

Determination of Volumetric Shrinkage of Soils by Dish Method

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Abstract. Shrinkage characteristics of soils are very important parameters for consideration in the design of a safe and stable foundation. Volumetric shrinkage test gives a very effective idea about shrinkage behaviour of the soils. Bureau of Indian Standards (BIS) recommended the method of test for soils, for determination of shrinkage factors, as per Indian Standards IS: 2720 (Part 6) – 1972 (Reaffirmed - 1995). This method is commonly used to determine various shrinkage factors of soils. This laboratory method is very sophisticated, costly and time taking method. Generally, this test is not available easily in the middle class and small towns and everyone cannot afford the expense of this test. Authors developed an alternative method named "Dish Method" to determine volumetric shrinkage of soils. The study suggests a very simple, quick, effective, and economical procedure for the determination of volumetric shrinkage of soils by - Steel Dish, Plastic Dish, and Paper Dish Methods. The proposed method provides a preliminary idea about the shrinkage characteristic of cohesive soil.

Keywords: Volumetric Shrinkage, Bureau of Indian Standard (BIS), Dish Method, Shrinkage and Swelling, Steel Dish.

1 Introduction

The study has been carried out in city Jabalpur and it's surrounding. In central India, city Jabalpur (23° 10' N, 79° 57' E, MSL - 402 M) is seismically sensitive because it is located in an earthquake-prone area. As per IS: 1893-1984, Jabalpur comes under earthquake zone III [2]. The study is particularly more applicable in cities like Jabalpur which are vulnerable to the occurrence of major earthquakes as one which took place earlier. An earthquake of M 6.0 on Richter scale rocked Jabalpur and the surrounding area in the early morning hours on 22nd May 1997. The epicenter of the earthquake was located about 12 km SE to the city of Jabalpur [5]. The maximum intensity observed in the epicenter area due to this earthquake was VIII on MMI scale. Maximum losses were observed on non engineered constructions. Its after-effects were the death of about 50 people and a great loss of property exceeding rupee 500 crores [7]. Looking to the seismic vulnerability of the city, a study has been done to bring out the engineering characteristics of soils in sensitive areas for safe and stable construction. In this case study, 10 such sensitive locations have been selected. Field and laboratory tests e.g. Trial Pits, Trial Bores, Soil Colour, Moisture Content, Specific Gravity, Grain Size Analysis, Liquid Limit, Plastic limit, Shrinkage Factors, and Free Swelling Index, etc. have been carried out for

determination of various parameters of the soil at selected locations [6]. All tests have been done as per Indian Standard methods recommended by Bureau of Indian Standard (BIS). During the case study in Jabalpur a method named - Dish Method, has been originated and developed by the authors. This method may be used as an alternative method for the determination of volumetric shrinkage of soils. Dish method may be considered as a conventional method for assessment of volumetric shrinkage very easy, fast and economically. Selected locations on which study has been done are listed in table 1 and also shown on the map of Jabalpur city in figure 1.

Table 1. List of Selected Locations.

S. No.	Selected Locations	Case Study Nos.	Longitude	Latitude
1	Deen Dayal Chowk Bus Stop	CS 1	23 ⁰ 11' 40" N	79 ⁰ 54' 49" E
2	Shatabdipuram	CS 2	23 ⁰ 10' 30" N	79 ⁰ 54' 32" E
3	Tilwara Ghat	CS 3	23 ⁰ 06' 15" N	79 ⁰ 52' 40" E
4	Rani Durgawati Park	CS 4	23 ⁰ 09' 40" N	79 ⁰ 56' 13" E
5	Gullawa Lake	CS 5	23 ⁰ 09' 44" N	79 ⁰ 54' 20" E
6	Kachhpura Bridge	CS 6	23 ⁰ 10' 10" N	79 ⁰ 54' 13" E
7	S.C. Bose Medical College	CS 7	23 ⁰ 09' 05" N	79 ⁰ 52' 10" E
8	Bhatoli Bridge	CS 8	23 ⁰ 05' 42" N	79 ⁰ 56' 32" E
9	Gokapur Lake J.E.C. Jabalpur	CS 9	23 ⁰ 11' 31" N	79 ⁰ 59' 20" E
10	Jawaharlal Nehru Agriculture University	CS 10	23 ⁰ 12' 13" N	79 ⁰ 57' 15" E



Fig.1. Selected Locations on Map of Jabalpur.
(Map Source: Jabalpur Ke Sarovar – Anmol Dharohar) [8]

2 Determination of Atterberg’s Limits of Soil as per IS: 2720 (Part 5) and Classification of Soil as per IS: 1498 – 1970

Atterberg’s limits, e.g., Liquid Limit, Plastic Limit, and Plasticity Index of Soils as per IS: 2720 (Part 5), and Classification of the soil as per IS: 1498 – 1970 for selected locations under study, are compiled in table 2.

Table 2. Atterberg’s Limits as per IS:2720 (Part 5) and Soil Classification as per IS: 1498-1970

S. No.	Case Study Nos.	Selected Locations	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Classification of Soils as per IS: 1498 - 1970
1	CS 1	Deen Dayal Chowk Bus Stop	56	27	29	CH
2	CS 2	Shatbdipuram	56	26	30	CH
3	CS 3	Tilwara Ghat	33	28	5	SML
4	CS 4	Rani Durgavati	40	26	14	CI

Park						
5	CS 5	Gullawa Lake	51	26	25	CH
6	CS 6	Kachhpura Bridge	51	22	29	CH
7	CS 7	S.C. Bose Medical College	55	24	31	CH
8	CS 8	Bhatoli Bridge	36	22	14	SMI
9	CS 9	Gokalpur Lake J.E.C. Jabalpur	40	26	14	SMI
10	CS 10	Jawaharlal Nehru Agriculture University	52	27	25	CH

3 Determination of Volumetric Shrinkage of Soil as per IS: 2720 (Part 6) - 1972

Shrinkage Factors e.g. Shrinkage Limit (%), Shrinkage Ratio, Volumetric Shrinkage (%) and Degree of Shrinkage (%) at all selected locations in Jabalpur (CS1 – CS10) have been worked out as per the IS: 2720 (Part 6) [4]. Results of Shrinkage Factors are mentioned in table 3

Table 3. Shrinkage Factors at Selected Locations as per IS:2720 (Part 6).

S. No.	Case Study Nos.	Selected Locations	Shrinkage Limit (%)	Shrinkage Ratio	Volumetric Shrinkage (%)	Degree of Shrinkage (%)
1	CS 1	Deen Dayal Chowk Bus Stop	13.56	1.95	67.77	40.39
2	CS 2	Shatbdipuram	11.6	1.77	52.8	34.55
3	CS 3	Tilwara Ghat	18.24	1.74	28.03	21.87
4	CS 4	Rani Durgavati Park	14.46	1.84	23.93	19.31
5	CS 5	Gullawa Lake	14.36	1.92	65.3	39.5
6	CS 6	Kachhpura Bridge	16.34	1.87	42.05	29.6

7	CS 7	S.C. Bose Medical College	15.06	1.76	84.98	45.94
8	CS 8	Bhatoli Bridge	15.49	1.72	35.75	26.34
9	CS 9	Gokulpur Lake J.E.C. Jabalpur	13.31	1.91	35.46	26.05
10	CS 10	Jawaharlal Nehru Agriculture University	16.29	1.73	36.67	26.83

4 Determination of Volumetric Shrinkage of Soil by Dish Method

Dish method is developed by authors to determine volumetric shrinkage of soils. This method can be considered as a primary method to assess the shrinkage behaviour of soils. The proposed method suggests the test for determination of volumetric shrinkage of soil very easily and economically. This test can be performed by anyone dish out of three types of shrinkage dishes e.g. Steel dish, Plastic dish or Paper dish. As per this method; firstly determine inner diameter and depth of these dishes by steel scale up to a least count 0.5 mm (Vernier caliper scale can also be used for more accuracy). Determine the volume of each type of dish. (In this case study, steel dish has been used and the diameter of the Steel dish is 5 cm and the depth of the dish is 2.5 cm). Take about 100 gm dry soil sample and mix with water in an amount sufficient to fill the soil voids fully and to make the soil pasty enough to be readily worked into the dish without entrapping air bubbles [3]. Fill the dish with the prepared soil sample in three equal layers properly pressed with a spoon. On filling each one-third layer, the dish should be gently struck on the firm surface until the paste is thoroughly compacted and all entrapped air has been brought to the surface. After filling the dish in three layers, strike off the excess soil by a flat spoon. Put the dish for drying in the open air under sunlight for 24 to 48 hours. On drying the sample, measure the dimensions of the dried soil pat with scale up to 0.5 mm. Finally, determine shrinkage in volume of the soil pat.

This method gives very appreciable results in comparison to laboratory test for determination of volumetric shrinkage as per Indian Standard IS: 2720 (Part 6). In this study volumetric shrinkage of soils for selected locations has been carried out with steel dish. Calculations for the determination of volumetric shrinkage of soils by steel dish method are shown in table 4 and pictures of the test procedure are shown in figure 2 (i) and (ii).

Table 4. Determination of Volumetric Shrinkage of Soils by Steel Dish Method.

S. No.	Case Study Nos.	Steel Dish				Dry Pat				Volumetric Shrinkage (%)
		Dia of Steel Dish	Depth of Steel Dish	Volume of Steel Dish	Wet Volume of Soil (V1)	Dia of Dry Pat	Depth of Dry Pat	Volume of Dry Pat	Dry Volume of Pat (V2)	
		CM	CM	CM ³	CM ³	CM	CM	CM ³	CM ³	{(V1 - V2) *100}/V2 (%)
1	CS1	5	2.5	49.06	49.06	4.5	1.9	30.20	30.20	62.44
2	CS2	5	2.5	49.06	49.06	4.65	1.95	33.10	33.10	48.23
3	CS3	5	2.5	49.06	49.06	4.7	2.3	39.88	39.88	23.01
4	CS4	5	2.5	49.06	49.06	4.7	2.35	40.75	40.75	20.40
5	CS5	5	2.5	49.06	49.06	4.5	1.9	30.20	30.20	62.44
6	CS6	5	2.5	49.06	49.06	4.6	2.2	36.54	36.54	34.26
7	CS7	5	2.5	49.06	49.06	4.3	1.9	27.58	27.58	77.91
8	CS8	5	2.5	49.06	49.06	4.7	2.2	38.15	38.15	28.61
9	CS9	5	2.5	49.06	49.06	4.6	2.3	38.20	38.20	28.42
10	CS10	5	2.5	49.06	49.06	4.65	2.2	37.34	37.34	31.39



Fig. 2. (i and ii). Dish Method for Determination of Volumetric Shrinkage (%) of Soils.

5 Comparison of Volumetric Shrinkage of Soils

During this study, the volumetric shrinkage of the soils at selected locations has been determined by dish method (developed by the author) and as per Indian Standard method IS: 2720 (Part 6) [4]. The difference in results of volumetric shrinkage by both the above-mentioned methods has also been determined. Comparisons of the results of both the methods for all ten selected locations are shown in Table 5.

Table 5. Comparison of Volumetric Shrinkage (%) between IS: 2720 (Part 6) and Dish Method [1].

S. No.	Name of Locations	Case Study Nos.	Volumetric Shrinkage as per IS: 2720 (Part 6) (%)	Volumetric Shrinkage by Dish Method (%)	Difference In Volumetric Shrinkage (%)
1	Deen Dayal Chowk Bus Stop	CS 1	67.77	62.44	5.33 %
2	Shatbdipuram	CS 2	52.8	48.23	4.57 %
3	Tilwara Ghat	CS 3	28.03	23.01	5.02 %
4	Rani Durgavati Park	CS 4	23.93	20.4	3.53 %
5	Gullawa Lake	CS 5	65.3	62.44	2.86 %
6	Kachhpura Bridge	CS 6	42.05	34.26	7.79 %
7	S.C. Bose Medical College	CS 7	84.98	77.91	7.07 %
8	Bhatoli Bridge	CS 8	35.75	28.01	7.74 %
9	Gokalpur Lake JEC Jabalpur	CS 9	35.46	28.42	7.04 %
10	Jawaharlal Nehru Agriculture	CS 10	36.67	31.39	5.28 %

6 Results and Discussion

Volumetric Shrinkage of the soils at selected locations has been determined by Indian Standard Method and by Dish Method. Volumetric Shrinkage of the soils determined by dish method is on an average 3% to 8% less than that of the volumetric shrinkage determined by IS: 2720 (Part 6) [4]. Comparison of the result is shown graphically in fig 3.

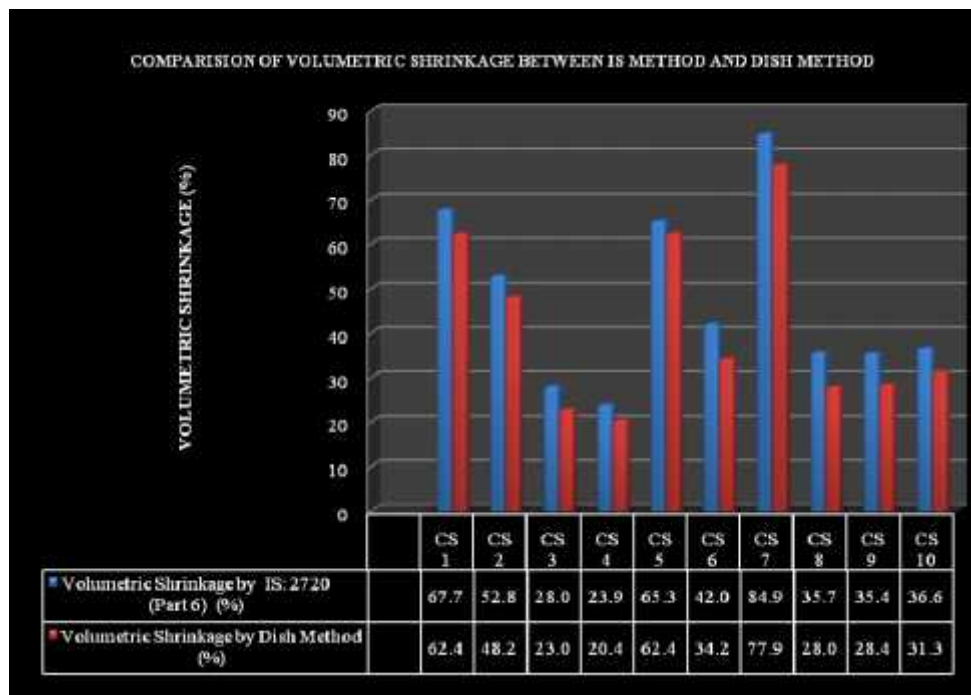


Fig. 3. Comparisons of Volumetric Shrinkage (%) by IS: 2720 (Part - 6) Method and Dish Method.

7 Conclusions

Shrinkage on drying is indicative of the structure of the soil. The greater the shrinkage the more dispersed the structure. Volumetric shrinkage of soils at ten selected locations in Jabalpur city and its surrounding has been assessed. Based on the methodology employed and result obtained, it is quite appreciable that volumetric shrinkage of the cohesive soils determined by the dish method is very close to that of determined by laboratory method as per IS: 2720 (Part 6) 1972. Dish method is very easy and economical. This method is so simple and can be used by common persons to assess shrinkage behaviour of the cohesive soil in small towns and villages where soil test facilities are commonly not available. The proposed method can be further extended to determine the degree of shrinkage of soil and thus soil can be easily classified as very poor, poor, medium or good soil.

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