra Prakash[5]

[1]*Corresponding Author and Scientist 'D', Central Soil and Materials Research Station, Ministry of Jal Shakti, DoWR, RD & GR, Government of India, Olof Palme Marg, Hauz Khas, New Delhi-110016.*
e-mail: shahidnoor19@gmail.com
[2]*Scientist 'E', Central Soil and Materials Research Station, Ministry of Jal Shakti, DoWR, RD & GR, Government of India, Olof Palme Marg, Hauz Khas, New Delhi-110016*
[3]*Director, Central Soil and Materials Research Station, Ministry of Jal Shakti, DoWR, RD & GR, Government of India, Olof Palme Marg, Hauz Khas, New Delhi-110016*
[4]*Scientist 'E', Central Soil and Materials Research Station, Ministry of Jal Shakti, DoWR, RD & GR, Government of India, Olof Palme Marg, Hauz Khas, New Delhi-110016.*
[5]*Scientist 'C', Central Soil and Materials Research Station, Ministry of Jal Shakti, DoWR, RD & GR, Government of India, Olof Palme Marg, Hauz Khas, New Delhi-110016.*

ABSTRACT
A shear zone is a zone of strong deformation (with a high strain rate) surrounded by rocks with a lower state of finite strain. The shear zone is the result of a huge volume of rock deformation due to intense regional stress, typically in the zones of subduction at depths down to a few kilometers In geology, a shear zone is a thin zone within the Earth's crust or upper mantle that has been strongly deformed, due to the walls of rock on either side of the zone slipping past each other. In the upper crust, where rock is brittle, the shear zone takes the form of a fracture called a fault. In the lower crust and mantle, the extreme conditions of pressure and temperature make the rock ductile. shear zone poses is a big challenge before the geotechnical engineers to realize the infrastructure projects. Shear zone is characterized by the large deformations/strains.
In the present study, Pressuremeter is used to characterize the material of the shear zone which was encountered at the site of hydroelectric projects.

I. INTRODUCTION

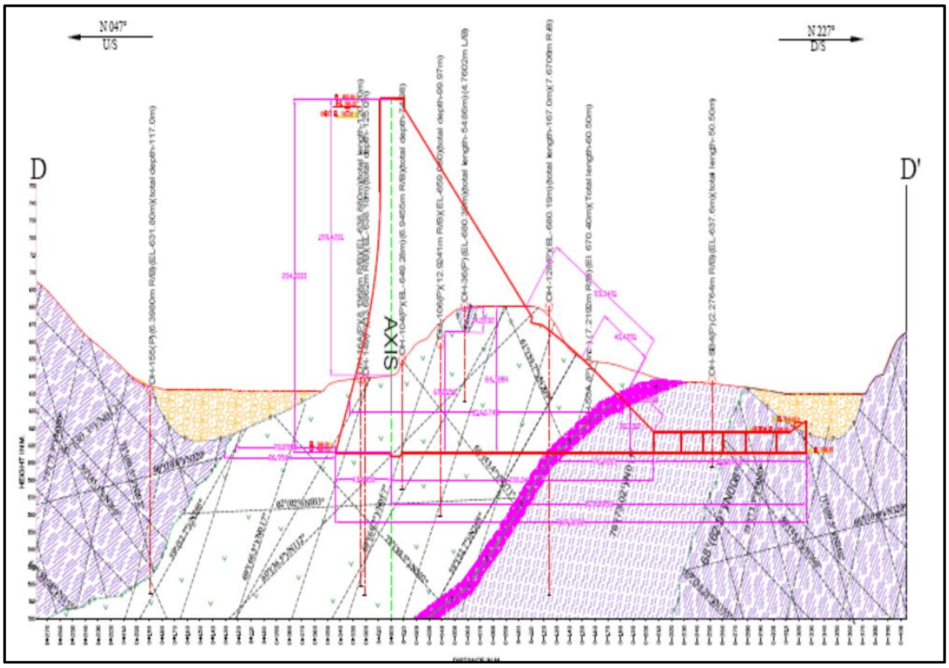
A shear zone is a zone of strong deformation (with a high strain rate) surrounded by rocks with a lower state of finite strain. The shear zone is the result of a huge volume of rock deformation due to intense regional stress, typically in the zones of subduction at depths down to a few kilometers. Shear zones are zones of intense ductile deformation that are thin relative their lateral extent. The material in the shear zone is produced by the crushing the rock due to lateral movements of rocks. The material of shear zone may be clay or silt and is highly plastic in depths and may be take the solid form due to high pressure. Characterization of the shear zone material is very important to determine the realistic values of the strength and deformations to realize the infrastructure projects. The current study presents the use of Pressuremeter to characterize the shear zone encountered at the location of hydroelectric project. Various in-situ tests in past were tried to characterize the shear zone, but all methods were failed as the shear zone material was very hard when dry and become washable on saturation. Even collection of undisturbed samples was also not possible.

II. The Project and its Geology

A concrete gravity Dam was planned over a river for the irrigation, water supply and hydro power generations. The project lies in rugged low-grade metamorphic terrain of Lesser Himalayas. The rocks around dam site belong to Chandpur Formation of the Jaunsar Group (Proterozoic) and fall on the southern limb of the E-W trending Jaunsar syncline. The rock types are slate, quartzite, their transitional/ interbedded variants and minor limestone. The metamorphic are intruded by a basic igneous body (Jaunsar Traps). This rocks consists mainly of dark greenish grey/ greyish green, medium grained, isotropic dolerite. The rock is sometimes fine grained and weakly foliated near the contacts of the basic body. The medium grained and isotropic rock material is very strong while the foliated or fine-grained material is strong to moderately strong. A narrow zone, of hybrid rock generally within a few metres in width, is discontinuously present along the contact of dolerite with the host slates and quartzites.

III. The Shear Zone

Zone of sheared and highly deformed rocks associated with the downstream contact of dam were observed on surface and in drifts varies from about 5m to 12m in width. It seems to be thicker in drift on left bank. The wider deformed zone seems to be the result of meager of a fault found on left bank, with the contact at lower level. The depth of the shear zone vary from 20 m to 150 m. The sheared zone along contact contains crushed/sheared rock, rock flour and subordinate calyces gouge. Basic rock was found to be moderately to highly weathered also at the contact for about 2m widths, in TRT excavation. In the under river drift, this contact has almost 5m thick sheared zone, including more than 1.2m thick plastic gougy zone, and about 5m wide zones of partial shearing/ deformation, in both the rocks. The nature of this contact is on left abutment, where this contact has a 5.45 m thick (apparent thickness, vertical) is observed that sheared zone containing clay gouge and crushed basic rocks. Figure 1 presents the location of shear zone encountered at the project site.



LOCATION OF SHEAR ZONE

IV. PRESSUREMETER TEST

Pressuremeter Test (PMT) is an in situ test to determine deformations and strength properties of soil or rock. PMT utilizes a probe that is inserted into the borehole upto the test depth of the strata. The probe is a flexible membrane that can be blown and expanded to provide pressure on the borehole wall so the soil or rock will be deformed. The probe is lowered into the borehole to the required test depth and the pressure is applied by in increments (10 nos.). Pressure and volume is observed from the control unit. The relationship curve of the pressure with lateral deformation of the soil is then used for the analysis of the test results of PMT.

V. THE EQUIPMENT

The equipment consists of a probe, a control unit/measuring device and a transmission line for water and gas. The flexible walls of the probe may consist of a single rubber membrane (single cell design) or of an inner rubber membrane fitted with an outer flexible sheath or cover (triple cell design) which will take up the shape of the borehole as pressure is applied. The control unit is kept on the ground adjacent to the bore hole.

The control unit includes a mechanism to apply pressure in increments or in volume increments to the probe and to measure the volume change or pressure change during the expansion of probe. The equipment which have hydraulic system and measuring cell and guard cells shall also include a regulator by which the pressure in the gas circuit is kept below the fluid pressure in the measuring cell. The magnitude of pressure difference between gas and fluid is adjustable to compensate for hydrostatic pressures developing in the probe.

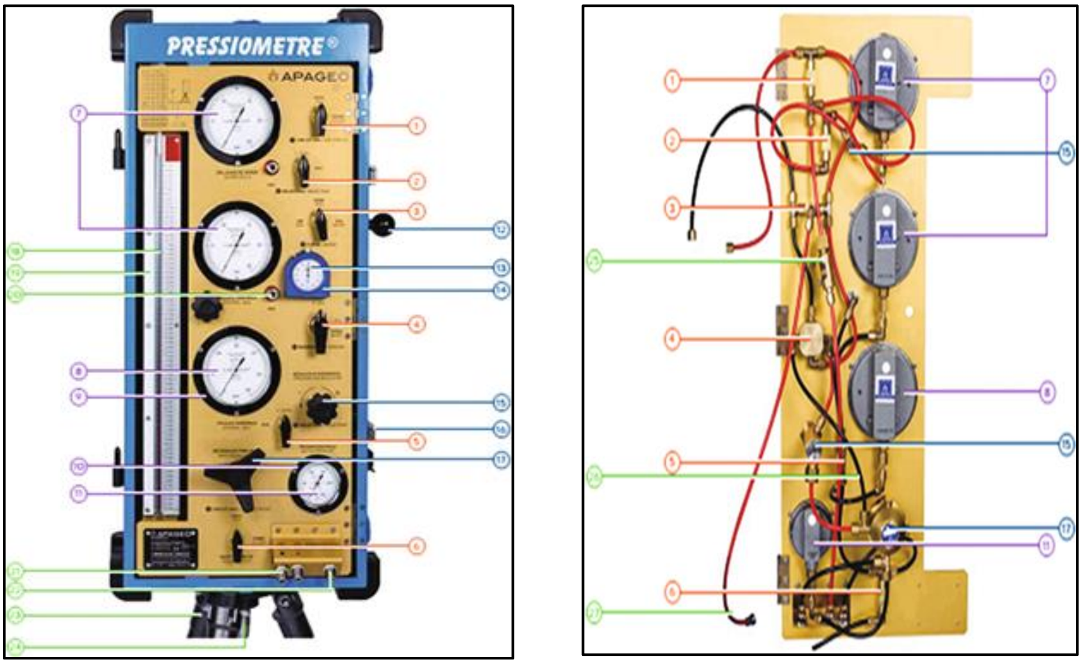


Figure 2: The Control Unit/Measuring Device

No.	Description	No.	Description
1	Gas circuit stop valve	15	Pressure Regulator
2	25/100 bar gas selection valve	16	Fixation of lid type 3
3	Bleed valve for both gas and water	17	Main pressure regulator
4	Inversion valve 0-10 m	18	Sight Tube Complete
5	25/100/60 bar water selection	19	Polycarbonate cover plate for sight tube
6	Water circuit stop valve	20	Quick female socket for extra gauge
7	0-25 bar gauge (vertical outlet)	21	Quick female socket for hose outlet(water & gas)
8	0-60 bar gauge (vertical outlet)	22	Quick female socket for nitrogen bottle inlet
9	Ø 100 gauge ring	23	Tripod
10	Ø 60 gauge ring	24	Stainless steel tripod axis
11	0-250 bar gauge (vertical outlet)	25	Filter housing complete
12	Ball fixation for Geobox[r]	26	Rilason tubing 3x6 pressuremeter inner black lead
13	Stop watch 1 minute	27	Rilason tubing 3x6 pressuremeter inner red lead
14	Protection case for stop watch		

Water and gas lines connects the probe with the control unit/ readout unit and consist of plastic tubing. In order to minimize the measuring errors, a coaxial tubing is used, whereby the inner tubing is prevented from expanding by a gas pressure at its perimeter. By applying the correct gas pressure, expansion of the inner tubing is reduced to a minimum. Single tubing can also be used. In both cases, volume loss correction is applied. Electric lines need special protection against groundwater. The Figure 2 presents the typical picture of an automatic Pressuremeter equipment.

VI. METHODOLOGY

To determine the strength and deformation properties of the shear zone materials, two bore holes were drilled in the shear zone. The depth of the bore hole on the left bank of the project where shear zone was encountered vary from 20 m to 30 m. The casing was provided in the bore holes above the shear zone to prevent the squeezing/collapse of the bore holes. The methods adopted for drilling the bore holes, should have minimum degrees of disturbance to the side of bore holes. In case of soils, the Pressuremeter tests must be performed immediately after the hole is formed.

Before conducting the Pressuremeter test, the pressuremeter equipment was calibrated for the pressure loss and volume loss so that the actual stresses and deformations can be obtained. The probe of the Pressuremeter was lowered in the bore hole and is inflated in equal pressure increments and measured the corresponding change in volume of probe till the limit pressure is reached or the cavity volume has doubled. The volume change is observed after 30 sec and 60 sec.. The pressure-volume curve is plotted between the corrected volume and the corrected pressure. A typical pressure-volume curve is shown in Figure 3. To estimate the corrected volume and the corrected pressure, pressure loss and volume loss correction are applied.

The pressuremeter modulus is determined by using the following formula,

$$E_{pmt} = 2(1+\nu)(V_0 + V_m)\frac{\Delta P}{\Delta V}$$

Where,

ν = Poisson's ratio

V_0 = Volume of the measuring cell of uninflated probe

V = Corrected volume of the measuring cell of the probe

ΔV = increase in volume of the measuring cell with the increment of pressure, ΔP

ΔP = Increase in the pressure in the measuring cell

V_m = Corrected volume in the measuring cell with the Increase of ΔV

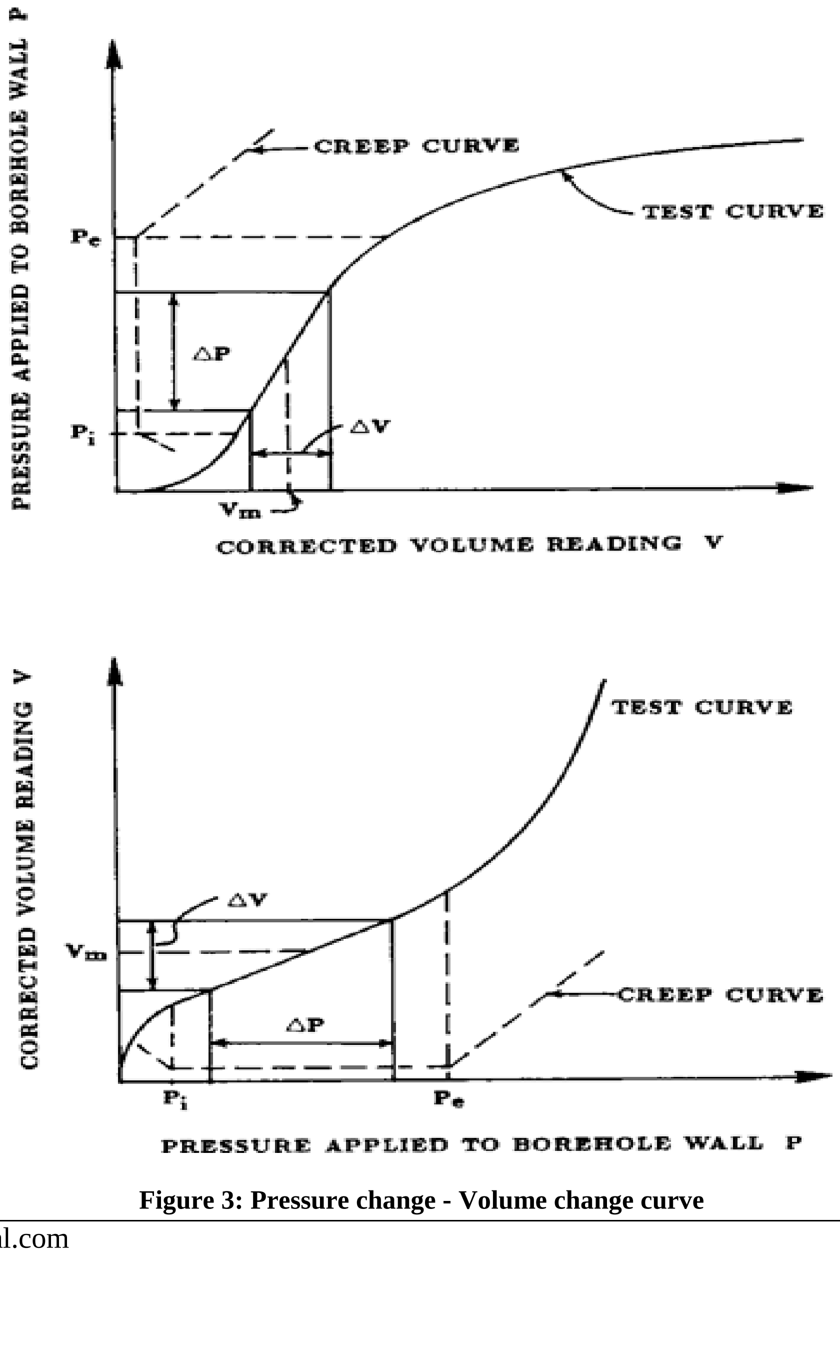


Figure 3: Pressure change - Volume change curve

VII. DISCUSSIONS OF RESULTS

The Pressuremeter test was conducted as per ASTM D 4719 and data was analysed and interpreted for evaluating the Menard Pressuremeter Modulus, Epmt and Limit Pressure, PL. The value of Poission's ratio is taken 0.33 for the shear zone materials.

Based upon the Pressuremeter test concluded in the bore holes, the values of Menard Pressuremeter Modulus, E_{pmt} vary from 4.721 x 10^4 kPa to 4.017 x 104 kPa and Limit Pressure, PL from 0.665 10^4 kPa to 0.64 x 104 kPa respectively. The graphical representation of the Volume V_s. Pressure is presented in Figure 4.

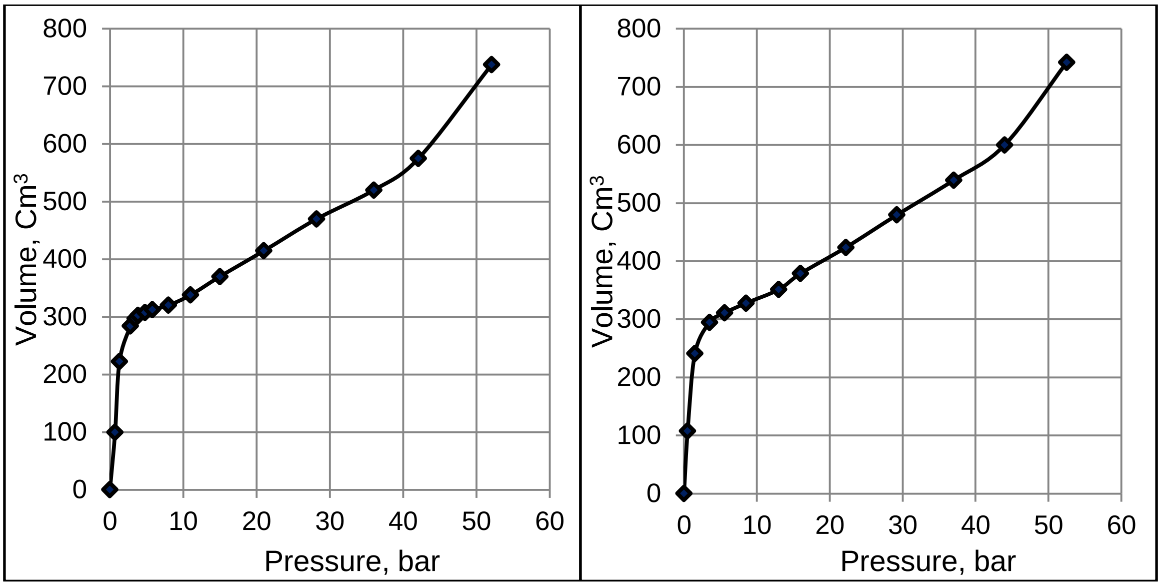


Figure 4: Pressure Vs. Volume change curve

VIII. CONCLUSIONS

The current paper presents the characterization of the shear zone by the Pressuremeter where other geotechnical and geological methods due their limitations could not be performed. the values of Menard Pressuremeter Modulus, Epmt vary from 4.721 x 104 kPa to 4.017 x 104 kPa and Limit Pressure, PL from 0.665 104 kPa to 0.64 x 104 kPa respectively. The tests results can be correlated to the deformation modulus to evaluate the deformations in shear zone.

The Pressuremeter is a new apparatus that is able to automatically perform a Pressuremeter test. and enables the geotechnical engineer to obtain repeatable measurements, and reduces inaccuracies that might be induced by the operator, uncertainties, and loss of head. The in- situ test performed demonstrate the feasibility of the auto-controlled test and the possibility to obtain good results. The provision of self-correction for pressure loss, volume loss in auto-controlled Pressuremeter, has many advantages and is of great interest especially in deep soils when using long tubing. The PMT expansion curve can be used to predict the load settlement behavior of shallow foundations and the load displacement curve of deep foundations under horizontal loading.

REFERENCES

[1]. AFNOR, NF P 94-110: Sols, Reconnaissances et essais-Essai pressiométrique Ménard. French Standard, Edited by afnor, Paris-La défense, Publisher Location, July 1991 (1991)

[2]. AFNOR, NF P 94-110-1: Sols, Reconnaissances et essais-Essai pressiométrique Ménard, Partie 1: Essai sans cycle. French Standard, Edited by afnor, Paris-La défense, Publisher Location, January 2000 (2000)

[3]. AFNOR, XP P 94-110-2: Sols, Reconnaissances et essais-Essai pressiométrique Ménard, Partie 1: Essai avec cycle. French Standard, Edited by afnor, Paris-La défense, Publisher Location, December 1999 (1999)

[4]. ASTM Standards D2240-15: Standard Test Method for Rubber Property - Durometer Hardness. Published August 2015. Originally approved in 1964. Last previous edition approved in August 2015 as D2240 – 15. Developed by Subcommittee: D11.10 (2015)

[5]. ASTM Standards D 4719-07: Standard Test Methods for Prebored Pressuremeter Testing in Soils. Current edition approved Feb. 15, 2007. Published April 2007. Originally approved in 1987. Under the jurisdiction of ASTM Committee D18 on Soil and Rock and the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations (2007)

[6]. Wissem Frikha and Serge Varaksin : Auto-Controlled Ménard Pressuremeter: A Novel Tool for Optimal Use of the Pressuremeter. Springer International Publishing AG 2018

[7]. CSMRS Report No.: 07/Soil-I/CSMRS/E/11/2023, November 2023.

[8]. Jean - Pierre Baud, Michel GAMBIN and Robert Heintz : Menard Pressuremeter Modulus: Relationship And Correlations Between Elastic, Pseudo Elastic And Cyclic E-Modulus As Defined By L. Ménard. Symposium International ISP7/PRESSIO 2015

[9]. Briaud J.-L. Ménard : Lecture - The pressuremeter test: Expanding its use. Proceedings of the 18th International Conference on Soil Mechanics and Geotechnical Engineering, Paris 2013

[10]. Ramsay JG. (1987). The Techniques of Modern Structural Geology. Volume 2: Folds and Fractures. Academic Press. ISBN 0-12-576902-4