# THE IMPACT OF GYPSUM ON THE STABILIZATION OF PEAT SOIL

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***Abstract-*** Peat soil, characterized by its high organic content, presents significant challenges in construction due to its compressibility and low strength. This study investigates the potential of gypsum as a stabilizing agent for peat soil. Laboratory experiments were conducted by adding varying amounts of gypsum (5–15%) to the soil, and the effects on dry density, optimum moisture content (OMC), Atterberg limits, and California Bearing Ratio (CBR) were evaluated. Results showed a 38.89% reduction in OMC at 15% gypsum, with the maximum dry density decreasing from 0.802 g/cc to 0.715 g/cc. The liquid limit decreased from 49% to 39%, and the plastic limit from 20% to 16%, reducing the plasticity index. Furthermore, unsoaked CBR values increased from 1.802% to 2.94% and soaked CBR values improved from 0.801% to 1.634%. These findings highlight gypsum's effectiveness in enhancing the engineering properties of peat soil.

***Keywords-*** Gypsum, Maximum Dry Density (MDD), Optimum Moisture Content (OMC) and California Bearing Ratio (CBR).

## 1 Introduction

Peat soil comes with a lot of challenges for construction because of its high water and organic content, and the weak load-bearing capacity. To solve these problems, a process is required to make peat soil better for building on. [1] Peat is widespread globally, except in deserts and the Arctic, with the largest areas found in the northern hemisphere. Peatlands cover approximately 4.5% of total land, around 1 billion acres. These soils are composed of 50–60% carbon and have a high water content of 50–110% in a wide range. [2] Chemically, peat soils are high in carbon and water; the normal composition is nitrogen (2-4%), phosphorus, and hydrogen (5-7%). [3] Soil stabilization, a contemporary approach, aims to improve soil properties for specific purposes, notably in construction, rendering it stable and suitable. Traditional methods often proved less cost-effective and environmentally friendly. [4] Gypsum, used in cement, plaster, and fertilizer production, also influences soil properties, especially in construction. Studies show it increases Maximum Dry Density (MDD) while reducing Optimum Moisture Content (OMC) in soil. Various gypsum additives are available for soil improvement.[5] Studies demonstrate gypsum's crucial role in stabilizing various soils, such as enhancing processed soft kaolin clay by combining it with Palm Oil Fuel Ash (POFA). Individual treatment with POFA had limited effectiveness in improving soil properties, suggesting that combining it with gypsum yields greater benefits.[6]

Andi Herius et al., [7] aimed to enhance the properties of peat soils for construction purposes by investigating the effectiveness of stabilizing them with a combination of Petra soil and cement. They evaluated the impact of different cement percentages (ranging from 2.5%, 7.5%, 12.5%, and 17.5%) alongside a constant Petra soil ratio of 1:75. Their findings showed significant improvements in soil density, stability, and bearing capacity. Leong Sing Wong et al., [8] explored kaolin's efficacy in stabilizing peat. Using laboratory tests, they found that a 10% kaolin replacement yielded the highest compressive strength, surpassing the required minimum. Stabilized peat showed significantly reduced permeability compared to untreated samples. Energy Dispersive X-ray (EDX) analysis indicated cement hydrolysis, while Scanning Electron Microscope (SEM) observations revealed pore refinement due to silica sand and kaolin. This study highlights kaolin's potential in enhancing strength and reducing permeability in stabilized peat.

# 2 Research Methodology

## *2.1 Materials*

In Pakistan, peat soil occurs in natural wetlands near the Northern Mountains and is categorized as fen or bog peat based on plant remains and formation methods.[9] This research examines soil from a Rawalpindi nursery, classified as highly organic PT peat soil according to USCS. Table 1 presents the key physical properties of peat soil.

Gypsum, tested at 5%, 10%, and 15%, is vital for soil stabilization. Recycling gypsum from leftover plasterboard for ground improvement is promising but requires investigation into its environmental effects on soil longevity.[10] Gypsum was added by weight to soil samples, with four trials conducted: one for natural soil and three with varying gypsum percentages.

*Table 1 Characteristics of Peat Soil*

| Characteristics | Values | Guidelines |
|---|---|---|
| Color | Blackish Brown | |
| Organic Content (%) | 40 | ASTM D2974–00 |
| Moisture Content (%) | 54 | ASTM D2974–00 |
| Liquid Limit (%) | 49 | ASTM D4318–17 |
| Plastic Limit (%) | 20 | ASTM D4318–17 |
| OMC (%) | 54 | ASTM D698-12 |
| MDD (g/cc) | 0.802 | ASTM D698–12 |

## *2.2 Testing*

### *2.2.1 Atterberg Limits*

The Atterberg limits, comprising the liquid limit and plastic limit tests, were conducted following ASTM standards (ASTM D4318-17). The Casagrande apparatus determined the liquid limit, recording the number of blows and the weights of dry and moist soil. For the plastic limit test, the soil sample was rolled out on a glass plate and thinned to fit a steel rod of 1 mm diameter. Gypsum was incrementally added by weight to soil specimens, ranging from 5% to 15%.

### *2.2.2 Compaction Test*

The optimum moisture content and maximum dry density of the soil were determined by the compaction test. ASTM D698-12 was adhered to, and the Standard Proctor test was performed. The compaction test, measured the MDD and OMC of soil at natural bases and after the addition of gypsum to check the parameters of this test in peat soil.

### *2.2.3 California Bearing Ratio*

The CBR test is used to check the strength of soil when used as subgrade, the higher the value of CBR higher the strength of the soil. The experiment was performed under the guidelines of ASTM D-1883-09 and the molds were prepared of natural soil and with gypsum percentages and the samples were produced for soaked test which were placed in water for 96 hours before the test. Both soaked and unsoaked tests were carried out and the results are shown in the next section.

# 3 Results

## *3.1 Atterberg Limits*

Figure 1 illustrates the relationship between moisture content and the number of blows, indicating the soil's liquid limit. The liquid limit of the natural soil and soil with added gypsum (0%, 5%, 10%, and 15%) was tested. The results showed that the liquid limit decreased from 49% to 39% with 15% gypsum, while the plastic limit decreased from 20% to 16%.

Consequently, the plasticity index (Liquid limit - Plastic limit) dropped from 29% to 23%, indicating reduced clay content. The addition of gypsum caused flocculation, altering soil consistency and improving workability and drainage

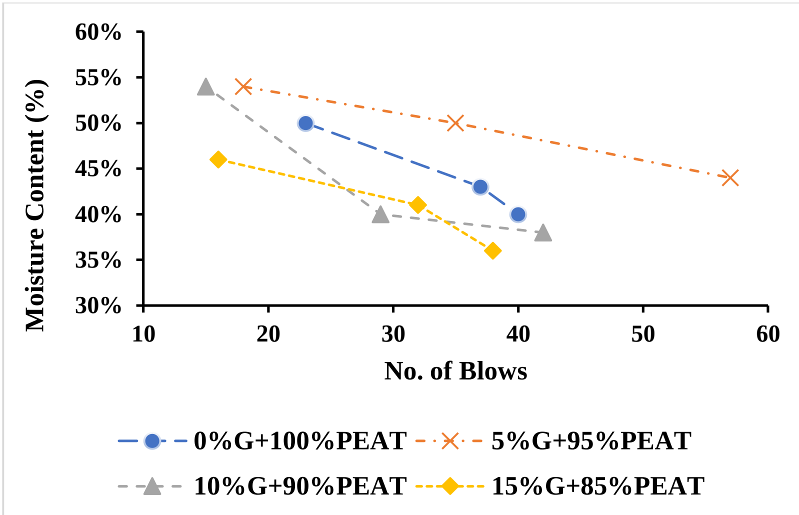


*Figure 1: Liquid Limit of Peat Soil with Gypsum*

### *3.2 Compaction Test*

Figure 2 shows the compaction characteristics of soil, showing that the Optimum Moisture Content (OMC) decreased with increasing gypsum percentages. At 15% gypsum, the OMC was 33%, compared to about 54% in natural peat, reducing the soil's water retention by 39%. The Maximum Dry Density (MDD) dropped from 0.802 g/cc to 0.715 g/cc. This reduction in density resulted from the high organic content of the soil, which decreased its natural density, and the addition of gypsum, which has a lower density, further reduced the soil's overall density.

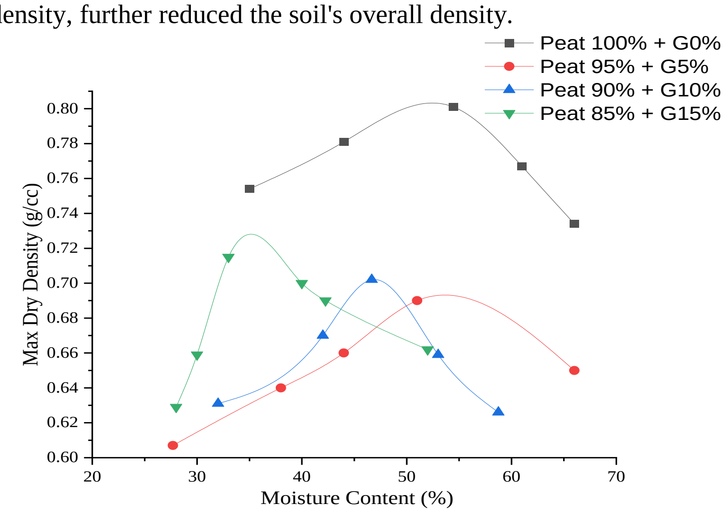


*Figure 2: Moisture Density relationship of soil*

### *3.2 California Bearing Ratio*

Gypsum enhances soil-bearing strength by filling pores. Figure 3 illustrates the relationship between gypsum content and the California Bearing Ratio (CBR). As gypsum content increased, CBR values rose from 1.805% to 2.94% in unsoaked conditions and from 0.801% to 1.634% in soaked conditions at 15% gypsum. This consistent increase in CBR values, as shown in Figure 3, indicates an improvement from poor to fair soil strength.

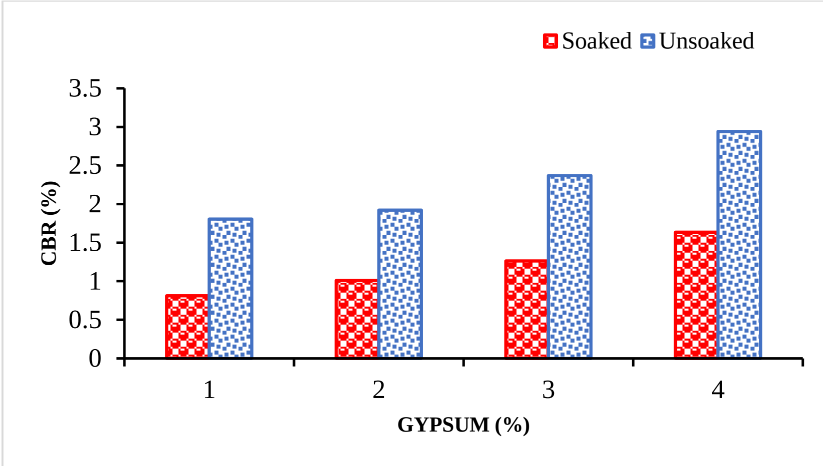


*Figure 3: Relationship of CBR with Gypsum*

## 4 Practical Implementation

These experiments studied peat soil with added gypsum to assess its impact on properties like Optimum Moisture Content (OMC), California Bearing Ratio (CBR), and Atterberg limits. Results indicated that gypsum enhances the soil's load-bearing capacity, moisture stability, and plasticity, crucial for construction projects involving peat soil.

## 5 Conclusion

The tests' results have led to the following conclusions to be drawn:

- The results revealed a 20.5% reduction in the liquid limit of peat soil, from 49% to 39% with 15% gypsum. Similarly, the plastic limit decreased from 20% to 16%, indicating a 20% reduction both with 15% gypsum. These reductions in both limits enhanced soil stability.
- The compaction test revealed that with 15% gypsum, the Optimum Moisture Content decreased to 33%, a 38.89% reduction from the natural peat's 54%.and the Maximum Dry Density also decreased to 0.715g/cc from 0.802g/cc.
- The CBR value of soil improved from 1.802% to 2.94% in unsoaked conditions and from 0.801% to 1.634% in soaked conditions with 15% gypsum addition, indicating enhanced soil strength.

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