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# Study of Consolidation Behaviour of Industrial Waste Contaminated Soil

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***Abstract*: Soil contamination is a fundamental issue which must be considered during all construction operations. There were many failures of projects which had been occurred due to ignorance of effect of soil contaminations. In order to find out the effect of industrial waste on engineering property and associated health risk various tests are to be performed like-OMC, MDD Test, Particle size distribution analysis , Consistency limits, Permeability of soil, Consolidation. In order to know the effect of these contaminant on soil properties above mentioned test are performed on virgin soil and after that on contaminated soil having different proportion of contaminations. These tests are performed on the basis of test laid down by Indian Standards.***

***Keywords: Soil Contamination, Maximum Dry Density (MDD), Optimum Moisture Content (OMC), Permeability, Consolidation***

## I. INTRODUCTION

*A. General*

Soil contamination is a fundamental issue which must be considered during all construction operations. Soil contamination is composed of either solid or liquid hazardous substances mixed with the naturally occurring soil. Usually, contaminants in the soil are physically or chemically attached to soil particles, or if they are not attached, are trapped in the small spaces between soil particles. Soil-waste interaction affects almost all the soil properties. The need to set up more industries led to the disposal of industrial wastes on to the land thus polluting the soil. Due to rapid urbanization, these waste disposed lands are reclaimed to construct multi-storeyed and other kinds of structures in developed as well as in developing countries for want of space. Case histories of structural damage to industrial and residential buildings resulting from chemical contamination of soils serve to emphasize the importance to be given to the problem of modification in engineering properties of soil due to chemical contamination.

Contaminated land may present a hazard to potential users of the land and affect vegetation. Exposure to contaminants can be through inhalation of dust or gases, contact with soil or through food grown on the land. Leachates (pollutants draining from the site in liquid form) can pollute groundwater and rivers or ponds.

*B. Objectives of the Study*

1) Determining the various properties of virgin (natural) soil.
2) Determining the various properties of industrial waste contaminated soil by mixing industrial waste in different proportion.
3) Comparing the engineering properties of virgin and industrial waste contaminated soil.
4) To study the effect of industrial waste on permeability and consolidation parameters of soil.

## II. MATERIALS AND METHODS

*A. Soil*

Soil used in investigation was taken from Delhi Technological University campus and has following properties:

Table 1
Geotechnical Properties of soil

| Property | Value |
|---|---|
| Sand content(4.75-0.075mm),% | 19.66 |
| Fine soil fraction (<75μ),% | 80.34 |
| Specific Gravity | 02.58 |
| Liquid Limit (%) | 33.54 |
| Plastic Limit (%) | 21.74 |
| Maximum Dry Density (MDD) kN/m$^3$ | 17.41 |
| Optimum moisture content (OMC),% | 13.87 |

 

*B. Industrial Waste*

The industrial waste was collected from a dying industry near Delhi and was taken in liquid form. Soil is contaminated with this waste keeping percentage of liquid waste by dry weight of soil below saturated water content of soil.

## III. EXPERIMENTAL INVESTIGATION

*A. Grain size distribution*

Sieve Analysis of soil was carried out as per IS 2720 (Part 4): 1985. Soil taken was passed through 4.75 mm sieve. The soil is soaked with water and washed thoroughly, stirred and left for soaking .Now, the soil soaked is passed through IS sieve 75 micron until the wash water if fairly clean. The weight of the soil retained on sieve is taken for dry sieve analysis. Soil is passed through series of sieves from 4.75 mm, 2mm, 1.18 mm, 600 μ, 425 μ, 300 μ, 150 μ and 75 μ through a mechanical shaker .The weight of soil retained on each sieve is measured and recorded separately.

*B. Liquid limit test*

The boundary water contents at which soil undergoes a change from one state to another are called "consistency limits". Liquid limit is the water content at which soil is practically in a liquid state but has infinitesimal resistance against flow. Liquid limit of soil was tested as per IS 2720 (Part 5):1985. Four tests are conducted by altering the moisture content and no of blows required are calculated in each case. A semi log plot between log N and water content is plotted and moisture content corresponding to 25 blows is noted. This water content is liquid limit of the soil sample.

*C. Plastic limit test*

The plastic limit is the water content at which soil just begin to crumble when rolled into a thread of approximately 3 mm diameter. Three samples are tested and average of three values is taken as plastic limit of soil. Plastic limit of soil was tested as per IS2720 (Part 5):1985.

*D. Compaction test*

Standard Proctor test was performed to determine OMC and MDD of the soil sample mixed with varying proportion of the admixture. It is performed strictly as per Five soil samples are tested and graph is plotted between dry density and water content. From this graph MDD and OMC is determined. The test was performed as per IS 2720 (Part 7):1980.

*E. Falling Head Permeability Test*

The coefficient of permeability is a constant of proportionality relating to the ease with which a fluid passes through a porous medium. The test was performed as per IS 2720 (Part 17):1986.

*F. Consolidation Test*

The main purpose of consolidation test is to obtain soil data which are used in predicting the rate and the amount of settlement of structure. The two most important soil properties furnished by a consolidation test are the coefficient of compressibility ($a_v$), through which one can determine the magnitude of compression and the coefficient of consolidation ($C_v$) which enables the determination of the rate of compression under a load increment. It also gives the useful information about stress history of the soil. It is used to predict the settlements of structures in the field. The test was performed as per IS 2720 (Part 15):1986.

## IV. RESULTS AND DISCUSSIONS

*A. Effect on Liquid Limit and Plastic Limit*

Table 2
Effect of contamination on Liquid Limit and Plastic Limit of soil

| Sample Mix | Liquid Limit | Plastic Limit |
|---|---|---|
| Virgin soil | 33.54 | 21.74 |
| 8% Contaminated Soil | 35.95 | 23.26 |
| 10% Contaminated Soil | 37.64 | 24.94 |
| 12% Contaminated Soil | 38.25 | 26.45 |
| 14% Contaminated Soil | 39.91 | 28.82 |

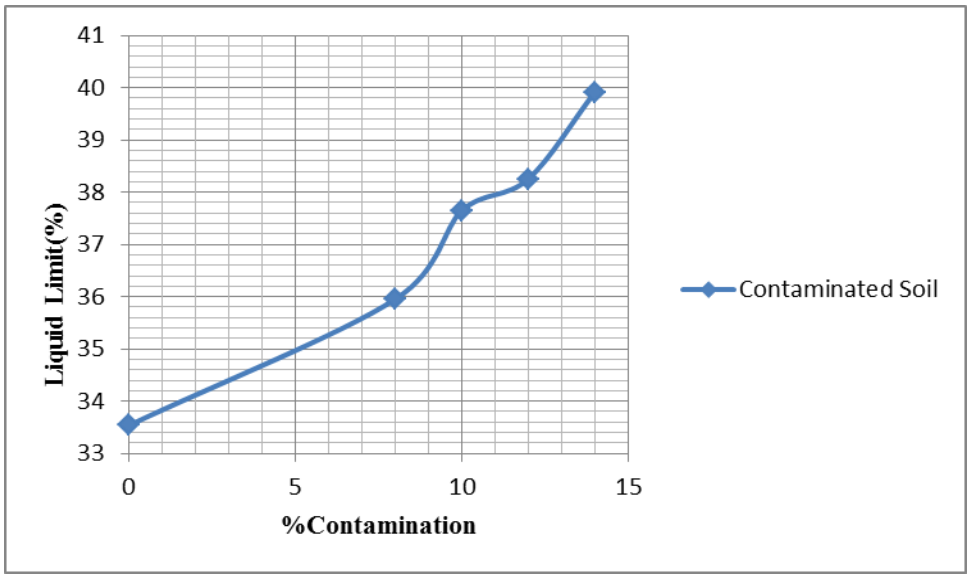


*Fig. 1 Liquid Limit Variation*

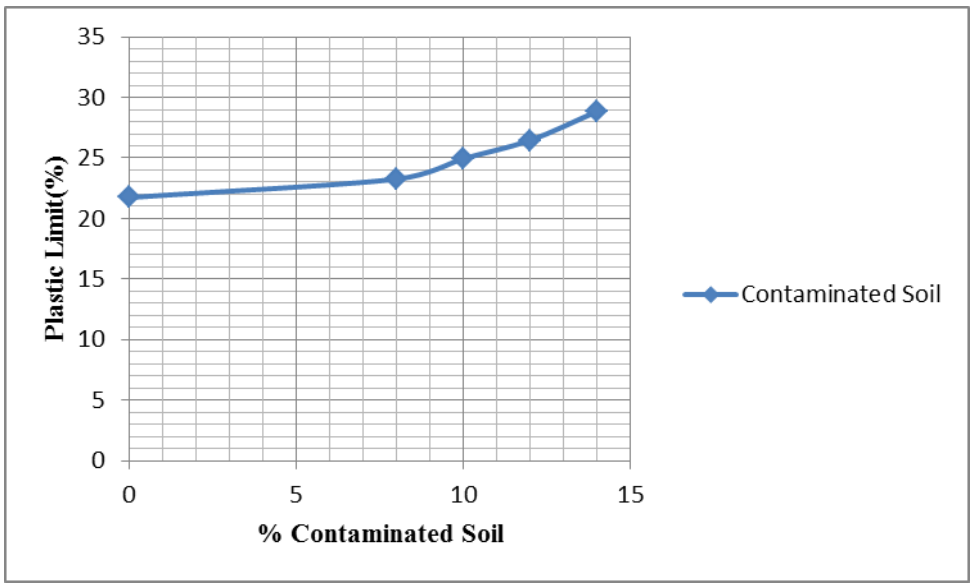


*Fig. 2 Plastic Limit Variation*

*B. Effect on compaction characteristics*

Table 3
Variation of MDD and OMC for various percentages of contamination

| **Sample Mix** | **MDD (kN/m$^3$)** | **OMC (%)** |
|---|---|---|
| Virgin soil | 17.41 | 13.87 |
| 8% Contaminated Soil | 16.84 | 14.26 |
| 10% Contaminated Soil | 16.08 | 14.68 |
| 12% Contaminated Soil | 15.48 | 15.24 |
| 14% Contaminated Soil | 14.75 | 15.80 |

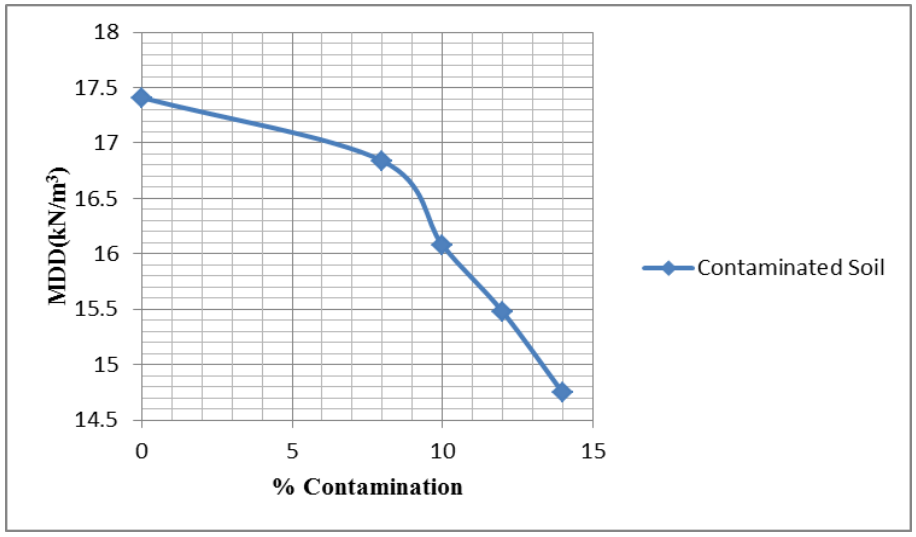


*Fig. 3 Variation of MDD*

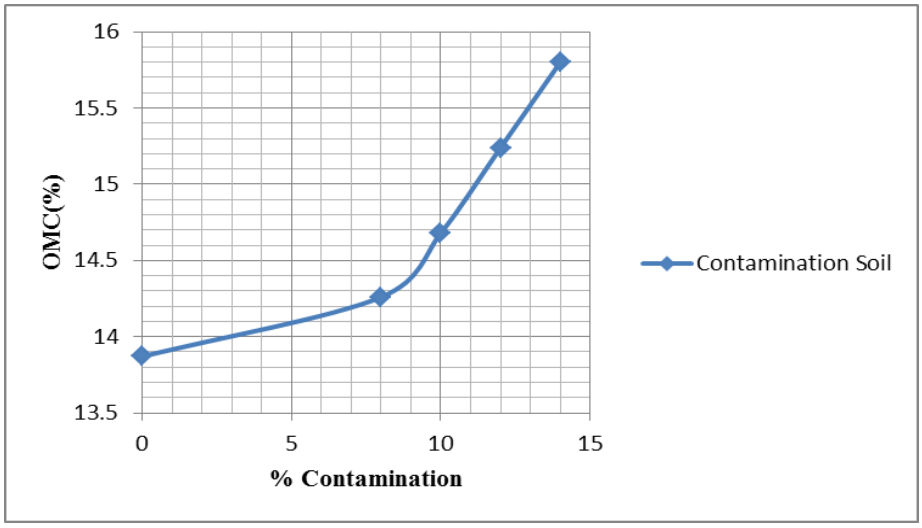


*Fig. 4 OMC Variation*

After conducting OMC-MDD test on various soil samples we found that on contaminating soil to various proportion with dye industry waste we found that OMC of the soil increased and MDD kept on decreasing on contamination. Increase in OMC and decrease in MDD occurs because of increase in voids in soil. This increment in the void ratio has been confirmed through permeability and liquid limit increment obtained.

*C. Effect on Permeability*

Table 4
Variation of Permeability for various contaminated soil

| **Soil Mix** | **Permeability(cm/s)** |
|---|---|
| Virgin Soil | $7.07 \times 10^{-5}$ |
| 8% Contaminated Soil | $8.64 \times 10^{-5}$ |
| 10% Contaminated Soil | $9.93 \times 10^{-5}$ |
| 12% Contaminated Soil | $10.57 \times 10^{-5}$ |
| 14% Contaminated Soil | $13.34 \times 10^{-5}$ |

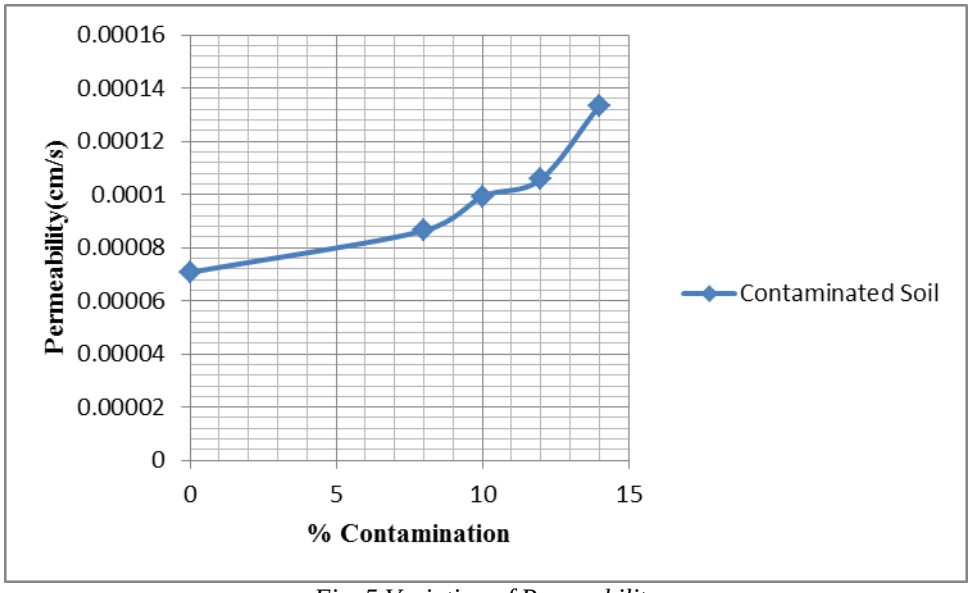


*Fig. 5 Variation of Permeability*

After conducting permeability test on various soil samples we found that on contaminating soil to various proportions with dye industry waste we found that there is increase in permeability of soil. Increase in permeability of soil may have occurred because of formation of flocculated structure due to which void ratio increases, hence due to presence of more voids permeability is increased.

*D. Effect on consolidation*

Table 5
Variation of consolidation parameters

| Soil sample | $C_v$ ($m^2$/sec) | $a_v$ ($m^2$/kN) |
|---|---|---|
| Virgin Soil | $1.58x10^{-4}$ | $8.81x10^{-4}$ |
| 8 % contaminated Soil | $2.52x10^{-4}$ | $7.30x10^{-4}$ |
| 10 % contaminated Soil | $2.79x10^{-4}$ | $7.65x10^{-4}$ |
| 12 % contaminated Soil | $3.75x10^{-4}$ | $6.12x10^{-4}$ |
| 14 % contaminated Soil | $5.91x10^{-4}$ | $5.68x10^{-4}$ |

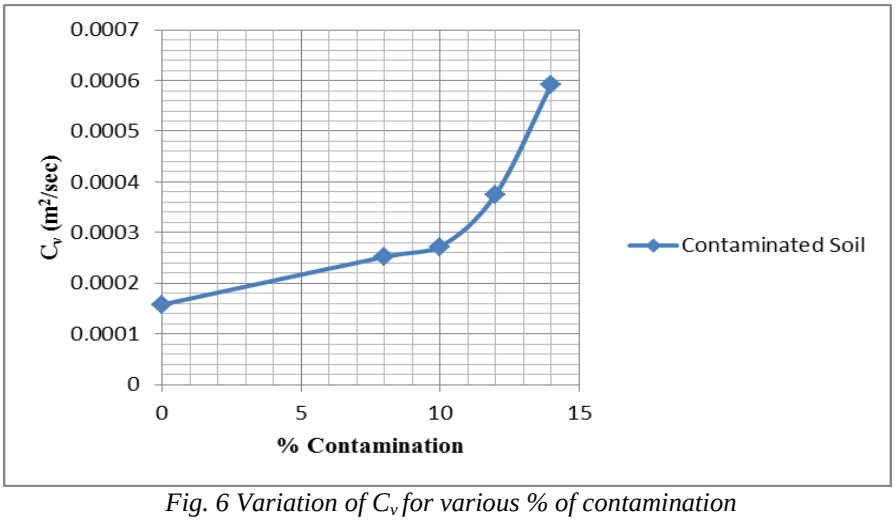


*Fig. 6 Variation of $C_v$ for various % of contamination*

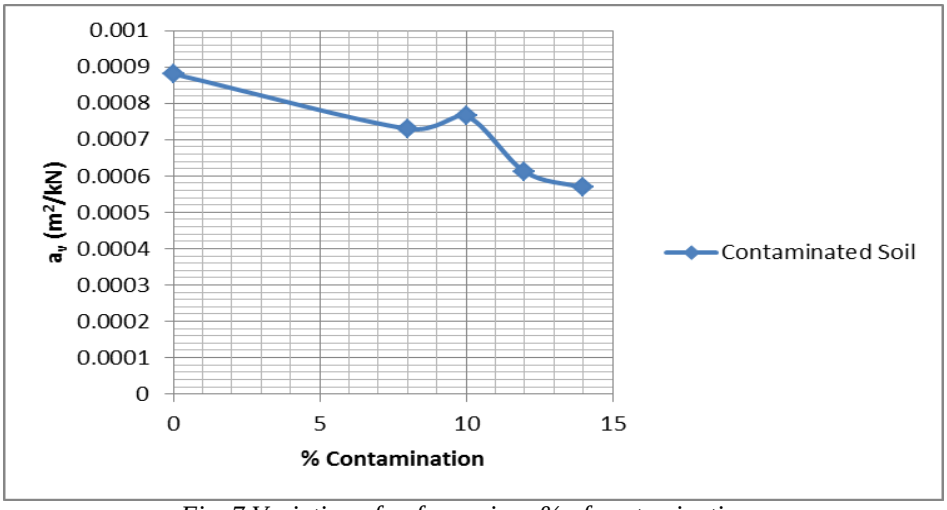


*Fig. 7 Variation of $a_v$ for various % of contamination*

After conducting consolidation test on various soil samples we found that on contaminating soil to various proportion with dye industry waste we found that there is increase in $C_v$ (coefficient of consolidation), and there is decrease in $a_v$ (coefficient of compressibility) . This indicates that our soil after contaminating consolidates quickly and amount of consolidation is less. Coefficient of consolidation $C_v$ increases as liquid limit and permeability of soil increases after contamination due to which pore water get drained out quickly and soil get consolidated.

## V. CONCLUSIONS

After performing various tests on virgin as well as contaminated soil, we came to conclusion that our soil properties are improved on contamination and it can be used as a stabilizer for the soil. Various improvement occurred in soil are –

- There is increase in liquid limit and plastic limit of the soil with the increase in contamination.
- There is increase in OMC and decrease in MDD of the soil with the increase in contamination.
- When its permeability is increased then it implies that liquid will drain out quickly from soil leading more safety against piping.
- As consolidation parameter $c_v$ is increased and $a_v$ is decreased lead to quick and slight settlement of soil when applied to loads this will lead to more or less immediate or primary settlement rather than secondary settlement hence all the settlement is done till the structure is constructed.

## REFERENCES

[1] Dogra, R.N and Uppal, I.S. (1958), "Chemical Stabilization of Sand and Sandy Soils (Laboratory Experiments with Sodium Silicate as Stabilizer)", Journal of the Indian Roads Congress, No.1, Nov.1958, pp.161-172.
[2] Mallikarjuna Rao, Triumala Rao, Reddy Babu (2008), "On Interaction of Clayey Soil with Textile Dye Waste". www.ejge.com/2008/ppro0709, Vol-13, Bundle A.
[3] Narasimha Rao, A.V. (2000), "The effect of Urea and Caustic soda on Geotechnical characteristics on Block Cotton soil", Proc.workshop on Environmental Geotechnology, 22nd March 2000, 2003,pp.64-71.
[4] Narasimha Rao, A.V. (2003), "Calcium chloride on strength characteristics on Block Cotton soil", The Institute of Engineering (India), 66th Annual Meeting Oct 27,2003, pp.43-49.
[5] IS 2720 (Part 3/Sec 1)-1980: Determination of specific gravity, Bureau of Indian Standards.
[6] IS 2720 (Part 4):1985: Grain size analysis, Bureau of Indian Standards.
[7] IS 2720 (Part 5):1985, "Determination of Liquid Limit and Plastic Limit", Bureau of Indian Standards.
[8] IS 2720 (Part 7)-1980: Determination of water content-dry density relation using light compaction, Bureau of Indian Standards.
[9] IS 2720 (Part 17): 1986, "Laboratory Determination of Permeability", Bureau of Indian Standards.
[10] IS 2720 (Part 15): 1986, "Determination of Consolidation Properties", Bureau of Indian Standards.