Determination Of Properties Of Soil With Ultrasonic Pulse Velocity

Prof. J. M. Raut[1], Dr.S.R.Khadeshwar[2], Dr. S.P.Bajad[3] Prof.K.S.Ansari[4]

[1]*Ph.D. Scholar & Asst. Prof. Y.C.C.E., Wanadongri Nagpur,*
[2]*Professor, Y.C.C.E., Wanadongri Nagpur*
[3]*Head dept. of civil engg. , Government Polytechnic, Amravati*
4[1]Ph.D. Scholar & Asst. Prof. Y.C.C.E., Wanadongri Nagpur

---***---

Abstract -*In this paper, traditional soil testing is done on six different soil samples from central India. These samples are tested by modern ultrasonic testing method. Presently ultrasonic testing method is used for doing Non-destructive testing on concrete. Here we have done intensive tests by both methodologies. Results of a series of ultrasonic pulse velocity tests on various in situ soil samples were presented and discussed. Ultrasonic pulse velocity tests provide compression and wave velocity information. While studying experimentally the relation between pulse velocities, dry density, water content and compacting effort are established. Laboratory test specimens were prepared by static and dynamic compaction method in Proctor mould (100 mm dia.). Wave velocity was measured on each of the compacted specimen by adopting the direct transmission method. Unconfined compressive tests were also conducted on compacted samples of 37mm diameter to establish the relation between compressive strength and pulse velocity. All soils tested exhibited an increasing pulse velocity with increase in dry density until the optimum water content. A rapid drop in pulse velocity was observed subsequently with decrease in density irrespective of the type of soil, compaction method, and size of the specimen. Calibration curves have been developed for this purpose. Since the ultrasonic pulse velocity determination through soil is very simple and fast. So as compared to traditional methods for calculating density, pulse velocity method is very fast & easy. By doing pulse velocity test on soil sample and using calibration curves of present study can determine density and unconfined compressive strength of soil very easily.*

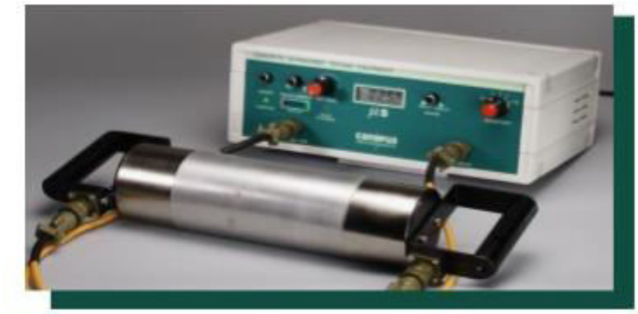
***Key Words*:**Ultrasonic, Pulse, Velocity, Soil, density

1.INTRODUCTION

In construction, soil is a significant part of the building process. If performed improperly, settlement of the soil could occur and result in unnecessary maintenance costs or structure failure. Almost all types of building sites and construction projects utilize conventional compaction techniques. There are five principle reasons to compact soil; Increases load-bearing capacity prevents soil settlement and frost damage, provides stability, Reduces water seepage, swelling & contraction and Reduces settling of soil. Soils are compacted for construction of various structures and facilities. Compacted soils are commonly used as embankments, sub grades, bases, and backfills for foundations and transportation facilities; and as hydraulic barriers for various facilities. Verifying the properties and condition of compacted soils is a significant component of design and construction with these materials. Compaction characteristics of soils are required for design, material selection, and quality control purposes. For this purpose the proctor compaction test is generally used to obtain the relation between water contain and dry density. But the time consumed by this test is more as well as the tests like unconfined compression test and their calculations are needed. To reduce this time we are trying to introduce the ultra-sonic pulse velocity method as an alternative. In-situ soils with various plasticity like black cotton soil, sandy soil etc. have been tested using conventional tests and then we performed the ultra sonic pulse velocity test on these samples & prepared the graph; water content v/s velocity, density v/s velocity and unconfined compressive strength v/s velocity. Then we found the relations by interpolating the results from the former conventional tests &ultra sonic pulse velocity test concluded the results. As the laboratory tests are conducted the standard values are obtained then In-situ sample is tested by conventional methods & cross check with the laboratory ultrasonic pulse velocity result then we concluded that our sample is standard. Now, any In-situ sample is tested by ultrasonic pulse velocity method and the parameters are defined for the soil sample regardless of conventional tests.

1.1 Test Procedure & Observations

CUTE 102A is a portable apparatus for Non-Destructive evaluation of concrete quality by Ultrasonic Pulse Velocity (UPV) measurement method. It is used to measure the transmission time of ultrasonic pulses in the test specimen, from which the velocity can be computed. A set of UPV readings can be used for further interpretations of structural concrete. The equipment is designed to comply with the recommendations of BS 1881 (Parts 210 & 203), ASTM C 597-71 (Reapproved 1979) and IS-13311 (Part I); 1992. The Instrument generates pulse of ultrasonic frequency, which is coupled into the concrete specimen under test by the transmitting transducer. The receiving transducer is used to detect these pulses & to convert them back into electrical pulses. Suitable coupling media are used to minimize the losses due to acoustic mismatch at the transducer-specimen interfaces. A 10MHz Quartz time base ensures accurate measurement of pulse transit time (T) with a resolution of 0.1 microseconds. The path Length (L) can be measured with a tape & hence the Ultrasonic Pulse Velocity (UPV) in the specimen under test can be computed as, V = L/T The CUTE 102A is a fully portable model with facility for using 12 V DC as well as 230 V AC supply.



Ultrasonic Pulse Velocity (UPV) Instrument

A liquid crystal display (LCD) provided on the front panel ensures good readability during outdoor use. The equipment is applicable for estimation of properties of concrete. We have used this instrument for conducting test on soil sample. Tests were conducted on clayey soils collected from different locations like black cotton soil from farm, besa, chandrapur etc.

TABLE I

Dry density in gm/cm3	Observed water content in %	UCS in gm/cm2	Velocity in mm/μs
Black cotton soil (LL73.16 PL15.00)			
4.62	23.10	0.153	0.429
4.72	26.32	0.218	0.496
4.78	27.66	0.232	0.537
4.58	29.93	0.178	0.528
4.80	32.94	0.110	0.456
Besa Soil (LL55.42 PL29.26			
5.37	23.10	0.156	0.561
5.28	25.9	0.097	0.584
5.19	27.95	0.152	0.646
5.1	28.6	0.013	0.395
5.02	31.8	0.010	0.200
Chandrapur soil (LL55.498 PL30.76			
5.03	18.40	0.135	0.520
5.82	20.04	0.164	0.615
5.37	21.52	0.180	0.784
4.96	24.88	0.055	0.727
5.20	30.15	0.048	0.447
Chandrapur soil near river(LL40.97 PL24.47)			
5.15	20.08	0.151	0.414
5.42	21.1	0.167	0.627
5.48	24.51	0.190	0.727
5.28	26.1	0.073	0.598
5.30	28.2	0.062	0.587
Soil near college ground (LL38.94 PL31.67)			
5.32	18.29	0.140	0.474
5.5	22.32	0.140	0.587
5.55	23.14	0.180	0.646
5.17	25.13	0.074	0.547
5.11	26.83	0.046	0.441
Sandy Soil(LL32.82 PL61.47)			
5.840	10.690	0.161	0.627
5.820	10.340	0.151	0.371
5.810	18.720	0.067	0.179
5.550	26.050	0.052	0.100
5.250	21.920	0.023	0.050

The testing program consisted of measuring all the basic properties of soil like liquid limit, plastic limit, and sieve analysis, standard proctor test and pulse wave velocity on compacted soil using the direct transmission method on soil sample of 100 mm diameter extracted from mould. Unconfined shear strength of soil also tested. Observations are tabulated In TABLE-I

1.2 Graph: - Velocity Vs Dry Density

Variation of density & velocity with water content for soil samples prepared by compaction in proctor mould are shown in graph respectively. The effect of plasticity is well reflected in graph, the soil of high plasticity has low density & higher moisture content. The maximum dry density & corresponding moisture contents for soils tested under different test conditions are shown in tables.

The velocity, water content relation indicates that the pulse velocity increased with water content of respective soil. A linear trend is observed from the data showing a co-relation between velocity & water content. Beyond optimum moisture content, the increase in water content showed reduction in pulse velocity for all type of soil tested. The relation between water content & velocity follows the relation between density & water content. Among the soil samples tested the peak velocity of low plastic soil is higher than the high plastic soil, which is not dependent on compaction method. Wave propagation as measured using this ultrasonic pulse velocity device appears to be mainly influenced by soil moisture content.

As we have seen that there is a relationship between velocity and dry density of soil from graph. From study of these two parameters for six soil samples typical variation are found and shown in graph. For any tested soil, the velocity increases with density and pattern follows for others too. Further it can be seen from graph that P waves are propagating with different order of velocity under different water contents irrespective of physical state. Test results of standard compaction energy as well as static compaction have also exhibited similar trend.

As the relation between velocity & density is linear irrespective of energy & method of compaction thus we can arrive at a conclusion i.e. an empirical relationship. The figure shows us the velocity versus density variation in case of soil. Thus by the help of linear regression relationship can be found.

Thus by the data we found from the test, we arrive at a conclusion i.e. grater the velocity of wave more is a dry density.

1.3 Velocity and Compressive Strength

Unconfined compressive strength measured on the compacted samples of 38 mm diameter are related with velocity of propagation of P waves as both of them are functions of density and moisture content independently. The relation between them for the various conditions of testing is shown. The compressive strength increases exponentially with increase in velocity. The lesser correlation coefficient is attributed to grouping the data from various test conditions. However, the results of specimens compacted at optimum moisture content have resulted in a better correlation coefficient.

3. CONCLUSIONS

In this study over 40 specimens were tested and pulse velocities were measured by direct transmission method. The parameters investigated were compaction energy, method of compaction, soil type, specimen size and water content. Based on the results following important conclusions are drawn

- Irrespective of the type of soil, method of compaction and energy of compaction, the relation between velocity and water content established an identical relation to that of a typical compaction characteristic curve of Proctor.
- Peak velocities and maximum densities were within ± 1% water content for the soil types tested.
- The pulse velocity increased with compaction energy and decreased with plasticity. The relation between velocity and density is linear for the soils tested.
- Unconfined compressive strength and secant modulus of compacted soils were correlated with velocity and are found to vary exponentially with velocity.

REFERENCES

[1] JoramM.Amir "Single Tube Ultrasonic Testing of Pile Integrity" ASCE Deep Foundation Congress, Vol. 1 pp. 836-850, Orlando
[2] NazliYesiller,JamesL.Hanson,Mumtaz A. Usmen " Ultrasonic Assessment of Stabilized Soils"
[3] S. M. Metev and V. P. Veiko, Laser Assisted Microtechnology, 2nd ed., R. M. Osgood, Jr., Ed. Berlin, Germany: Springer-Verlag, 1998.
[4] J. Breckling, Ed., The Analysis of Directional Time Series: Applications to Wind Speed and Direction, ser. Lecture Notes in Statistics. Berlin, Germany: Springer, 1989, vol. 61.
[5] S. Zhang, C. Zhu, J. K. O. Sin, and P. K. T. Mok, "A novel ultrathin elevated channel low-temperature poly-Si TFT," IEEE Electron Device Lett., vol. 20, pp. 569–571, Nov. 1999.
[6] M. Wegmuller, J. P. von der Weid, P. Oberson, and N. Gisin, "High resolution fiber distributed measurements with coherent OFDR," in Proc. ECOC'00, 2000, paper 11.3.4, p. 109.
[7] R. E. Sorace, V. S. Reinhardt, and S. A. Vaughn, "High-speed digital-to-RF converter," U.S. Patent 5 668 842, Sept. 16, 1997.
[8] A. Karnik, "Performance of TCP congestion control with rate feedback: TCP/ABR and rate adaptive TCP/IP," M. Eng. thesis, Indian Institute of Science, Bangalore, India, Jan. 1999.
[9] J. Padhye, V. Firoiu, and D. Towsley, "A stochastic model of TCP Reno congestion avoidance and control,"

Univ. of Massachusetts, Amherst, MA, CMPSCI Tech. Rep. 99-02, 1999.

[10] Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification, IEEE Std. 802.11, 1997.

[11]

[12] Brown, E.T. and Babu, G.L.S. (2009), Strength of a model of jointed soil, Soils and Foundations, 96(SM2), 685-704.

[13] Einstein, H.H., Choudhury, D. and Viswanadham, B.V.S. (2010), Model studies on mechanics of engineering, Jl. of Geotech. and Geoenv. Engineering, ASCE, 140(3), 229-248.

[14] Right, K.H., Murty, D.S. and Venkatachalam, G. (1995), Review of reliability engineering in geotechnics, 4th Intl. Conf. on Reliability Engineering, Feb. 3-5, 1995, Madrid, J.H.Lu, M.V.Chin, A.Juneja (eds.), Balkema (Pubs.), Vol. 1, 201-210.

[15] Singh, D. (1991), Static response of fibre reinforced soil, Doctoral Thesis, Indian Institute of Technology Bombay, Mumbai, India.