

Evaluation of potential site for mineral processing plant

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Abstract. Nuclear moisture-density gauge is a type of instrument for measuring density and moisture of the material in a relatively thin zone beneath a surface of the material by using low activity of neutron and gamma radiation source. Density and moisture content data of the compacted layers are needed to determine the degree of compaction of soils, aggregate, concrete, asphalt or other materials used in civil engineering works. A gamma radiation source is mounted inside gauge housing with the source rod vertically extended to various depth positions. Direct transmission gamma radiation technique is used to obtain the count reading for the number of photons emitted before it is converted into density reading by microprocessor. This paper presents the inspection technique and results for the measurement of soil moisture and density carried out at potential site for mineral processing plant, Malaysian Nuclear Agency. Primarily, the experiment was conducted to ensure the compaction of ground is suitable for the plant construction. From the calculation, the percentages of soil wet density compaction (%WD Compact) are within acceptable limits with respect to the standard compacted wet soil density measured in the laboratory.

1. Introduction

In the construction of large structures such as roads, buildings, and levees, measurement of density and moisture content of soil is vital. Conventional and commonly used technique to determine density and moisture content of soil requires samples of soil column obtain from core sampling method and the soil from it conserved in an air-tight container. The volume of the core sampler is known and the soil weight was determined. From this measurement, the unit weight, or density of the wet soil, can be calculated. The soil must then be dried in an oven for at least twelve hours, weighed again, and the moisture content computed. This conventional method causes undue difficulties for both the contractor and the inspector at a construction site. The delay for test results is an economic liability to the contractor, while the inspector is limited by time in the number of tests he can take. Recent developments in nuclear moisture-density techniques offer a possibility for rapid, in-situ tests for soil moisture and density. Quick and efficient determination of these factors is of important concern to engineers and contractors.

2. Materials and Method

Density measurements are based on the rate of gamma photons emitted from a gamma source to be scattered or absorbed in approximate proportion to the density of the material through which they are passed. On the other hand, the process of thermalization or slowing down of fast neutrons, is the



principle on which nuclear soil moisture detectors operate. Fast neutrons are thermalized by hydrogen in a soil mass. A count of thermalized neutrons produced by neutron irradiation of a soil indicates the amount of hydrogen, and therefore water, in the soil. As short irradiation times are required for both methods, complete results of nuclear moisture and density tests can be available in minutes.

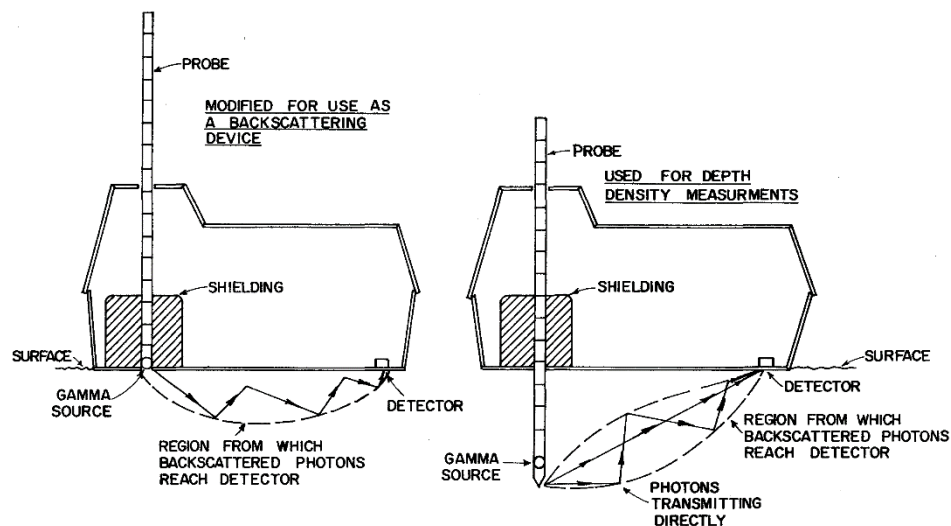


Figure 1: Gamma backscatter (left) and direct transmission (right) method.

The objective of the procedure was to evaluate the compaction value of soils on potential site for the construction of Mineral Processing Plant at Malaysian Nuclear Agency. The plant is a small scale system which is operated to ascertain the behaviour of Thorium-based nuclear process before utilizing it on a large industrial scale. A surface moisture-density gauge model Troxler 3430 was used throughout the evaluation. The instrument offers a selectable depth of measurement, ranging from back scatter position (0 mm) to 300 mm. The depth of 100 mm and counting time of one minute were used in the test. Measurement were done on flat surfaces only and a scrapper plate was used to prepare the surfaces. Care was taken not to distort the hole when removing the drill rod. The gauge was placed on the surface so that the source rod can enter the hole without disturbing any loose material around it. The source rod was lowered into the hole using the handle and trigger mechanism to 6 inches. The gauge was gently slide toward the ratemeter to make sure that the source rod was firmly in contact to the side of the hole. A set of three measurement per site was recorded. Figure 2 shows the test sites where the moisture and density measurements was taken.

2.1. Moisture Measurement

If the measurement of water content (moisture) of the soft ground, direct transmission gauge is more widely used compared to the backscatter type. Transmitted fast neutrons from the source are slowed down during interaction with the nuclei of the constituent atoms in the ground. Fast neutron lose maximum energy when collide with hydrogen nucleus. The amount of fast neutrons will decrease, as

more hydrogen is present in the ground. Therefore, fast neutron counting rates are roughly expressed as an exponential function of moisture content (water density), as expressed by the following equation,

$$R_m = A \exp(-B \rho_m) \quad (1)$$

where,

- R_m : neutron count ratio,
- A, B : calibration coefficients,
- Q_m : moisture content

3. Results and discussions

The results of the evaluation of potential site for mineral processing plant are tabulated in table 1. Figure 2 shows the sites where the moisture and density content readings are taken. Wet density, moisture, and dry density were recorded for each test site. The statistical stability test for the instrument was performed to detect any fluctuations in the readings. The analysis yields an acceptable result for the density and moisture within ideal limits. The higher wet density indicates the lesser amount of air spaces (voids) in the soil. The compaction of concrete and road asphalt also measured by dividing with standard density for the materials measured in the laboratory.

Dry density reading indicates the amount of soil density for with the absence of water (or the weight of a unit volume of a dry sample of soil, after the latter has been heated at a temperature of 103 degrees). Dry density readings measured for soil at sites 1 till 8 are within the range of 1700-1841 kg/m³. Thus, they are within acceptable limits compared to the standard readings for compacted soil measured in laboratory (1836 kg/m³), as indicated by percentage of wet density compaction. The lower the percentage of wet density compaction, the higher the amount of moisture contained in soil making it less suitable for any construction work. Ground on sites 3 and 4 are hard soil making it contain less moisture and higher compaction values compared with other soil regions.

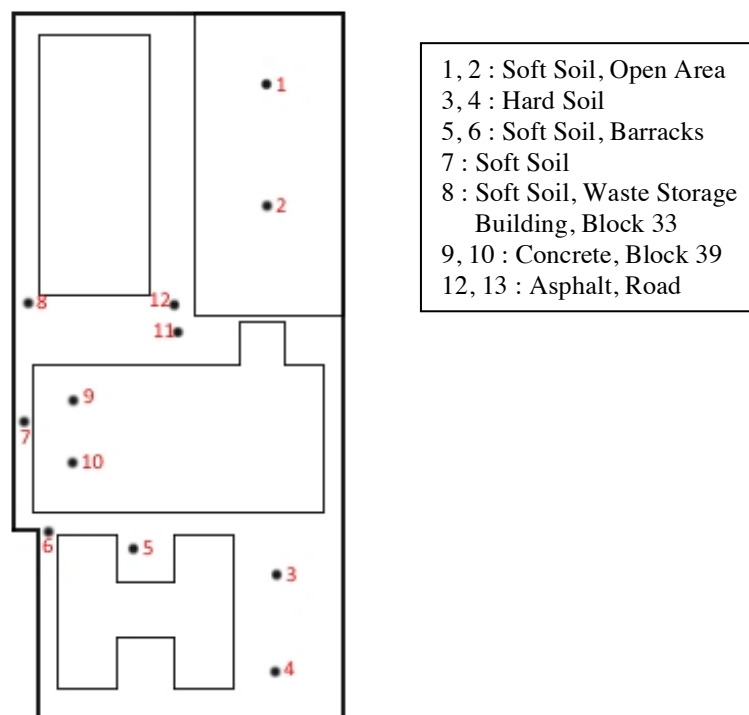


Figure 2. Site Map for Mineral Processing Plant where moisture and density content readings were taken.

Mineral Processing Plant is suggested to be located at Block 39. Sites numbered 9 and 10 are concrete ground within Block 39. The readings for the asphalt road are also taken at sites 11 and 12. The wet compaction readings for those sites indicates less than 90 percent compaction values with respect to the standard readings for concrete (2170 kg/m³) and asphalt (2230 kg/m³) taken in laboratory experiments.

Table 1: Test results for the percentage of wet density compaction.

Position (refer to Figure 2)	1	2	3	4	5	6	7	8
Material Measured	Soft Soil	Soft Soil	Hard Soil	Hard Soil	Soft Soil	Soft Soil	Soft Soil	Soft Soil
Wet Density (WD) (kg/m ³)	2006	1997	2032	2011	2053	2083	2028	2027
Moisture (kg/m ³)	279	297	205	170	267	260	284	230
Dry Density (kg/m ³)	1727	1700	1827	1841	1786	1823	1744	1797
Moisture (%)	14	14.8	10.3	8.5	13.4	13	14.2	11.5
WD Compact (%)	94.1	92.6	99.5	100.3	97.3	99.3	88.2	88.1

Table 2: Test results for the percentage of wet density compaction for both concrete and road asphalt

Position (refer to Figure 2)	9	10	11	12
Material Measured	Concrete	Concrete	Road Asphalt	Road Asphalt
Wet Density (WD) (kg/m ³)	2014	2001	1995	2025
Moisture (kg/m ³)	109	93	36	46
Dry Density (kg/m ³)	1908	1908	1959	1979
Moisture (%)	5.5	4.7	1.8	2.3
WD Compact (%)	87.9	87.9	87.8	88.7

4. Conclusion

The wet density measurement using nuclear gauge technique was used to evaluate the potential site for Mineral Processing Plant. From the values of percentages of wet density compaction, decisions can be made instantly by contractors whether or not the soil layer has appropriate compaction value. The evaluation result will help the contractors to determine the stability of the sites. Evaluation on compaction values for other materials like concrete and asphalts can also be made provided that the standard dry density for the materials are known before the gauge calibration is carried out. Soft soil recorded moisture percentage between 11.5 and 14.8 percent while hard soil recorded percentage between 8.5 and 10.3 percent. For concrete, moisture reading are 93 kg/m^3 and 109 kg/m^3 . For road asphalt, moisture reading are 36 kg/m^3 and 46 kg/m^3 .

5. References

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