

Modelling and Simulation of Dry Density on Variation of Permeability and Specific Gravity in Silty Clay Deposition

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Abstract

In geotechnical engineering, it is imperative to comprehend the behaviour of silty clay deposits to ensure effective structural design and analysis. This study primarily focused on investigating how permeability and specific gravity influence the dry density of silty clay deposits. The objective was to develop an integrated model to predict variations in dry density in relation to these parameters, thereby addressing knowledge gaps regarding local conditions and external factors that affect predictability. Laboratory experiments were conducted to measure the permeability, specific gravity, and dry density of silty clay samples. The findings consistently showed experimental dry density values exceeding 100 kg/m^3 , with notable peaks such as 1861.20 kg/m^3 (predicted) and 1739.1 kg/m^3 (experimental) at varying depths. Graphical analysis confirmed a strong linear relationship among dry density, permeability, and specific gravity, validating the predictive model against the experimental results. The results indicated that the experimental values offered the best fits and frequently surpassed the typical permissible limits set for foundation soils, which are generally above 1300 kg/m^3 . However, discrepancies between predictive and experimental outcomes underscored the impact of external factors such as spatial heterogeneity, compaction effort, and mineralogy, which hindered consistent predictability. These findings reinforce the critical relationship among permeability, specific gravity, and dry density in silty clay deposits. Further research should aim to expand the dataset and explore additional variables to enhance model accuracy and applicability in engineering practices. It is essential to provide recommendations for improved site-specific assessments and methodological refinements in data collection and analysis to optimize the use of silty clay in civil engineering projects.

Keywords: *Modelling, Dry Density, Permeability, Specific Gravity, and Silty Clay Deposition*

1. Introduction

Clays are common types of fine-grained soils widely used in geotechnical projects. Understanding the behaviour and properties of these soils is critical for the accurate design and analysis of various structures such as foundations, slopes, and retaining walls. Two important parameters that greatly influence the behavior of silty clay deposits are permeability and specific gravity. Permeability refers to the ability of a soil to allow water through interconnected voids. This is an important property that affects the drainage properties of soil deposits and groundwater flow. The permeability of silty clays varies widely depending on factors such as particle size distribution, compaction, and mineralogy. Understanding the relationship between hydraulic conductivity and other soil properties is important for predicting the hydraulic conductivity and infiltration behavior of silty clay deposits. Specific gravity, on the other hand, is a measure of the density of a substance relative to the density of water. This provides valuable information about soil porosity, porosity, and compaction properties. For silty clays, specific gravity can be influenced by factors such as mineralogy, organic matter content, and compaction operations. The specific gravity of a soil affects its shear strength, compressibility, and settlement behavior. The dry density of soil is an important parameter characterizing its compaction state. It is affected by various factors such as soil permeability and specific gravity. Understanding the relationship between dry density, permeability, and specific gravity of silty clay deposits is important for optimizing compaction operations and predicting soil engineering properties during construction. Modelling and simulation of dry density changes based on permeability and specific gravity in muddy clay deposits

$$\int \frac{\partial^2 \phi}{\partial x^2} = \frac{\beta \tau}{K} \dots\dots\dots (5)$$

$$\frac{\partial \phi}{\partial x} = \beta \tau x + C_1 \dots\dots\dots (6)$$

Integrating (6); $\phi_1 = \frac{\beta \tau}{2} x^2 + C_1 x + C_2 \dots\dots\dots (7)$

$$x = 0, \phi = \phi_0 \rightarrow \phi_0 = C_2$$

$$x = \infty, \phi = 0 \therefore \rightarrow \phi_1 = \phi_2$$

Obtaining the auxiliary equation for equation (3)

$$V \frac{\partial^2 \phi}{\partial z^2} = U \frac{\partial \phi}{\partial z} - \beta \tau = 0 \dots\dots\dots (8)$$

$$Vm^2 - Um - \beta \tau = 0 \dots\dots\dots (9)$$

$$m = \frac{U \pm \sqrt{U^2 - 4UV}}{2V} \dots\dots\dots (10)$$

So, we have:

$$\phi_2(z) = \alpha_1 \text{Cos } m_1 z + \alpha_2 \text{Sin } m_2 z \dots\dots\dots (11)$$

Combining equations (7) and (11), the assumed solution becomes:

$$\phi(x, z) = \phi_1(x) + \phi_2(z)$$

$$\phi(x, z) = \phi_0 + \alpha_1 \text{Cos } m_1 z + \alpha_2 \text{Sin } m_2 z$$

3. Materials and Methods

Sampling and Preparation:

To get started, we collected soil samples from the field, ensuring that they truly represent the area we were interested in. we took multiple subsamples from different locations and depths to capture any variations in the ground conditions. After gathering the samples, we let them air-dry. Once dry, we placed the samples in a preparation container, where we removed excess moisture, organic matter, and debris. This step helped break apart any large clumps and eliminated stones and particles that were too big. Measuring Water Content: Next, we measured the water content. First, we weighed an empty water container and recorded its weight as W1. Then, we took a portion of the soil sample and weighed it, marking this weight as W2. We placed the soil in a moisture container and dried it in the oven at about 105°C until it reached a stable weight. After drying, we allowed it to cool in a desiccator and weighed it again, labeling this weight as W3. With all these measurements, we could calculate the moisture content using the formula: Moisture Content = [(W2 – W3) / (W3 – W1)] × 100%. Proctor Compression Test: we then conducted the Proctor Compression Test, either using the Standard or Modified method. we set the compression hammer to the appropriate drop height and weight, usually 5.5 pounds or 10 pounds. We added the soil to a mold in layers, ensuring that each layer was evenly distributed and compacted with a specified number of blows. As we went along, we recorded the weight and water content for each layer. We repeated this process at several moisture content levels, experimenting with about 3 to 5 different settings, including the range we thought would be optimal for compaction. Dry Density Measurement: For measuring dry density, we carefully

removed the compacted soil sample from the mold and trimmed off any excess soil around the edges. we weighed the compacted sample and recorded this weight as W4. Using this measurement, we calculated the dry density with the following formula: $Dry\ Density = (W4 / V)$ where V represents the volume of the mold. we made sure to repeat the test for each moisture content level to gather a range of dry densities.

Data Analysis and Interpretation: Finally, we analyzed the data by plotting a compaction curve. We placed dry density on the Y-axis and moisture content on the X-axis. From the curve, we identified the maximum dry density by finding the moisture content that coincided with the peak. This peak indicated the optimum water content, and from there, we determined the maximum dry density value based on my compaction results.

4. Results and Discussion

Table 1: Predictive and Experimental Values of Dry Density at Different Depths

Depth	Predictive Dry Density on Variation of Permeability and Specific Gravity [Kg/m3] [0.0000072/2.6]	Experimental Dry Density on Variation of Permeability and Specific Gravity [Kg/m3] [0.0000072/2.6]
0.2	33.83998153	31.62
0.4	67.67996307	63.24
0.6	101.5199446	94.86
0.8	135.3599261	126.48
1	169.1999077	158.1
1.2	203.0398892	189.72
1.4	236.8798707	221.34
1.6	270.7198523	252.96
1.8	304.5598338	284.58
2	338.3998153	316.2
2.2	372.2397969	347.82
2.4	406.0797784	379.44
2.6	439.9197599	411.06
2.8	473.7597415	442.68
3	507.599723	474.3
3.2	541.4397045	505.92
3.4	575.2796861	537.54
3.6	609.1196676	569.16
3.8	642.9596491	600.78
4	676.7996307	632.4
4.2	710.6396122	664.02
4.4	744.4795937	695.64
4.6	778.3195753	727.26
4.8	812.1595568	758.88
5	845.9995383	790.5
5.2	879.8395199	822.12

5.4	913.6795014	853.74
5.6	947.5194829	885.36
5.8	981.3594645	916.98
6	1015.199446	948.6
6.2	1049.039428	980.22
6.4	1082.879409	1011.84
6.6	1116.719391	1043.46
6.8	1150.559372	1075.08
7	1184.399354	1106.7
7.2	1218.239335	1138.32
7.4	1252.079317	1169.94
7.6	1285.919298	1201.56
7.8	1319.75928	1233.18
8	1353.599261	1264.8
8.2	1387.439243	1296.42
8.4	1421.279224	1328.04
8.6	1455.119206	1359.66
8.8	1488.959187	1391.28
9	1522.799169	1422.9
9.2	1556.639151	1454.52
9.4	1590.479132	1486.14
9.6	1624.319114	1517.76
9.8	1658.159095	1549.38
10	1691.999077	1581
10.2	1725.839058	1612.62
10.4	1759.67904	1644.24
10.6	1793.519021	1675.86
10.8	1827.359003	1707.48
11	1861.198984	1739.1

Table 2: Predictive and Experimental Values of Dry Density at Different Depths

Depth	Predictive Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] [0.0000013/2.62]	Experimental Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] [0.0000013/2.62]
1	30.54983996	28.54
2	61.09967992	57.08
3	91.64951987	85.62
4	122.1993598	114.16
5	152.7491998	142.7
6	183.2990397	171.24
7	213.8488797	199.78

8	244.3987197	228.32
9	274.9485596	256.86
10	305.4983996	285.4
11	336.0482395	313.94
12	366.5980795	342.48
13	397.1479195	371.02
14	427.6977594	399.56
15	458.2475994	428.1
17	519.3472793	485.18
18	549.8971192	513.72
19	580.4469592	542.26
20	610.9967992	570.8
21	641.5466391	599.34
22	672.0964791	627.88
23	702.646319	656.42
24	733.196159	684.96
25	763.745999	713.5
26	794.2958389	742.04
27	824.8456789	770.58
29	885.9453588	827.66
30	916.4951987	856.2
31	947.0450387	884.74
33	1008.144719	941.82
34	1038.694559	970.36
35	1069.244399	998.9
36	1099.794238	1027.44
37	1130.344078	1055.98
38	1160.893918	1084.52
39	1191.443758	1113.06
40	1221.993598	1141.6
42	1283.093278	1198.68
43	1313.643118	1227.22
44	1344.192958	1255.76
46	1405.292638	1312.84
47	1435.842478	1341.38
48	1466.392318	1369.92
49	1496.942158	1398.46
50	1527.491998	1427
51	1558.041838	1455.54
52	1588.591678	1484.08
53	1619.141518	1512.62
54	1649.691358	1541.16
55	1680.241198	1569.7
56	1710.791038	1598.24

57	1741.340878	1626.78
58	1771.890718	1655.32
59	1802.440558	1683.86
60	1832.990397	1712.4

Table 3: Predictive and Experimental Values of Dry Density at Different Depths

Depth	Predictive Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] [0.0000014/2.64]	Experimental Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] 0.0000014/2.64]
2.5	76.37495789	71.35
3.5	106.924941	99.89
4.5	137.4749242	128.43
5.5	168.0249073	156.97
6.5	198.5748905	185.51
7.5	229.1248737	214.05
8.5	259.6748568	242.59
9.5	290.22484	271.13
10.5	320.7748231	299.67
11.5	351.3248063	328.21
12.5	381.8747894	356.75
13.5	412.4247726	385.29
14.5	442.9747557	413.83
15.5	473.5247389	442.37
16.5	504.074722	470.91
17.5	534.6247052	499.45
18.5	565.1746884	527.99
19.5	595.7246715	556.53
20.5	626.2746547	585.07
21.5	656.8246378	613.61
22.5	687.374621	642.15
23.5	717.9246041	670.69
24.5	748.4745873	699.23
25.5	779.0245704	727.77
26.5	809.5745536	756.31
27.5	840.1245367	784.85
28.5	870.6745199	813.39
29.5	901.224503	841.93
30.5	931.7744862	870.47
31.5	962.3244694	899.01
32.5	992.8744525	927.55
33.5	1023.424436	956.09
34.5	1053.974419	984.63

35.5	1084.524402	1013.17
36.5	1115.074385	1041.71
37.5	1145.624368	1070.25
38.5	1176.174351	1098.79
39.5	1206.724335	1127.33
40.5	1237.274318	1155.87
41.5	1267.824301	1184.41
42.5	1298.374284	1212.95
43.5	1328.924267	1241.49
44.5	1359.47425	1270.03
46.5	1420.574217	1327.11
47.5	1451.1242	1355.65
48.5	1481.674183	1384.19
49.5	1512.224166	1412.73
50.5	1542.774149	1441.27
51.5	1573.324132	1469.81
52.5	1603.874116	1498.35
53.5	1634.424099	1526.89
54.5	1664.974082	1555.43
55.5	1695.524065	1583.97
56.5	1726.074048	1612.51
57.5	1756.624031	1641.05

Table 4: Predictive and Experimental Values of Dry Density at Different Depths

Depth	Predictive Dry Density on Variation of Permeability [Kg/m ³] [0.0000067/2.67]	Experimental Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] [0.0000067/2.67]
0.2	31.48998273	30.2
0.4	62.97996547	60.4
0.6	94.4699482	90.6
0.8	125.9599309	120.8
1	157.4499137	151
1.2	188.9398964	181.2
1.4	220.4298791	211.4
1.6	251.9198619	241.6
1.8	283.4098446	271.8
2	314.8998273	302
2.2	346.3898101	332.2
2.4	377.8797928	362.4
2.6	409.3697755	392.6
2.8	440.8597583	422.8
3	472.349741	453

3.2	503.8397237	483.2
3.4	535.3297065	513.4
3.6	566.8196892	543.6
3.8	598.309672	573.8
4	629.7996547	604
4.2	661.2896374	634.2
4.4	692.7796202	664.4
4.6	724.2696029	694.6
4.8	755.7595856	724.8
5	787.2495684	755
5.2	818.7395511	785.2
5.4	850.2295338	815.4
5.6	881.7195166	845.6
5.8	913.2094993	875.8
6	944.699482	906
6.2	976.1894648	936.2
6.4	1007.679447	966.4
6.6	1039.16943	996.6
6.8	1070.659413	1026.8
7	1102.149396	1057
7.2	1133.639378	1087.2
7.4	1165.129361	1117.4
7.6	1196.619344	1147.6
7.8	1228.109327	1177.8
8	1259.599309	1208
8.2	1291.089292	1238.2
8.4	1322.579275	1268.4
8.6	1354.069258	1298.6
8.8	1385.55924	1328.8
9	1417.049223	1359
9.2	1448.539206	1389.2
9.4	1480.029189	1419.4
9.6	1511.519171	1449.6
9.8	1543.009154	1479.8
10	1574.499137	1510
10.2	1605.989119	1540.2
10.4	1637.479102	1570.4
10.6	1668.969085	1600.6
10.8	1700.459068	1630.8
11	1731.94905	1661

Table 5: Predictive and Experimental Values of Dry Density at Different Depths

Depth	Predictive Dry Density on Variation of Permeability and Specific Gravity [Kg/m³] [0.0000087/2.69]	Experimental Dry Density on Variation of Permeability and Specific Gravity [Kg/m³] [0.0000069/2.69]
2.5	51.11244958	48.6
3.5	71.55742941	68.04
4.5	92.00240924	87.48
5.5	112.4473891	106.92
6.5	132.8923689	126.36
7.5	153.3373487	145.8
8.5	173.7823286	165.24
9.5	194.2273084	184.68
10.5	214.6722882	204.12
11.5	235.117268	223.56
12.5	255.5622479	243
13.5	276.0072277	262.44
14.5	296.4522075	281.88
15.5	316.8971874	301.32
16.5	337.3421672	320.76
17.5	357.787147	340.2
18.5	378.2321269	359.64
19.5	398.6771067	379.08
20.5	419.1220865	398.52
21.5	439.5670664	417.96
22.5	460.0120462	437.4
23.5	480.457026	456.84
24.5	500.9020058	476.28
25.5	521.3469857	495.72
26.5	541.7919655	515.16
27.5	562.2369453	534.6
28.5	582.6819252	554.04
29.5	603.126905	573.48
30.5	623.5718848	592.92
31.5	644.0168647	612.36
32.5	664.4618445	631.8
33.5	684.9068243	651.24
34.5	705.3518041	670.68
35.5	725.796784	690.12
36.5	746.2417638	709.56
37.5	766.6867436	729
38.5	787.1317235	748.44

39.5	807.5767033	767.88
40.5	828.0216831	787.32
41.5	848.466663	806.76
42.5	868.9116428	826.2
43.5	889.3566226	845.64
44.5	909.8016025	865.08
46.5	950.6915621	903.96
47.5	971.1365419	923.4
48.5	991.5815218	942.84
49.5	1012.026502	962.28
50.5	1032.471481	981.72
51.5	1052.916461	1001.16
52.5	1073.361441	1020.6
53.5	1093.806421	1040.04
54.5	1114.251401	1059.48
55.5	1134.696381	1078.92
56.5	1155.14136	1098.36
57.5	1175.58634	1117.8

Table 6: Predictive and Experimental Values of Dry Density at Different Depths

Depth	Predictive Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] [0.0000085/2.72]	Experimental Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] [0.0000085/2.72]
1	20.44497995	18.44
2	40.8899599	36.88
3	61.33493985	55.32
4	81.7799198	73.76
5	102.2248998	92.2
6	122.6698797	110.64
7	143.1148597	129.08
8	163.5598396	147.52
9	184.0048196	165.96
10	204.4497995	184.4
11	224.8947795	202.84
12	245.3397594	221.28
13	265.7847394	239.72
14	286.2297193	258.16
15	306.6746993	276.6
17	347.5646592	313.48
18	368.0096391	331.92
19	388.4546191	350.36
20	408.899599	368.8

21	429.344579	387.24
22	449.7895589	405.68
23	470.2345389	424.12
24	490.6795188	442.56
25	511.1244988	461
26	531.5694787	479.44
27	552.0144587	497.88
29	592.9044186	534.76
30	613.3493985	553.2
31	633.7943785	571.64
33	674.6843384	608.52
34	695.1293183	626.96
35	715.5742983	645.4
36	736.0192782	663.84
37	756.4642582	682.28
38	776.9092381	700.72
39	797.3542181	719.16
40	817.799198	737.6
42	858.6891579	774.48
43	879.1341379	792.92
44	899.5791178	811.36
46	940.4690777	848.24
47	960.9140577	866.68
48	981.3590376	885.12
49	1001.804018	903.56
50	1022.248998	922
51	1042.693977	940.44
52	1063.138957	958.88
53	1083.583937	977.32
54	1104.028917	995.76
55	1124.473897	1014.2
56	1144.918877	1032.64
57	1165.363857	1051.08
58	1185.808837	1069.52
59	1206.253817	1087.96
60	1226.698797	1106.4

Table 7: Predictive and Experimental Values of Dry Density at Different Depths

Depth	Predictive Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] [0.0000055/2.75]	Experimental Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] [0.0000055/2.75]
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0.2	25.84998579	24.62
0.4	51.69997158	49.24
0.6	77.54995737	73.86
0.8	103.3999432	98.48
1	129.2499289	123.1
1.2	155.0999147	147.72
1.4	180.9499005	172.34
1.6	206.7998863	196.96
1.8	232.6498721	221.58
2	258.4998579	246.2
2.2	284.3498437	270.82
2.4	310.1998295	295.44
2.6	336.0498153	320.06
2.8	361.899801	344.68
3	387.7497868	369.3
3.2	413.5997726	393.92
3.4	439.4497584	418.54
3.6	465.2997442	443.16
3.8	491.14973	467.78
4	516.9997158	492.4
4.2	542.8497016	517.02
4.4	568.6996874	541.64
4.6	594.5496732	566.26
4.8	620.3996589	590.88
5	646.2496447	615.5
5.2	672.0996305	640.12
5.4	697.9496163	664.74
5.6	723.7996021	689.36
5.8	749.6495879	713.98
6	775.4995737	738.6
6.2	801.3495595	763.22
6.4	827.1995453	787.84
6.6	853.049531	812.46
6.8	878.8995168	837.08
7	904.7495026	861.7
7.2	930.5994884	886.32
7.4	956.4494742	910.94
7.6	982.29946	935.56
7.8	1008.149446	960.18
8	1033.999432	984.8
8.2	1059.849417	1009.42
8.4	1085.699403	1034.04
8.6	1111.549389	1058.66
8.8	1137.399375	1083.28

9	1163.249361	1107.9
9.2	1189.099346	1132.52
9.4	1214.949332	1157.14
9.6	1240.799318	1181.76
9.8	1266.649304	1206.38
10	1292.499289	1231
10.2	1318.349275	1255.62
10.4	1344.199261	1280.24
10.6	1370.049247	1304.86
10.8	1395.899233	1329.48
11	1421.749218	1354.1

Table 8: Predictive and Experimental Values of Dry Density at Different Depths

Depth	Predictive Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] [0.0000088/2.73]	Experimental Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] [0.0000088/2.73]
1	19.73997992	18.73
2	39.47995984	37.46
3	59.21993976	56.19
4	78.95991968	74.92
5	98.69989959	93.65
6	118.4398795	112.38
7	138.1798594	131.11
8	157.9198394	149.84
9	177.6598193	168.57
10	197.3997992	187.3
11	217.1397791	206.03
12	236.879759	224.76
13	256.6197389	243.49
14	276.3597189	262.22
15	296.0996988	280.95
17	335.5796586	318.41
18	355.3196385	337.14
19	375.0596185	355.87
20	394.7995984	374.6
21	414.5395783	393.33
22	434.2795582	412.06
23	454.0195381	430.79
24	473.7595181	449.52
25	493.499498	468.25
26	513.2394779	486.98

27	532.9794578	505.71
29	572.4594177	543.17
30	592.1993976	561.9
31	611.9393775	580.63
33	651.4193373	618.09
34	671.1593172	636.82
35	690.8992972	655.55
36	710.6392771	674.28
37	730.379257	693.01
38	750.1192369	711.74
39	769.8592168	730.47
40	789.5991968	749.2
42	829.0791566	786.66
43	848.8191365	805.39
44	868.5591164	824.12
46	908.0390763	861.58
47	927.7790562	880.31
48	947.5190361	899.04
49	967.259016	917.77
50	986.9989959	936.5
51	1006.738976	955.23
52	1026.478956	973.96
53	1046.218936	992.69
54	1065.958916	1011.42
55	1085.698896	1030.15
56	1105.438875	1048.88
57	1125.178855	1067.61
58	1144.918835	1086.34
59	1164.658815	1105.07
60	1184.398795	1123.8

Table 9: Predictive and Experimental Values of Dry Density at Different Depths

Depth	Predictive Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] [0.0000081/2.76]	Experimental Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] [0.0000081/2.76]
2.5	49.34995157	46.75
3.5	69.0899322	65.45
4.5	88.82991283	84.15
5.5	108.5698935	102.85
6.5	128.3098741	121.55
7.5	148.0498547	140.25
8.5	167.7898353	158.95

9.5	187.529816	177.65
10.5	207.2697966	196.35
11.5	227.0097772	215.05
12.5	246.7497578	233.75
13.5	266.4897385	252.45
14.5	286.2297191	271.15
15.5	305.9696997	289.85
16.5	325.7096804	308.55
17.5	345.449661	327.25
18.5	365.1896416	345.95
19.5	384.9296222	364.65
20.5	404.6696029	383.35
21.5	424.4095835	402.05
22.5	444.1495641	420.75
23.5	463.8895448	439.45
24.5	483.6295254	458.15
25.5	503.369506	476.85
26.5	523.1094866	495.55
27.5	542.8494673	514.25
28.5	562.5894479	532.95
29.5	582.3294285	551.65
30.5	602.0694092	570.35
31.5	621.8093898	589.05
32.5	641.5493704	607.75
33.5	661.289351	626.45
34.5	681.0293317	645.15
35.5	700.7693123	663.85
36.5	720.5092929	682.55
37.5	740.2492735	701.25
38.5	759.9892542	719.95
39.5	779.7292348	738.65
40.5	799.4692154	757.35
41.5	819.2091961	776.05
42.5	838.9491767	794.75
43.5	858.6891573	813.45
44.5	878.4291379	832.15
46.5	917.9090992	869.55
47.5	937.6490798	888.25
48.5	957.3890605	906.95
49.5	977.1290411	925.65
50.5	996.8690217	944.35
51.5	1016.609002	963.05
52.5	1036.348983	981.75
53.5	1056.088964	1000.45

54.5	1075.828944	1019.15
55.5	1095.568925	1037.85
56.5	1115.308905	1056.55
57.5	1135.048886	1075.25

Table 10: Predictive and Experimental Values of Dry Density at Different Depths

Depth	Predictive Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] [0.00000137/2.8]	Experimental Dry Density on Variation of Permeability and Specific Gravity [Kg/m ³] [0.00000137/2.8]
0.2	25.43638696	24.8
0.4	50.87277391	49.6
0.6	76.30916087	74.4
0.8	101.7455478	99.2
1	127.1819348	124
1.2	152.6183217	148.8
1.4	178.0547087	173.6
1.6	203.4910956	198.4
1.8	228.9274826	223.2
2	254.3638696	248
2.2	279.8002565	272.8
2.4	305.2366435	297.6
2.6	330.6730304	322.4
2.8	356.1094174	347.2
3	381.5458043	372
3.2	406.9821913	396.8
3.4	432.4185782	421.6
3.6	457.8549652	446.4
3.8	483.2913522	471.2
4	508.7277391	496
4.2	534.1641261	520.8
4.4	559.600513	545.6
4.6	585.0369	570.4
4.8	610.4732869	595.2
5	635.9096739	620
5.2	661.3460608	644.8
5.4	686.7824478	669.6
5.6	712.2188348	694.4
5.8	737.6552217	719.2
6	763.0916087	744
6.2	788.5279956	768.8
6.4	813.9643826	793.6
6.6	839.4007695	818.4

6.8	864.8371565	843.2
7	890.2735435	868
7.2	915.7099304	892.8
7.4	941.1463174	917.6
7.6	966.5827043	942.4
7.8	992.0190913	967.2
8	1017.455478	992
8.2	1042.891865	1016.8
8.4	1068.328252	1041.6
8.6	1093.764639	1066.4
8.8	1119.201026	1091.2
9	1144.637413	1116
9.2	1170.0738	1140.8
9.4	1195.510187	1165.6
9.6	1220.946574	1190.4
9.8	1246.382961	1215.2
10	1271.819348	1240
10.2	1297.255735	1264.8
10.4	1322.692122	1289.6
10.6	1348.128509	1314.4
10.8	1373.564896	1339.2
11	1399.001283	1364

Table 11: Optimum Dry Density at Different Depths

Location	1	2	3	4	5	6	7	8	9	10
Predictive	1861.199	1832.99	1756.624	1731.9491	1175.59	1227	1421.75	1184.4	1135	1399
Experimental	1739.1	1712.4	1641.05	1661	1117.8	1106	1354.1	1123.8	1075.3	1364

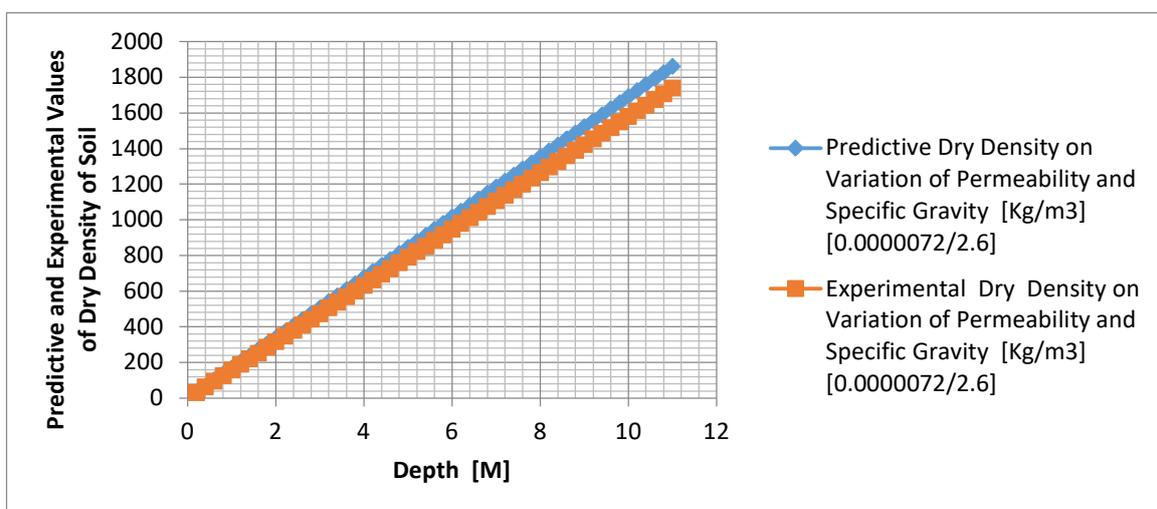


Figure 1: Predictive and Experimental Values of Dry Density at Different Depths

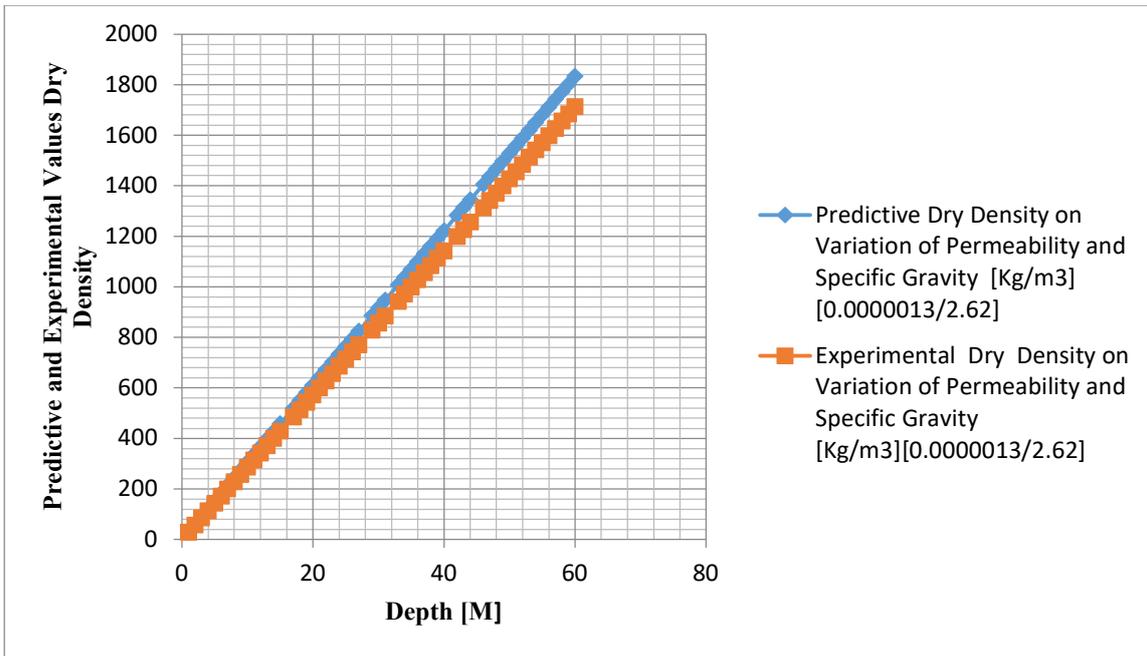


Figure 2: Predictive and Experimental Values of Dry Density at Different Depths

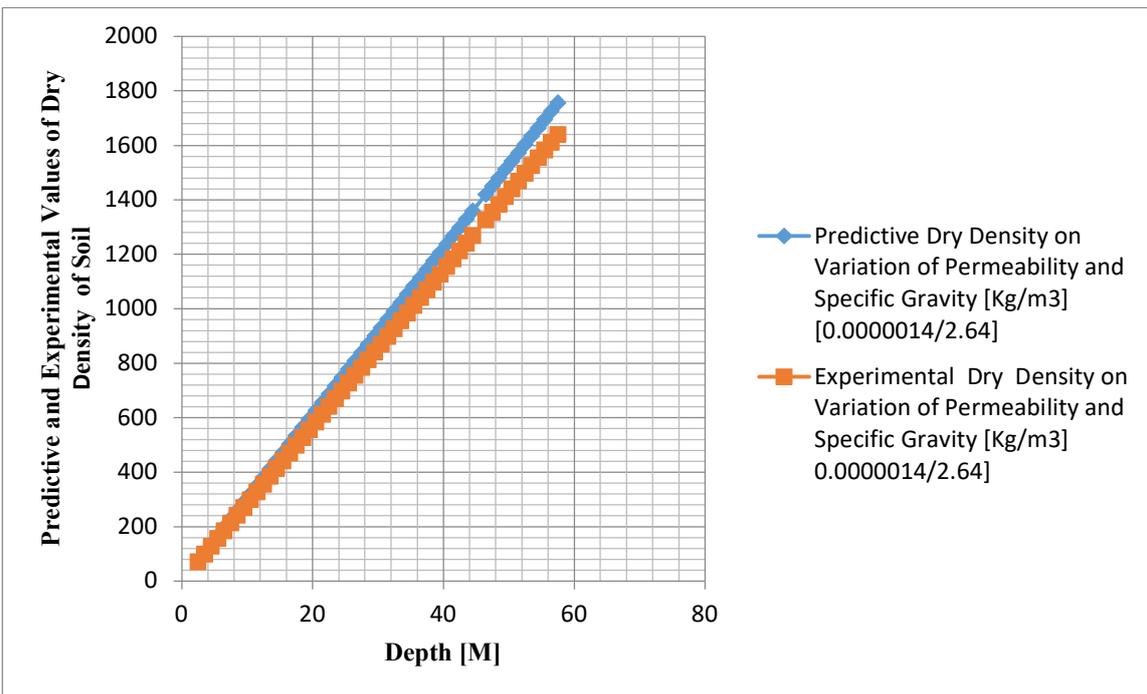


Figure 3: Predictive and Experimental Values of Dry Density at Different Depths

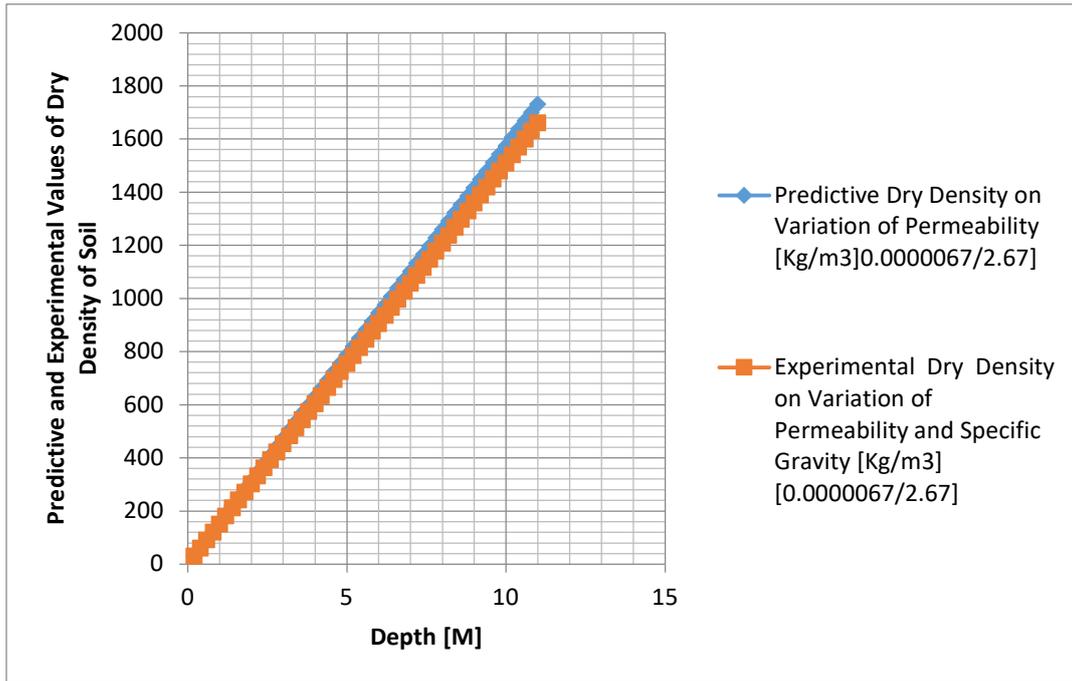


Figure 4: Predictive and Experimental Values of Dry Density at Different Depths

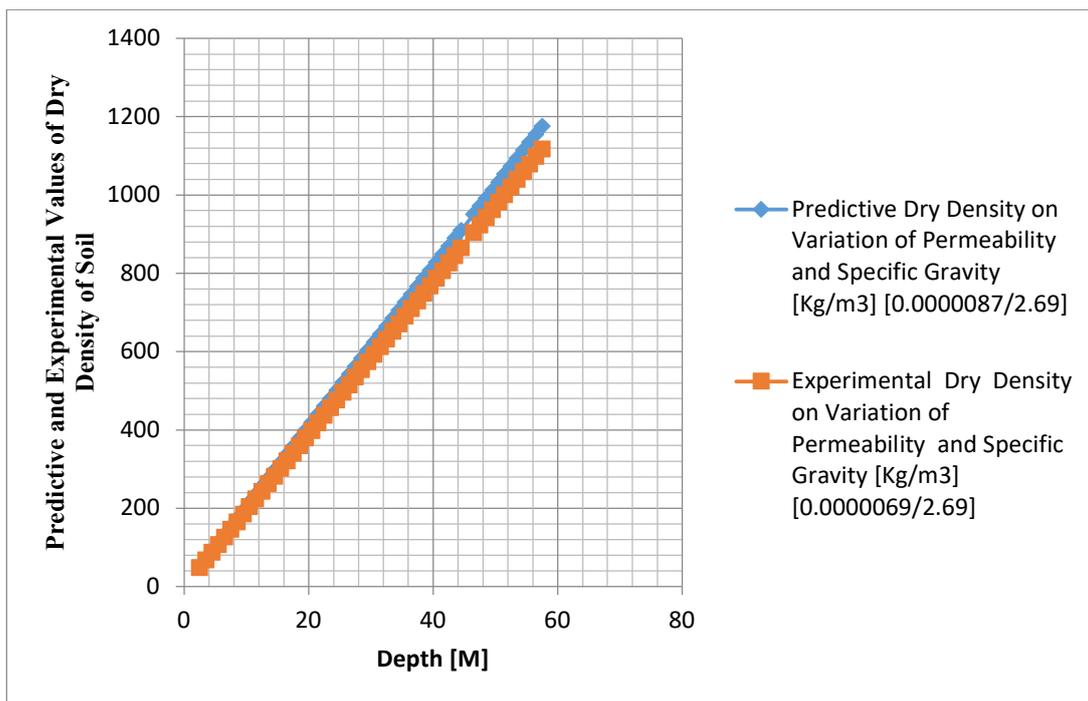


Figure 5: Predictive and Experimental Values of Dry Density at Different Depths

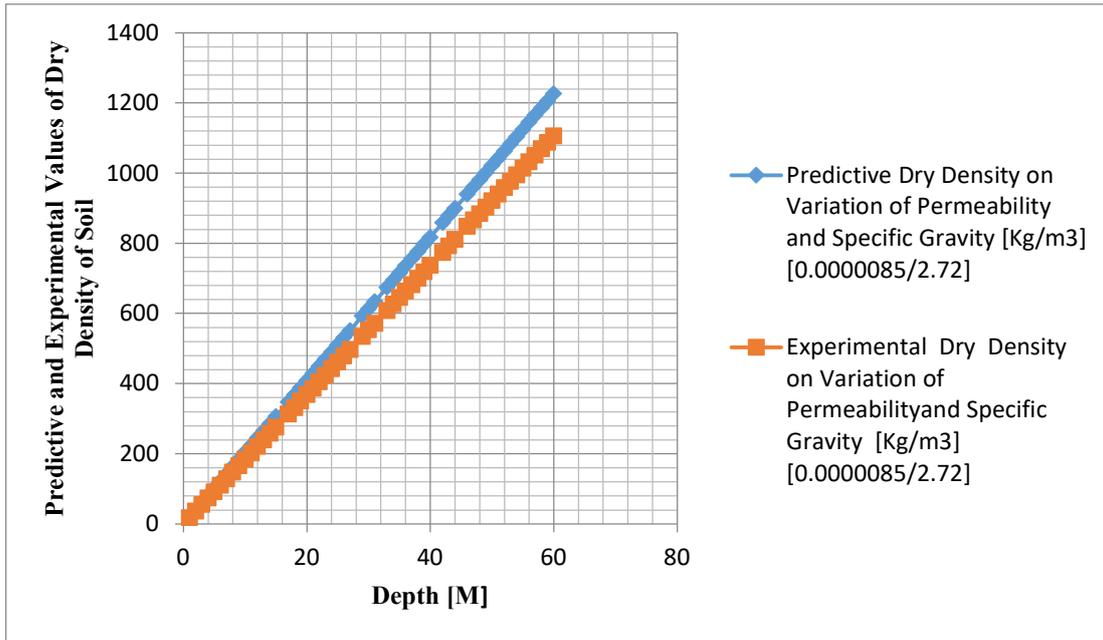


Figure 6: Predictive and Experimental Values of Dry Density at Different Depths

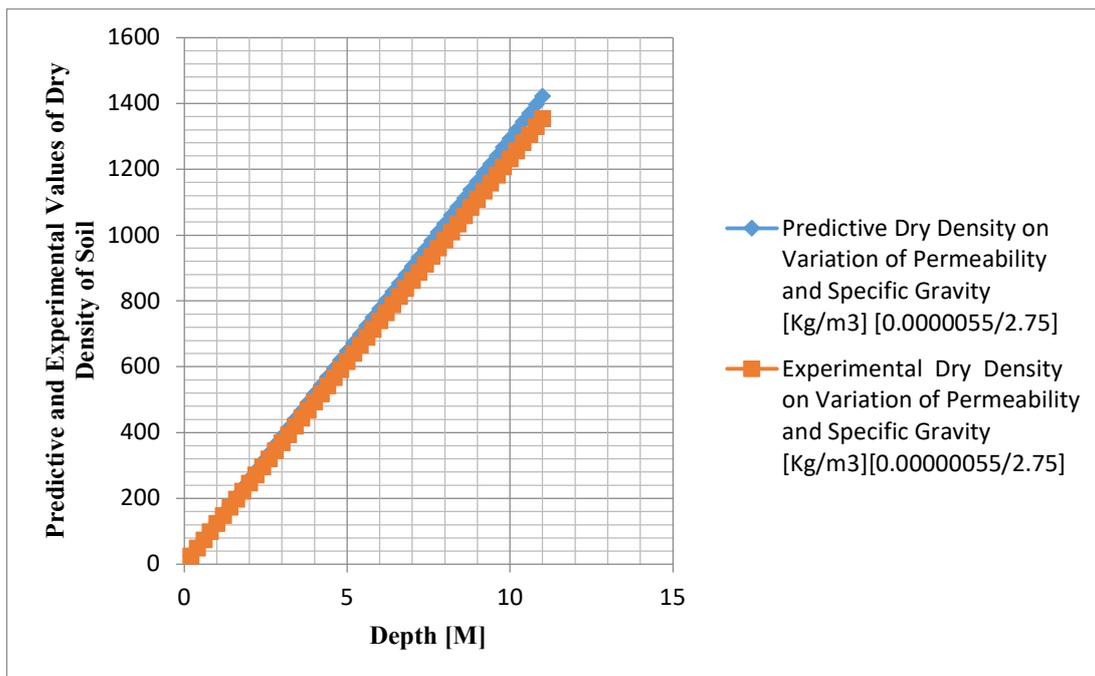


Figure 7: Predictive and Experimental Values of Dry Density at Different Depths

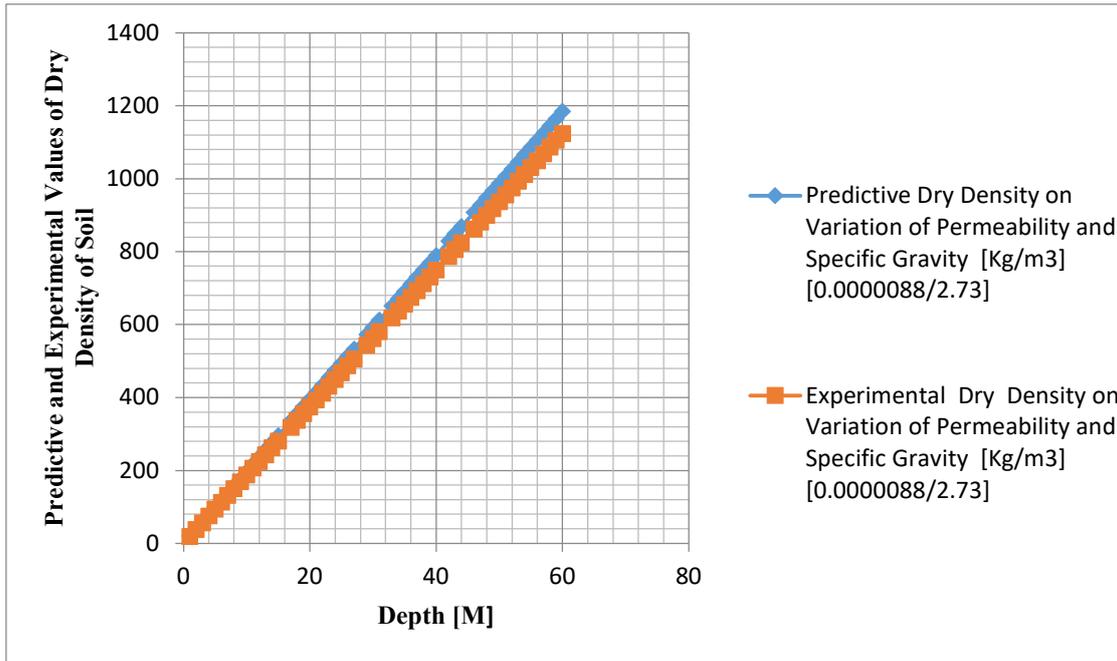


Figure 8: Predictive and Experimental Values of Dry Density at Different Depths

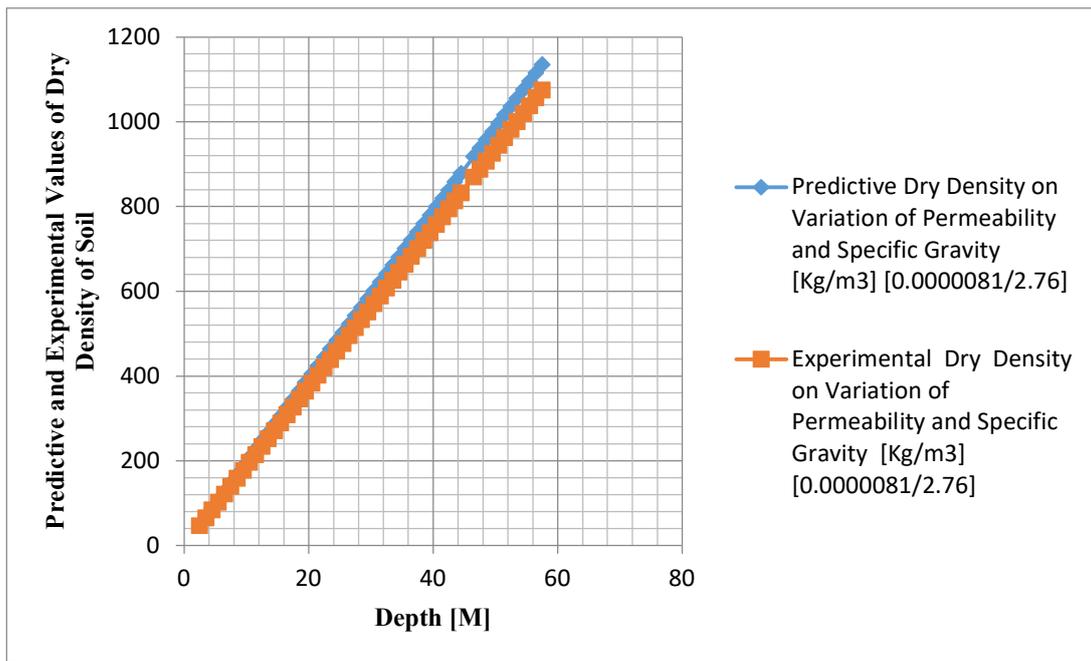


Figure 9: Predictive and Experimental Values of Dry Density at Different Depths

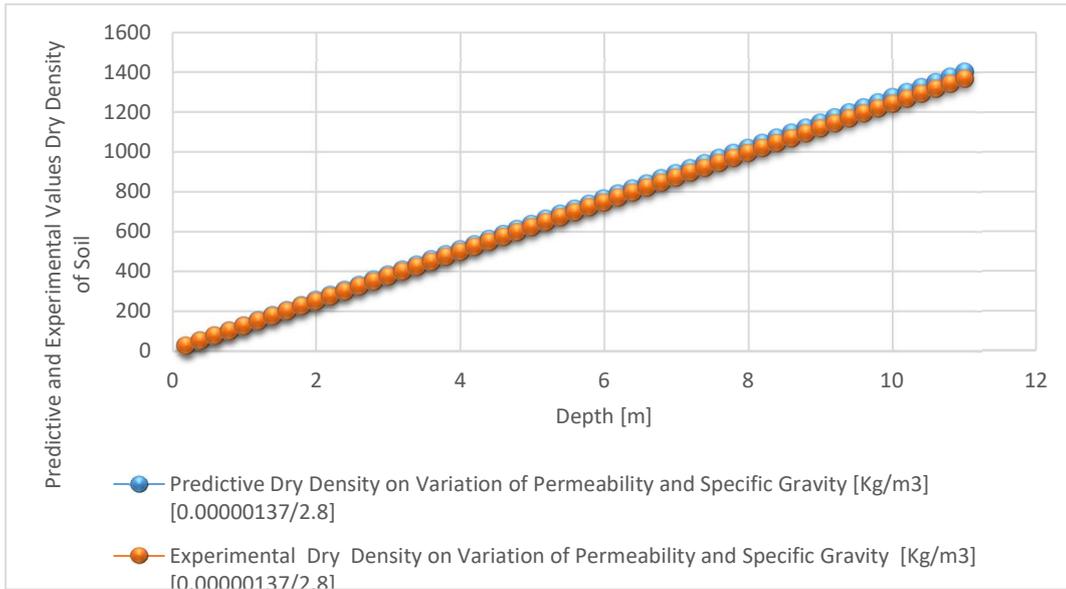
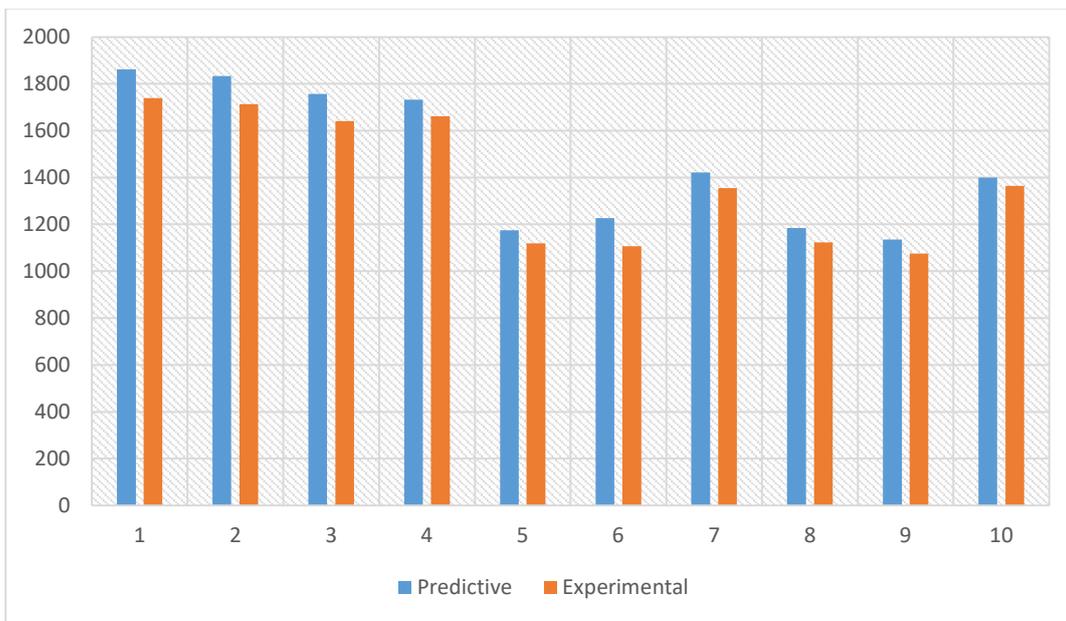


Figure 10: Predictive and Experimental Values of Dry Density at Different Depths



Results from dry density modeling and simulation studies on permeability and specific gravity changes in silty clay deposits show linear best-fit trends across all figures. This suggests a clear relationship between these parameters and the dry density of silty clays. A linear trend indicates that as permeability and specific gravity change, soil dry density also changes predictably. However, selecting optimal values at different locations will cause fluctuations in the graph. This indicates that the relationships between permeability, specific gravity, and dry density may not be perfectly consistent across locations and samples. The variations observed in the graph indicate that additional factors may be influencing the dry density of silty clays, alongside permeability and specific gravity. Several elements could be responsible for the fluctuations depicted in the chart, including soil heterogeneity, varying compaction forces, the presence of organic matter, contaminants, and mineralogical variations. These factors can alter the interplay between permeability, specific gravity, and dry density, resulting in localized differences in the behavior of silty clays and leading to discrepancies in predicted dry density values. It is essential

to consider these factors when interpreting results and making predictions with the model. To enhance accuracy, site-specific conditions, such as the presence of organic matter and variations in mineralogy, should be taken into account. Utilizing local calibration or adjustment factors may be necessary to address the unique characteristics of silty clays at each location. Moreover, conducting further laboratory tests and field measurements across various sites will aid in validating and refining the model, thereby improving the reliability of predictions. Collecting additional data will also assist in identifying further influencing variables, contributing to the development of a comprehensive model that effectively captures the complex factors affecting dry density in silty clay deposits. There is significant potential for creating such a model. Several factors can contribute to the variation in dry density values observed in the modeling and simulation of permeability and specific gravity effects in silty clay deposits. One significant factor is spatial heterogeneity. Silty clay deposits often display variations in composition, mineralogy, and compaction properties across different areas. The presence of distinct layers or zones within the sediment can result in variations in dry density values. Another important factor is compaction effort. Differences in the intensity of compaction during construction can significantly influence the dry density achieved. Variations in compaction energy, moisture content, and the techniques used can lead to discrepancies in density values. Additionally, organic matter content plays a critical role. Silty clay deposits may contain decomposed vegetation and peat, which can impact compaction behavior, thereby affecting dry density. Organic materials exhibit different compressibility and shear strength properties compared to mineral soils, resulting in varying density values. Moreover, monitoring mineralogy is essential. The mineral composition of silty clays can vary, and different minerals exhibit distinct compaction and solidification behaviors. These mineralogical variations can lead to differences in dry density values due to changes in grain arrangement and interparticle forces. Moisture content is another key variable. Fluctuations in moisture content can significantly influence the compaction properties of silty clays. The relationship between moisture content and dry density follows an optimal moisture content curve; deviations from this optimal point can result in variations in density values. Lastly, overburden pressure—the vertical stress applied to a silty clay deposit—can also affect its compaction behavior. Variations in the magnitude and distribution of tailings pressure throughout a deposit can lead to differences in dry density values. During sampling and laboratory testing, the collection and handling of soil samples may introduce interferences that affect the measured dry density. Disturbances in the samples can alter particle arrangement and compression behavior. Additionally, variability in testing procedures—such as compression testing and specific gravity measurements—can result from factors including sample preparation, operator technique, and instrument calibration. To achieve more accurate predictions and minimize the influence of these factors, it is essential to consider site-specific conditions, conduct detailed site surveys, and perform comprehensive analyses of soil properties. Field sampling, field testing, and a thorough understanding of the local geology are crucial for improving the reliability of dry density predictions for silty clay deposits.

In summary, the study's findings indicated a linear trend of best fit for dry density, permeability, and specific gravity in muddy clay deposits. However, the observed variability in the plots suggests that a cautious approach should be adopted, taking other factors into account. Future research should focus on improving models and expanding the data set by incorporating additional variables to enhance the accuracy and applicability of predictions in real engineering research.

5. Conclusion

In summary, studies on dry density modeling and simulation have yielded significant insights into the changes in permeability and specific gravity of silty clay deposits. The findings indicate a linear optimal trend linking permeability, specific gravity, and dry density, thereby establishing a clear relationship among these parameters. However, the selection of optimal values across different locations resulted in variations in the plotted data, suggesting the influence of additional factors on the dry density of silty clay deposits. These variations may be attributed to elements such as spatial heterogeneity, compaction effort, organic content, mineral composition, water content, overburden pressure, sample interference, and test variability. Such factors alter the behavior and characteristics of silty clays, leading to fluctuations in dry density values. To enhance the accuracy and reliability of predictions, it is crucial to consider site-specific conditions, including the presence of organic material and

variations in mineralogy. Calibration or adjustment factors may be necessary to accommodate the unique characteristics of the silt-clay deposits at each site. Furthermore, additional experimental data and field measurements are essential to validate and refine the model. By incorporating larger datasets and conducting more extensive laboratory tests and field studies, we can better capture the complex interactions that affect the dry density of silty clay deposits. Overall, this study offers a foundational understanding of the relationship between permeability, specific gravity, and dry density within silty clay deposits. It underscores the importance of considering multiple influencing factors and highlights the need for further research to improve prediction accuracy. This discovery enriches the geotechnical engineering knowledge base, aiding engineers in the design and construction of structures on silty clay soils.

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