Evaluation of Compaction in Mixed Soil

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Abstract – In this investigation to evaluation of density, optimum moisture content, particle size as well as mineral consisted at any models, standard compaction, size analysis and X-ray diffraction tests have been employed. This paper is deal with understanding effect of mineral on compaction characteristics of mixed soil models. In this regard the possibility of compaction level analysis in mixed soil models under loose and compacted conditions have been investigated. The result indicated mineralogy characteristics of soil has direct correlation with soil compaction and its optimum moisture content.

Key Word: Compaction, Soil Mixing Model and Soil Mineralogy

1. INTRODUCTION

The unit weight play importance factors in soil bearing capacity, to improve soil strength several investigations had been done which are as following:

There is a laboratory study reported on stabilizing peat soil using Ordinary Portland cement (OPC) as binding agent and Polypropylene fibers as additive [1]. In a scientific research work an experimental investigation on behavior of geogrid embedded in red clay is conducted under eight different moistures content of the soils [2]. There was mentioned Geotextiles have been successfully used for reinforcement of soils to improve of the soil bearing capacity [3]. There is an investigation describes the behavioral aspect of soils mixed with fly ash to improve the load bearing capacity of the soil [4]. There have been presented a number of laboratory model test results for the ultimate bearing capacity of surface strip foundation supported by a granular trench made in soft clay. The result indicated ultimate bearing capacity increases with the increase of the depth of the granular trench to a maximum value and remains constant thereafter [5]. In a scientific work reported a series of laboratory model tests to investigate the using of shredded waste tires as reinforcement to increase the bearing capacity of soil. [6]. There is reported some field and laboratory study were conducted to find engineering properties of peat soil and to stabilize of that [7]. There is presented an innovative use of soil-cement mixing method using jet-grouting technique to improve the bearing capacity of subbase foundation for road construction in Thailand [8]. There is also a report on deep mixing method is emphasized on column type techniques using lime/cement [9]. It has also been a report on rigorous upper-bound solution and a corresponding compatible velocity field of bearing capacity of rectangular footing based on plasticity limit analysis theory [10].

In this research work by mixing six types of soils, two types of gravels and sand, 31 mixed soil models developed, their behavior under OMC compacted and loose in different levels of moisture have been considered, no report on improvement of mysore soils by use of its minerals has been reported.

2. METHODOLOGY and EXPERIMENTS

In this research work using several types of soils (red soil which is plastic soil and black, green, yellow, dark and light brown soils which are non plastic soils), gravels and sand, 31 mixed soil models have been developed (table 1) and behavior of all models in term of compatibility in particular level of moisture is discussed. Figure 1 indicated the morphology of the all soils and sand, which has been used in developed models.

Table 1 Mixed soil models

Sl. No	% of Red Soil	% of Sand	% of Gravel 4.75 mm	% of Gravel 2 mm	% of Black Soil	% of Green Soil	% of Dark Brown Soil	% of Yellow Soil	% of Light Brown Soil
1	100	0	0	0	0	0	0	0	0
2	55	45	0	0	0	0	0	0	0
3	55	0	45	0	0	0	0	0	0
4	55	0	0	45	0	0	0	0	0
5	55	15	15	15	0	0	0	0	0
6	55	0	0	0	45	0	0	0	0
7	55	0	0	0	0	45	0	0	0
8	55	0	0	0	0	0	45	0	0
9	55	0	0	0	0	0	0	45	0
10	90	0	0	0	2	2	2	2	2
11	80	0	0	0	4	4	4	4	4
12	70	0	0	0	6	6	6	6	6
13	60	0	0	0	8	8	8	8	8
14	50	0	0	0	10	10	10	10	10
15	70	0	0	0	10	10	10	0	0
16	70	0	0	0	10	10	0	10	0
17	70	0	0	0	10	10	0	0	10
18	70	0	0	0	10	0	10	10	0
19	70	0	0	0	10	0	10	0	10
20	70	0	0	0	10	0	0	10	10
21	70	0	0	0	15	15	0	0	0
22	70	0	0	0	15	0	15	0	0
23	70	0	0	0	0	0	0	15	15
24	70	0	0	0	15	0	0	15	0
25	70	0	0	0	15	0	0	0	15
26	70	0	0	0	0	15	15	0	0
27	70	0	0	0	0	15	0	15	0
28	70	0	0	0	0	15	0	0	15
29	70	0	0	0	0	0	15	15	0
30	70	0	0	0	0	0	15	0	15
31	55	0	0	0	0	0	0	0	45

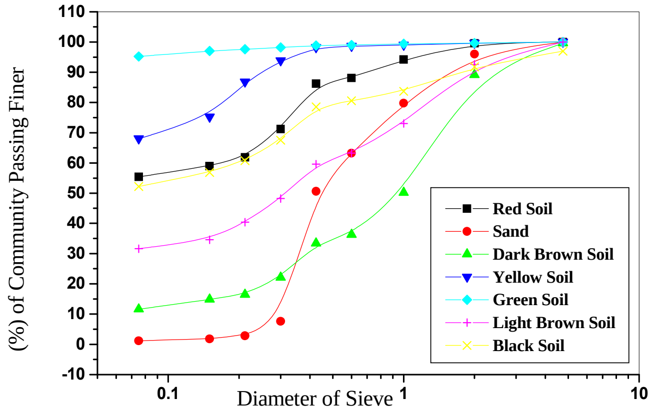

Fig 1 result of sieve analysis of soils [11]

3. RESULTS and DISCUSSION

An economical method to improve of soil characteristics is compaction. The soil mixing method could be used to increasing speed of construction and accessing acceptable result. The new models, which created from different soil, have new characteristics and increases structure and significantly reduces dimension of foundation. In the present investigation, the result of compaction tests on 31models illustrated in Table 3 and Fig 2a-b to 32a-b. Using the measured data of weight of the water present in the soil, weight and volume of the soil under compacted condition, bulk density (γ_b) and dry density (γ_d) of the mixed soils were calculated. Percent of water content in the mixed soils verses γ_b and γ_d were plotted and Optimum Moisture Content (OMC) at maximum γ_d was determined. It is an attempt to identify suitable unit weight of mixed soil model under loose and compacted condition. In mixed soil models 1,2,3,4 and 5 due to absent of non-plastic soil less OMC is observed, non plastic soil increases OMC in the model.

The important minerals present in the soils of the investigations are quartz, muscovite, biotite, carbonates and fluorapatite. Clay minerals like illite, saponite, sauconite, pyrophyllite, orthochamosite, brucite, clinochlore, nacrite, odinite, amesite, chamosite, cancrisilite, chamosite and orthochamosite also were present as minor constituents. Only the red soil has considerable amount of clay minerals, where as the remaining other soils have meager concentrations. Availability of clay mineral in the mixed soil model increased level of compactness (table 2).

From the Fig 2a-b to 32a-b could observe different type of curve under loose and compacted condition. Under OMC compacted condition maximum level of unit weight is appeared, if a loose soil placed in OMC condition, in this situation 95% result is decreasing unit weight, and it is due to creation of void ration in the loose soil due to saturation.

From the sieve analysis and mineralogy identification could deduced the soil mineralogy specially clay mineral has more effect on soils compaction compare to soil morphology

Table 2 Result of X-Ray Diffraction on Soil Sample

Sl No	Soil Name	Mineral presented in the soil sample
1	Red soil	Illite, muscotive, quartz, saponite, sauconite and carbonate- fluorapatite
2	Black soil	Quartz, pyrophyllite, carbonate- fluorapatite and orthochamosite
3	Yellow soil	Brucite, clinochlore, quartz and sandoite
4	Light brown soil	Quartz and carbonate-cyanotrichite
5	Dark brown soil	Nacrite, odinite, amesite, chamosite and biotite
6	Green soil	Quartz, cancrisilite, chamosite, orthochamosite and brucite

Table 3 Result of standard compaction test

Sl. No	Weight of Compacted soil placed in mould (gr)	γb (gr/cm^3)	Wt of cup + weight of wet soil (gr)	Wt of cup + weight of dry soil (gr)	Wt of empty Cup (gr)	Wt of water (gr)	Wt of dry soil (gr)	% of water	γ_d (gr/cm^3)
Mixed Soil Type 1									
1	1665	1.84	60.65	58.69	23.11	1.96	35.58	5.51	1.74
2	2020	2.24	60.95	57.04	22.14	3.91	34.9	11.2	2.01
3	2085	2.31	70.3	63.82	22.12	6.48	41.7	15.54	1.99
4	1970	2.18	68.7	61.58	20.29	7.12	41.29	17.24	1.86
5	1970	2.18	84.5	74.21	23	10.29	51.21	20	1.82
Mixed Soil Type 2									
1	1610	1.78	60.6	58.21	23.1	2.39	35.11	6.81	1.67
2	1920	2.13	58.46	55.88	24.2	2.58	31.68	8.14	1.96
3	2010	2.23	55.8	52.57	22.14	3.23	30.43	10.61	2.01
4	2040	2.26	73.3	67.11	22.12	6.19	44.99	13.76	1.99
5	2020	2.24	81.6	72.89	20.3	8.71	52.59	16.56	1.92
6	1970	2.18	72.35	64.17	22.98	8.18	41.19	19.86	1.82
7	1920	2.13	67.48	59.45	21.86	8.03	37.59	21.36	1.75
Mixed Soil Type 3									
1	1980	2.19	57.73	56.17	22.43	1.56	33.74	4.62	2.1
2	2080	2.3	60.48	57.24	23.89	3.26	33.35	9.72	2.1
3	2160	2.39	55.96	52.76	22.92	3.2	29.84	10.72	2.16
4	2115	2.34	52.89	49.03	22.44	3.86	26.59	14.52	2.04
5	2030	2.25	57.59	52.03	22.28	5.56	29.75	18.69	1.89

Mixed Soil Type 4									
1	1815	2.01	59.9	57.34	23.34	2.56	34	7.53	1.87
2	1950	2.16	53.9	51.6	22.43	2.3	29.17	7.88	2
3	2130	2.36	59.43	55.79	21.74	3.64	34.05	10.69	2.13
4	2193	2.43	68.1	63.28	23.64	4.82	39.64	12.15	2.17
5	2080	2.3	57.69	62.11	21.77	5.58	40.34	13.83	2.02
6	1950	2.16	57.18	51.9	24.18	5.28	27.72	19.05	1.81
Mixed Soil Type 5									
1	1620	1.79	66.49	65.27	38.1	1.22	27.17	4.49	1.72
2	1935	2.14	54.36	52	23.13	2.36	28.87	8.18	1.98
3	2120	2.35	52.45	49.79	22.01	2.66	27.78	9.58	2.14
4	2150	2.38	77.85	73.59	36.96	4.26	36.63	11.6	2.13
5	2095	2.32	54.92	51.35	23.07	3.57	28.28	12.62	2.06
6	2000	2.21	68.59	62.66	23.75	5.93	38.91	15.24	1.92
7	2010	2.22	59.19	52.39	21.89	5.8	30.5	19.02	1.87
Mixed Soil Type 6									
1	1330	1.47	51.07	48.97	22.12	2.1	26.85	7.82	1.37
2	1390	1.54	40.25	38.72	20.29	1.53	18.43	8.3	1.42
3	1435	1.59	41.76	40.08	24.2	1.68	15.88	10.58	1.44
4	1500	1.66	40.25	38.21	21.86	2.04	16.35	12.48	1.48
5	1620	1.79	46.05	42.83	23.11	3.22	19.72	16.33	1.54
6	1780	1.97	54.55	49.1	22.98	5.45	26.12	20.87	1.63
7	1850	2.05	47.02	42.47	22.15	4.55	20.32	22.39	1.67
8	1820	2.02	64.67	59.23	38.19	5.44	21.04	25.86	1.6
9	1700	1.88	79.73	69.83	36.96	9.9	32.87	30.12	1.45

Mixed Soil Type 7									
1	1820	2.02	39.75	37.49	23.34	2.26	14.15	15.97	1.74
2	1930	2.14	60.87	54.77	22.44	6.1	32.33	18.86	1.8
3	1980	2.19	55.91	49.36	21.74	6.55	27.62	23.71	1.77
4	1945	2.15	75.08	64.21	23.64	10.87	40.57	26.79	1.7
5	1930	2.14	81.17	67.42	21.78	13.75	45.64	30.13	1.64
Mixed Soil Type 8									
1	1980	2.19	65.97	61.92	22.92	4.05	39	10.39	1.99
2	2150	2.38	53.58	49.65	22.66	3.93	26.99	14.56	2.08
3	2050	2.27	53.73	49.21	22.43	4.52	26.78	16.87	1.94
4	2015	2.23	77.65	68.34	22.43	9.31	45.91	20.28	1.86
5	1970	2.18	64.19	55.61	23.89	5.58	31.73	27.7	1.71
Mixed Soil Type 9									
1	1650	1.83	48.08	46.01	23.12	2.07	22.89	9.04	1.68
2	1930	2.14	54.66	50.59	22	4.07	28.59	14.24	1.87
3	1995	2.21	47.15	43.3	23.7	3.76	19.69	19.1	1.86
4	1910	2.11	62.1	54.55	21.89	7.55	32.66	23.12	1.72
5	1895	2.1	57.37	50.03	23.07	7.34	26.96	27.22	1.65

Mixed Soil Type 10									
1	1910	2.11	56.06	52.23	23.34	3.83	28.89	13.26	1.87
2	1990	2.2	54.05	49.49	22.4	4.56	27.09	16.83	1.88
3	1975	2.19	52.8	47.58	21.74	5.22	25.84	20.20	1.82
4	1920	2.13	82.02	70.8	23.64	11.22	47.16	23.79	1.72
5	1880	2.08	55.6	48.72	21.78	6.88	26.94	25.54	1.66
Mixed Soil Type 11									
1	1900	2.1	51.32	47.73	23.14	3.59	24.59	14.59	1.84
2	1985	2.19	39.93	37.16	22	2.77	15.16	18.27	1.86
3	1960	2.17	48.26	44.00	23.7	4.26	20.3	20.99	1.79
4	1950	2.16	55.37	48.72	21.91	6.65	26.81	24.04	1.74
5	1930	2.14	65.42	56.51	23.09	8.51	33.42	25.46	1.70
Mixed Soil Type 12									
1	1670	1.85	44.98	42.38	22.93	2.6	19.45	13.37	1.63
2	1940	2.15	52.75	48.43	22.66	4.32	25.77	16.76	1.84
3	1930	2.14	46.70	42.63	22.44	4.07	20.19	20.16	1.78
4	1900	2.10	52.72	46.77	22.43	5.95	24.34	24.45	1.69
5	1890	2.09	63.11	54.68	23.89	8.43	30.79	27.38	1.64
Mixed Soil Type 13									
1	1730	1.92	51.72	48.02	23.33	3.7	24.69	14.99	1.67
2	1920	2.13	51.4	47.29	22.44	4.11	24.85	16.54	1.82
3	2010	2.23	44.52	40.69	21.74	3.83	18.95	20.21	1.85
4	1930	2.14	58.08	51.78	23.65	6.3	28.13	22.39	1.75
5	1900	2.10	54.14	47.14	21.80	7	25.34	27.62	1.65
Mixed Soil Type 14									
1	1590	1.76	50.79	47.94	22.66	2.85	25.28	11.27	1.58
2	1820	2.02	42.42	39.78	22.44	2.64	17.34	15.22	1.75
3	1950	2.16	58.32	52.67	22.43	5.65	30.24	18.68	1.82
4	1920	2.13	54.01	48.24	23.90	5.77	24.34	23.71	1.72
5	1840	2.04	43.70	39.23	22.10	4.47	17.13	26.09	1.62
Mixed Soil Type 15									
1	1680	1.86	62.73	58.47	23.34	4.26	35.13	8.25	1.72
2	1870	2.07	52.94	48.81	22.44	4.13	26.37	15.66	178
3	1930	2.14	44.51	40.82	21.74	3.69	19.08	19.34	1.79
4	1830	2.03	59.28	51.06	21.77	8.22	29.29	28.04	1.58
Mixed Soil Type 16									
1	1600	1.77	60.87	56.01	23.34	4.86	32.67	14.87	1.54
2	1870	2.07	55.25	50.59	22.44	4.66	28.15	16.55	1.78
3	1950	2.16	72.53	63.17	21.74	9.36	41.43	22.59	1.76
4	1870	2.07	61.56	53.93	23.64	7.63	30.29	25.19	1.65
5	1840	2.04	63.80	54.60	21.77	9.20	32.83	28.02	1.59

Mixed Soil Type 17									
1	1705	1.88	60.55	57.95	36.96	2.60	20.99	12.39	1.68
2	1825	2.02	59.71	56.59	38.20	3.12	18.39	16.97	1.73
3	1950	2.16	53.77	48.17	22.15	5.50	26.02	21.14	1.78
4	1850	2.05	60.27	53.03	22.98	7.24	30.03	24.11	1.65
5	1830	2.03	52.24	46.09	23.11	6.15	22.98	26.76	1.59
Mixed Soil Type 18									
1	1810	2.00	59.43	56.45	36.96	2.98	19.49	15.29	1.74
2	1850	2.05	74.37	69.19	38.20	5.18	30.99	16.71	1.76
3	1950	2.16	53.11	47.78	22.15	5.33	25.63	20.79	1.79
4	1825	2.02	54.5	47.50	23.11	7.00	24.39	28.70	1.57
Mixed Soil Type 19									
1	1670	1.85	47.66	45.37	23.15	2.29	22.22	10.31	1.68
2	1930	2.14	45.84	42.50	22.02	3.34	20.48	16.31	1.84
3	1960	2.17	51.88	47.17	23.70	4.71	23.47	20.07	1.81
4	1940	2.15	65.99	57.64	21.91	8.35	35.73	23.37	1.74
5	1840	2.04	59.36	51.75	23.09	7.61	28.66	26.55	1.61
Mixed Soil Type 20									
1	1755	1.94	47.61	44.84	21.87	2.77	22.97	12.06	1.73
2	1830	2.03	48.63	45.07	24.20	3.56	20.87	17.06	1.73
3	1930	2.14	57.93	51.43	20.31	6.5	31.12	20.89	1.77
4	1870	2.07	45.43	40.76	22.32	4.67	18.44	25.33	1.65
5	1790	1.98	52.24	45.50	22.69	6.74	22.81	29.55	1.53
Mixed Soil Type 21									
1	1670	1.85	38.67	36.79	22.98	1.88	13.81	13.61	1.63
2	1820	2.02	51.64	47.41	21.07	4.23	26.37	16.04	1.74
3	1905	2.11	61.80	55.06	22.69	6.74	32.37	20.82	1.75
4	1980	2.19	57.55	51.12	23.17	6.43	27.95	23.00	1.78
5	1860	2.06	63.33	55.07	23.29	8.26	31.78	25.99	1.63
Mixed Soil Type 22									
1	1730	1.92	48.3	45.56	22.67	2.74	22.89	11.97	1.71
2	1880	2.08	56.35	51.60	22.20	4.75	29.40	16.16	1.79
3	2030	2.25	64.17	57.15	22.14	7.02	35.00	20.06	1.87
4	1950	2.16	70.46	64.73	39.97	5.73	24.76	23.14	1.75
5	1930	2.14	67.44	57.95	22.80	9.79	35.15	27.85	1.67

Mixed Soil Type 23									
1	1670	1.85	57.4	53.30	22.98	4.10	30.32	13.52	1.63
2	1820	2.02	50.10	45.73	21.07	4.37	24.66	17.72	1.71
3	1940	2.15	70.88	62.81	22.69	8.07	40.12	20.11	1.79
4	1850	2.05	54.78	48.63	23.17	6.15	25.46	24.16	1.65
5	1850	2.05	66.34	56.62	23.29	9.72	33.33	29.16	1.59

Mixed Soil Type 24									
1	1570	1.74	52.66	49.20	21.87	3.46	27.33	12.66	1.54
2	1680	1.86	49.40	45.27	24.20	4.13	21.07	17.60	1.58
3	1880	2.08	60.12	53.26	20.31	6.86	33.05	20.75	1.72
4	1850	2.05	57.21	50.26	22.32	6.96	27.93	24.92	1.64
5	1780	1.97	54.40	47.36	22.69	7.04	24.67	28.54	1.53
Mixed Soil Type 25									
1	1550	1.72	53.68	50.47	23.15	3.21	27.32	11.75	1.54
2	1640	1.82	57.80	53.20	22.02	4.60	31.18	14.75	1.58
3	1830	2.03	56.17	50.99	23.70	5.18	27.29	18.98	1.70
4	1910	2.12	52.78	47.07	21.91	5.71	25.16	22.69	1.72
5	1800	1.99	51.80	45.56	23.09	6.24	22.47	27.77	1.56
Mixed Soil Type 26									
1	1650	1.83	64.84	60.46	22.93	4.38	37.53	11.67	1.64
2	1730	1.92	56.30	51.86	22.66	4.44	29.2	15.21	1.66
3	2000	2.21	61.62	55.40	22.44	6.22	32.96	18.87	1.86
4	1980	2.19	58.14	51.94	22.43	6.20	29.51	21.00	1.81
5	1980	2.19	57.90	51.36	23.89	6.54	27.47	23.80	1.77
Mixed Soil Type 27									
1	1630	1.81	49.77	46.30	22.10	3.47	24.2	14.34	1.58
2	1820	2.02	55.17	50.43	23.24	4.74	27.19	17.43	1.72
3	2020	2.24	57.43	51.48	22.19	5.95	29.29	20.31	1.86
4	1950	2.16	56.57	50.18	24.19	6.39	25.99	24.59	1.73
5	1870	2.07	53.06	46.30	22.29	6.76	24.01	28.15	1.62
Mixed Soil Type 28									
1	1750	1.94	55.35	50.70	23.15	4.65	27.55	16.88	1.66
2	2000	2.21	51.42	46.62	22.02	4.80	24.60	19.51	1.85
3	1900	2.10	60.73	53.56	23.70	7.17	29.86	24.01	1.69
4	1850	2.05	60.81	52.55	21.09	8.26	30.64	26.94	1.61
Mixed Soil Type 29									
1	1650	1.83	48.50	45.32	22.93	3.18	22.39	14.20	1.59
2	1870	2.07	50.56	46.30	22.66	4.26	23.64	18.02	1.75
3	2080	2.30	57.98	51.93	22.44	6.05	29.49	20.52	1.91
4	1970	2.18	59.25	52.16	22.43	7.09	29.73	23.85	1.76
5	1890	2.09	51.71	46.02	23.89	5.69	22.13	25.71	1.67
Mixed Soil Type 30									
1	1600	1.77	58.60	54.36	22.1	4.24	32.26	13.14	1.57
2	1900	2.10	56.00	51.43	23.24	4.57	28.19	16.21	1.81
3	2070	2.29	58.40	52.62	22.19	5.78	30.43	18.99	1.93
4	1970	2.18	61.00	53.87	24.19	7.13	29.68	24.02	1.76
5	1950	2.16	80.70	67.7	22.29	13.0	45.41	28.63	1.68

Mixed Soil Type 31									
1	1680	1.86	47.76	45.34	22.92	2.42	22.42	10.79	1.68
2	1990	2.20	53.69	49.77	22.66	3.92	27.11	14.46	1.92
3	2005	2.22	48.18	44.15	22.43	4.03	21.72	18.55	1.87
4	1960	2.17	47.79	43.35	22.43	4.44	20.92	21.22	1.79
5	1930	2.14	57.82	51.16	23.89	6.66	27.27	24.42	1.72

Volume of mould= 903.208(cm^3)

4. CONCLUSION

- From the compaction tests results, different types of compaction curve have been observed.
- The result indicated mineralogy characteristics of soil has direct correlation with soil compactness and its optimum moisture content.
- Plastic soil has more OMC compare to non plastic soil
- Only the red soil has considerable amount of clay minerals, where as the remaining other soils have meager concentrations
- The behavior of some mineral in the mixed soil model is similar to cement in concrete mixed design
- Soil mineralogy has more effect on soils compaction compare to soil morphology

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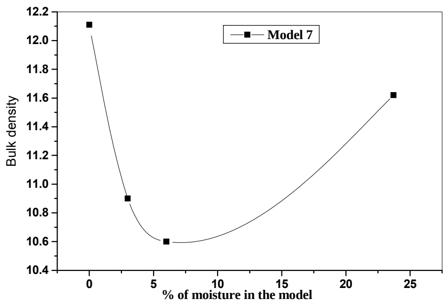


Fig 8-a Moisture vs bulk density in loose condition

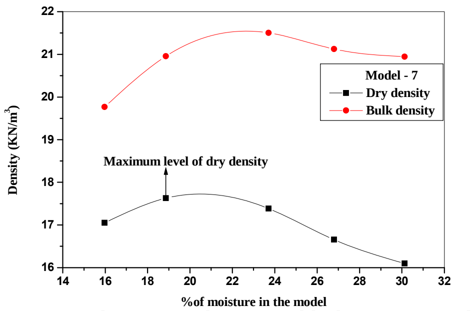


Fig 8-b Moisture vs density in model, when it is compacted

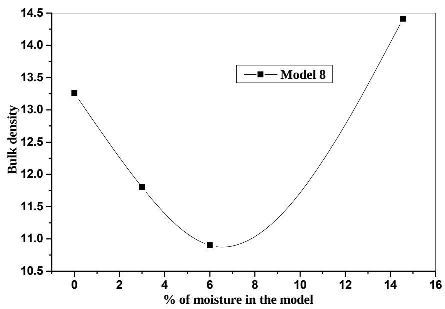


Fig 9-a Moisture vs bulk density in loose condition

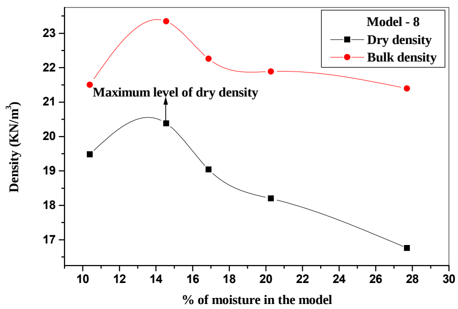


Fig 9-b Moisture vs density in model, when it is compacted

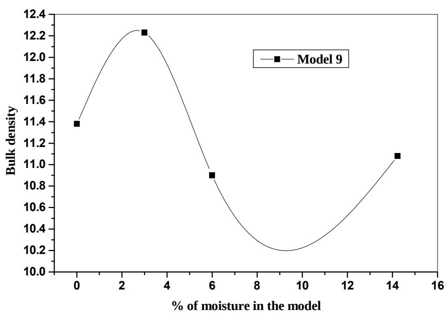


Fig 10-a Moisture vs bulk density in loose condition

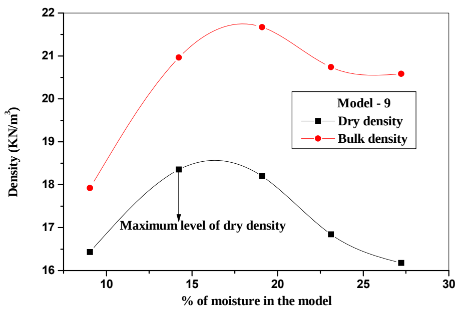


Fig 10-b Moisture vs density in model, when it is compacted

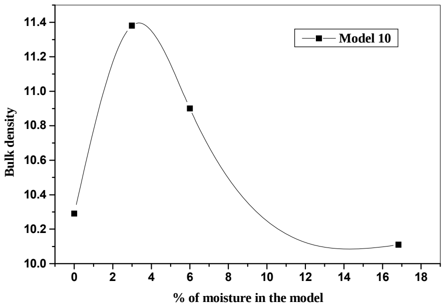


Fig 11-a Moisture vs bulk density in loose condition

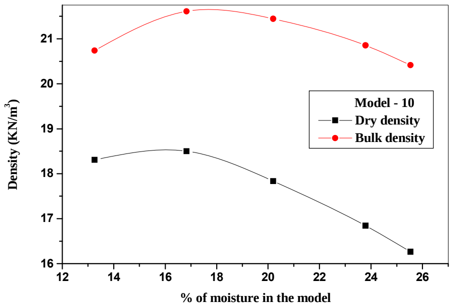


Fig 11-b Moisture vs density in model, when it is compacted

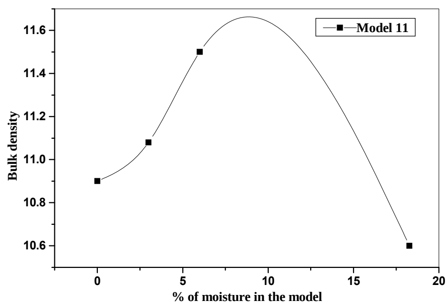


Fig 12-a Moisture vs bulk density in loose condition

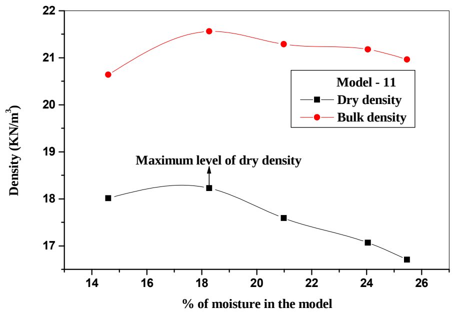


Fig 12-b Moisture vs density in model, when it is compacted

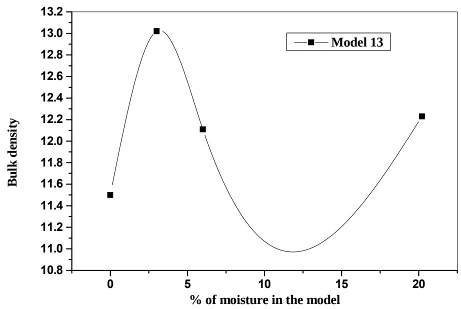


Fig 14-a Moisture vs bulk density in loose condition

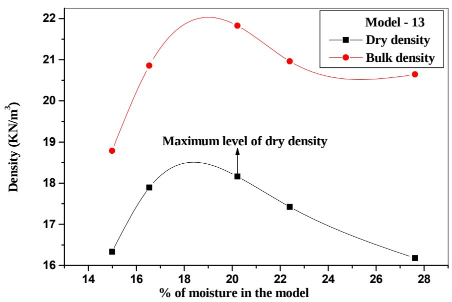


Fig 14-b Moisture vs density in model, when it is compacted

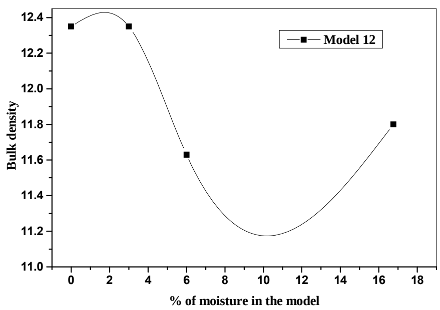


Fig 13-a Moisture vs bulk density in loose condition

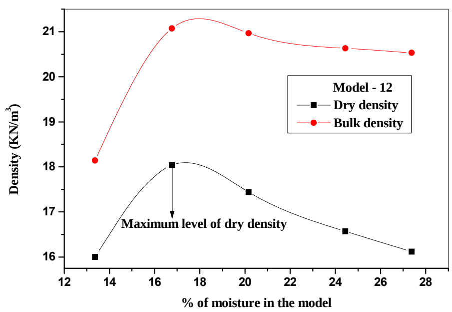


Fig 13-b Moisture vs density in model, when it is compacted

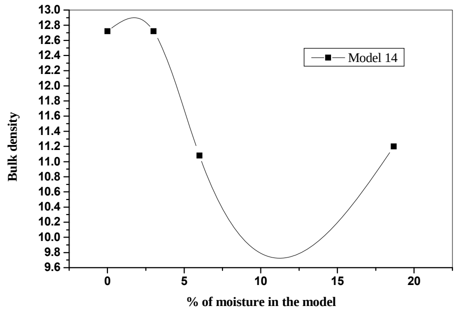


Fig 15-a Moisture vs bulk density in loose condition

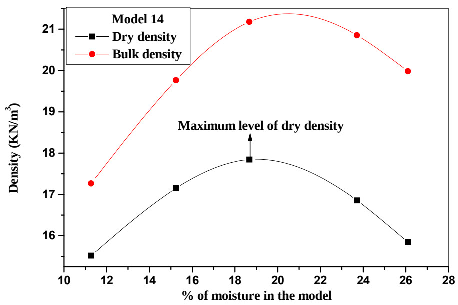


Fig 15-b Moisture vs density in model, when it is compacted

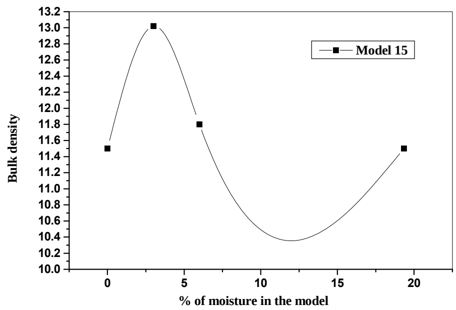


Fig 16-a Moisture vs bulk density in loose condition

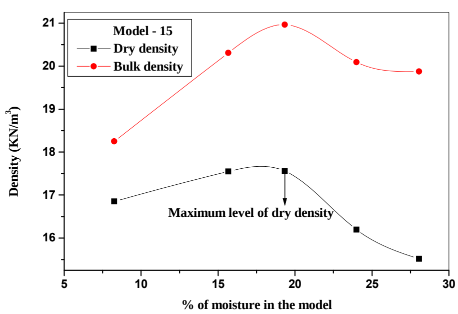


Fig 16-b Moisture vs density in model, when it is compacted

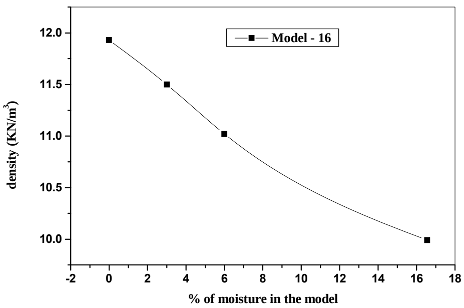


Fig 17-a Moisture vs density in loose condition

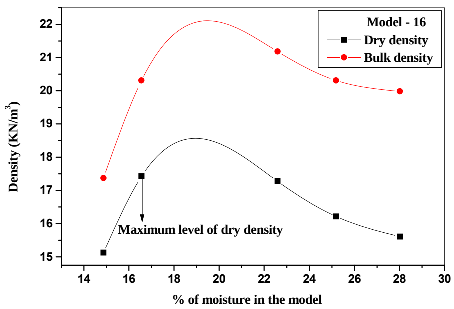
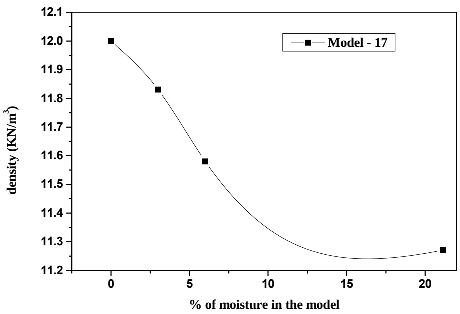


Fig 17-b Muisture vs density in model, when it is compacted



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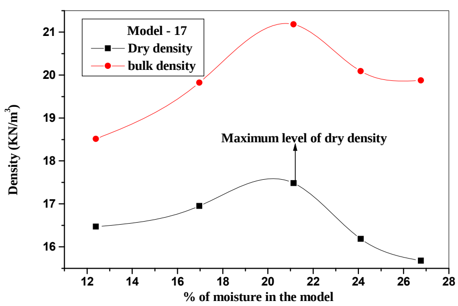


Fig 18-b Moisture vs density in model, when it is compacted

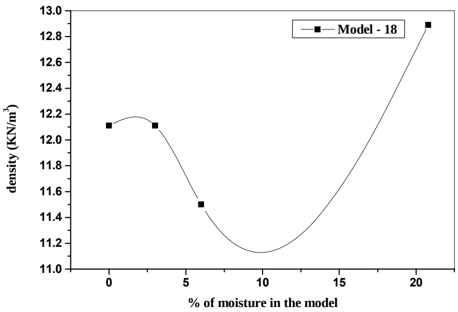


Fig 19-a Moisture vs density in loose condition

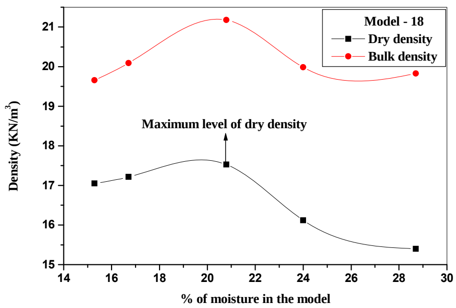


Fig 19-b Moisture vs density in model, when it is compacted

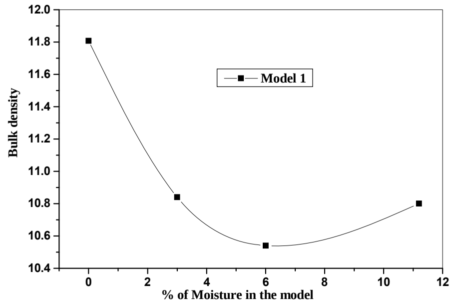
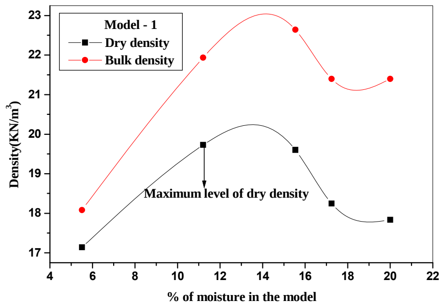


Fig 2-a Moisture vs bulk density in loose condition of model



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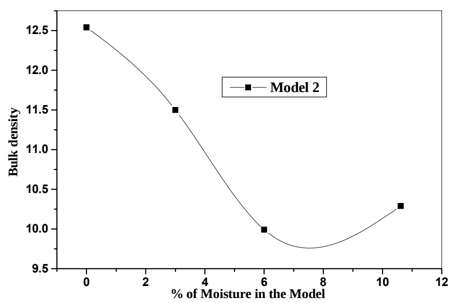

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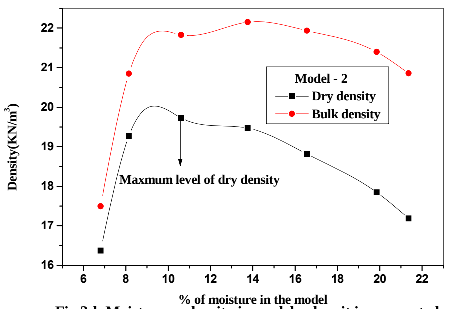
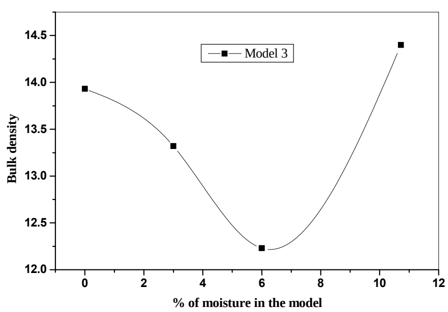


Fig 3-b Moisture vs density in model, when it is compacted



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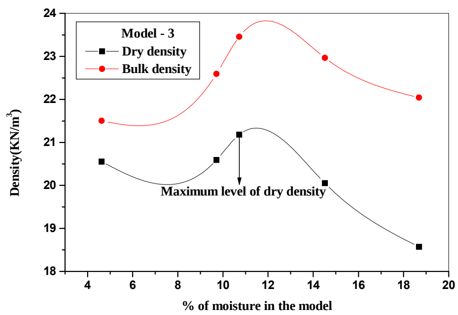


Fig 4-b Moisture vs density in model, when it is compacted

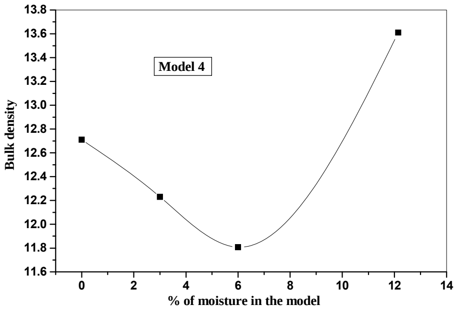


Fig 5-a Moisture vs bulk density in loose condition

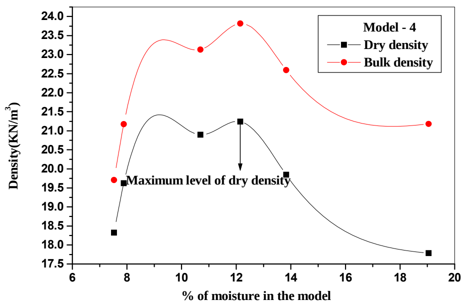


Fig 5-b Moisture vs density in model, when it is compacted

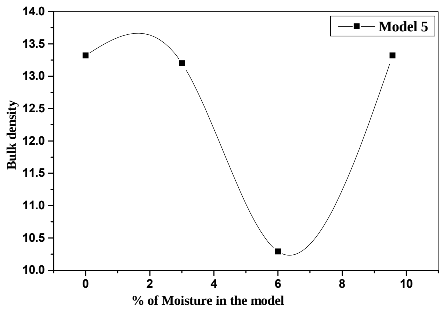


Fig 6-a Moisture vs bulk density in loose condition

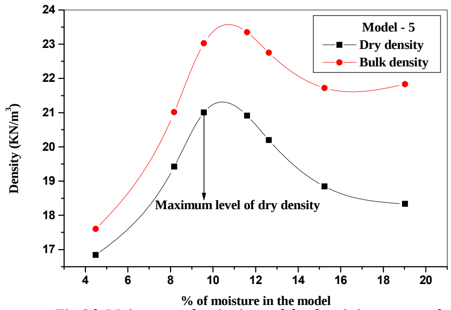


Fig 6-b Moisture vs density in model, when it is compacted

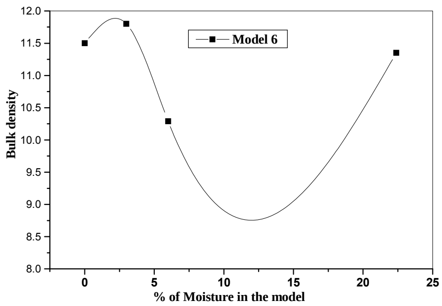


Fig 7-a Moisture vs bulk density in loose condition

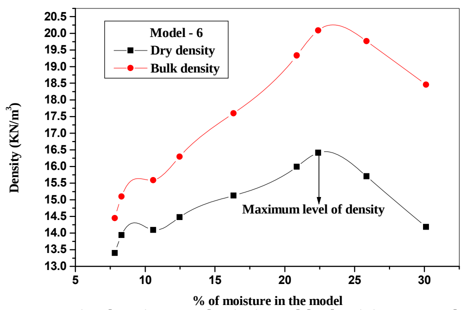


Fig 7-b Moisture vs density in model, when it is compacted

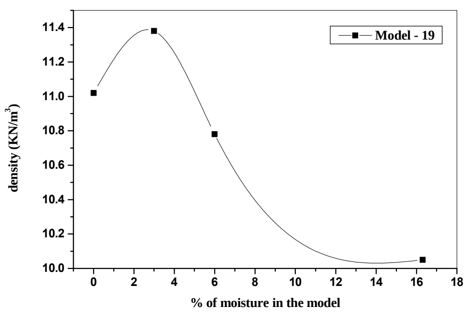


Fig 20-a Moisture vs density in loose condition

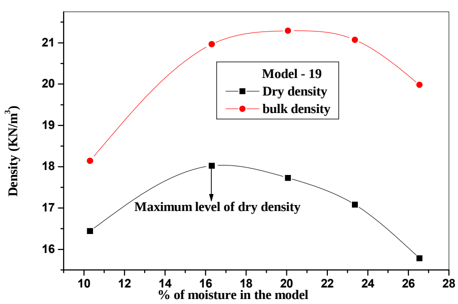


Fig 20-b Moisture vs density in model, when it is compacted

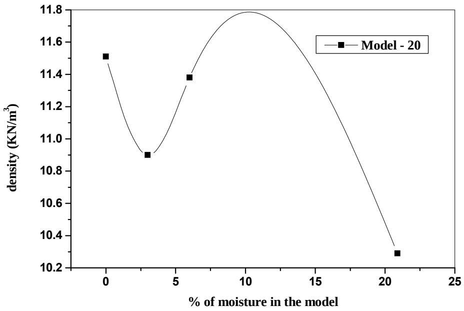


Fig 21-a Moisture vs density in loose condition

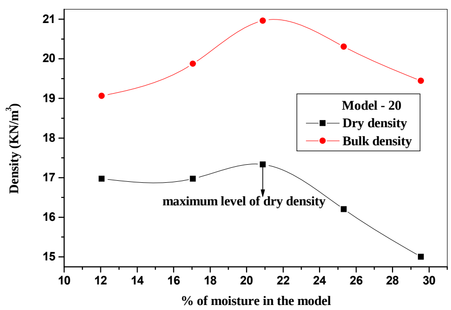
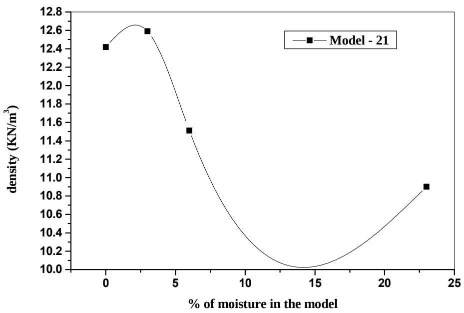


Fig 21-b Moisture vs density in model, when it is compacted



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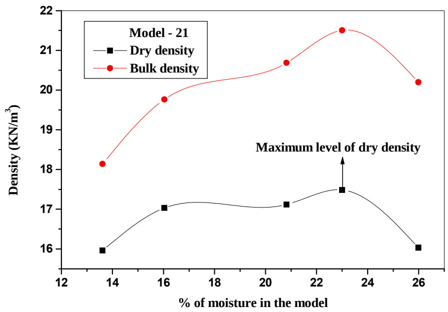

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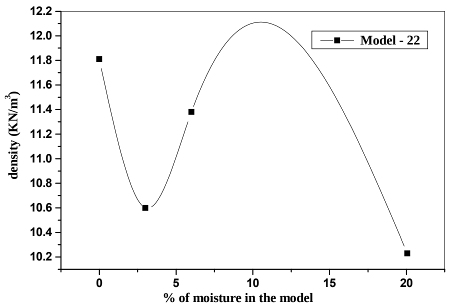

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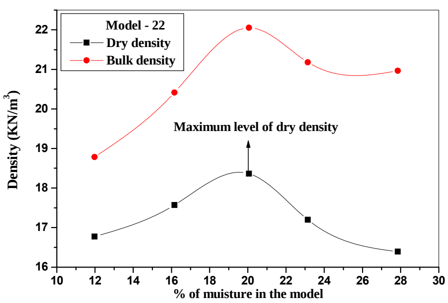

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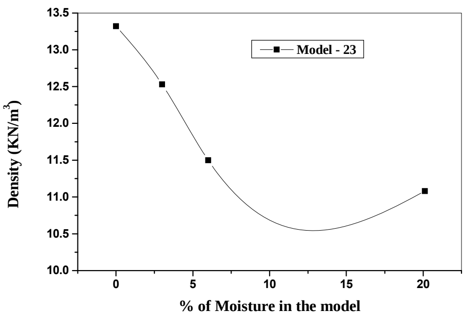


Fig 24-a Moisture vs Density in Loose Condition

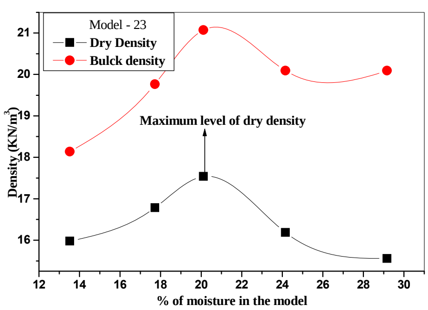


Fig 24-b Moisture vs Density in Loose Condition

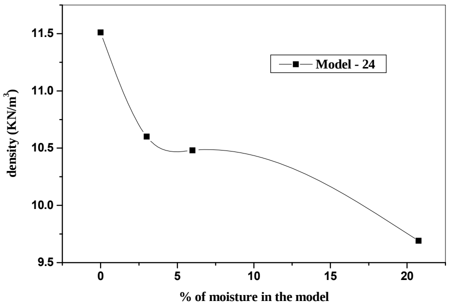


Fig 25-a Moisture vs density in loose condition

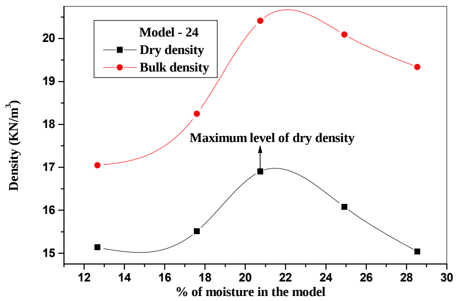
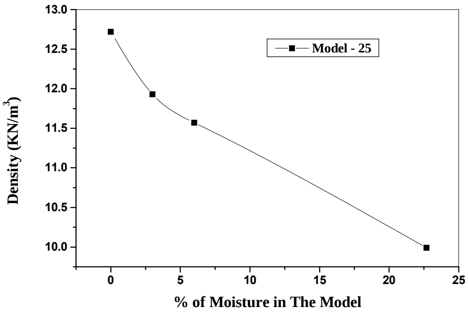


Fig 25-b Moisture vs density in model, when it is compacted



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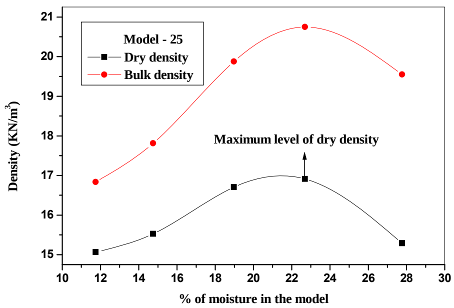


Fig 26-b Moisture vs density in model, when it is compacted

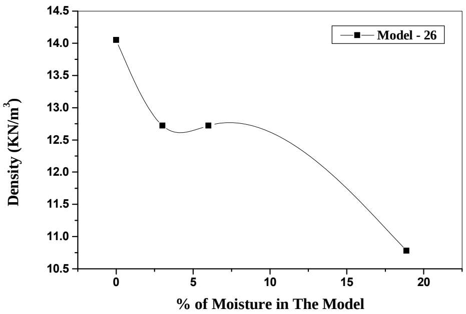


Fig 27-a Moisture vs Density in Loose Condition

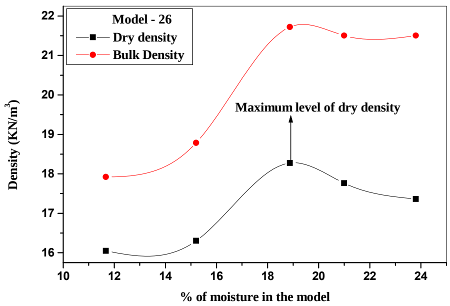


Fig 27-b Moisture vs density in model, when it is compacted

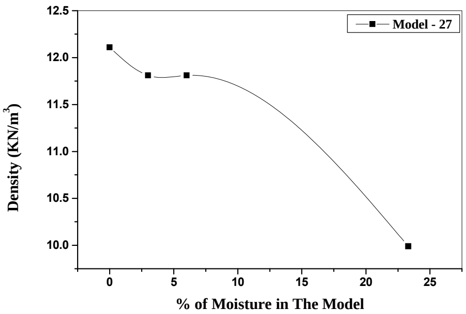


Fig 28-a Moisture vs Density in Loose Condition

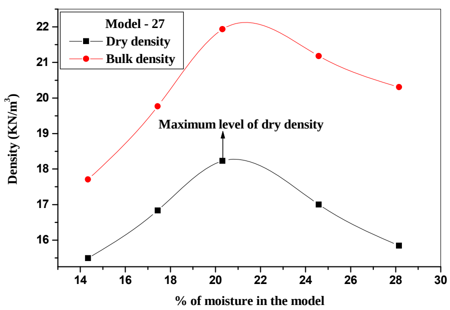


Fig 28-b Moisture vs density in model, when it is compacted

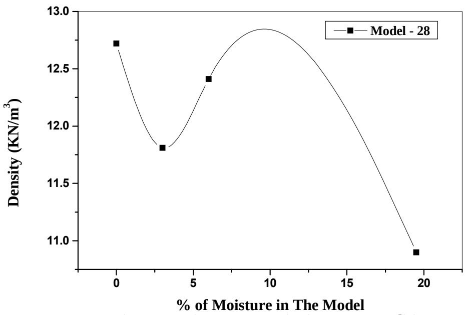
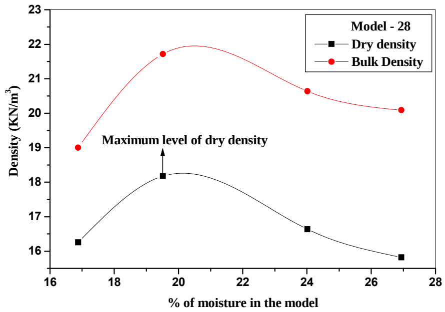


Fig 29-a Moisture vs Density in Loose Condition



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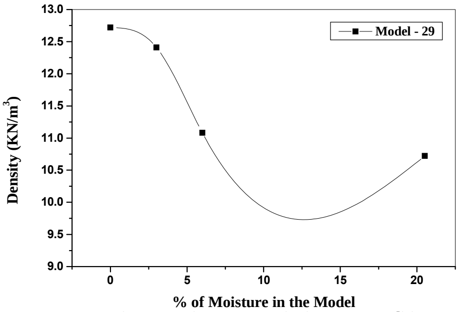

Fig 30-a Moisture vs Density in Loose Condition

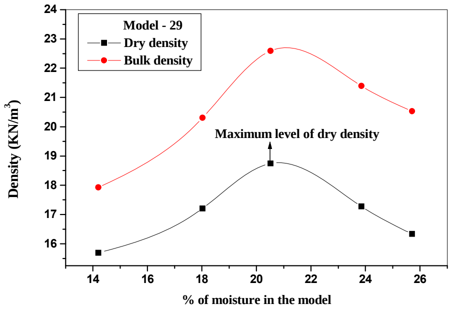

Fig 30-b Moisture vs density in model, when it is compacted

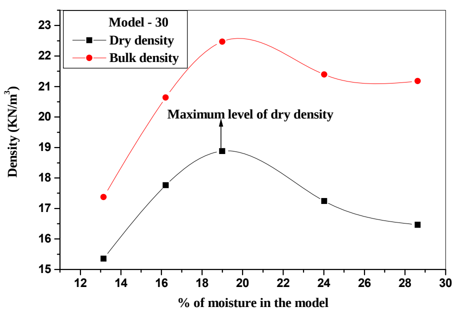

Fig 31-b Moisture vs density in model, when it is compacted

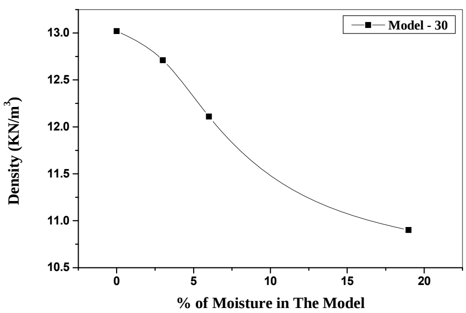

Fig 31-a Moisture vs Density in Loose Condition

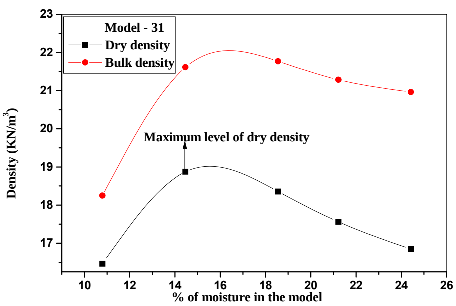

Fig 32-b Moisture vs density in model, when it is compacted

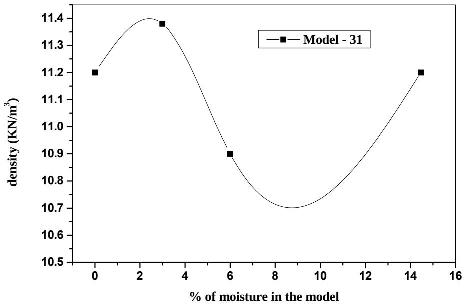

Fig 32-a Moisture vs density in loose condition