Solution for the number of degree of soil compaction Discussion

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Abstract: In this paper, the optimal soil moisture content and construction of China and Turkey is expected compaction moisture poor, converted to soil compaction unit volume need to add the volume of water, and then compacted soil dry density (per unit volume of soil quality) for replacement of compacted soil dry density compensation, so as to arrive at compaction of soil maximum dry density, on-site without test or three-click test, can greatly improve the efficiency of construction.

Key words: Math solution; Maximum dry density; Dry density compensation optimal; Moisture content;

Discussion

1 Preface

Commonly used in civil engineering as a degree of compaction of soil compaction quality control indicators, and the degree of compaction is the construction of soil and soil compaction dry density of the maximum dry density ratio of the percentage, so how to determine the soil's maximum dry density for pressure it's difficult. Traditional method is to use 5 clicks is law, but it is the law of 5 clicks maximum dry density and dry density construction with a non-identity, often greater than 100% degree of compaction of the situation, the three-click method is also known as Hilf rapid control method, although the moisture content needs to be done, but done under the three moisture content test, heavy workload, difficult to understand, maximum dry density is not necessary to obtain accurate search, a number of solutions (dry density of Compensation) Act only need to know the optimal soil moisture content and field moisture content and wet density, faster and more accurate, never will be greater than 100% degree of compaction of the situation, does not affect the construction schedule.

2 Maximum dry density method (traditional method)

2.1 Click Five is the Law

Based on soil moisture content in different dry density changes under the curve drawn, the highest point on the curve is the maximum dry density, moisture content corresponding to the
optimal moisture content. Traditional
approach is to estimate the optimal
moisture content, optimum moisture
content and then +2%, +4% and -2%
opportunity moisture content, -4%
respectively, so the preparation of soil
samples test.

2.2 Three-click method

Three-click method is rapid Hilf
control method, also known as the United
States engineers developed Hilf stone soil
compaction rapid quality control method,
and the trial in 1957. Characteristics of
this method are: no determination of
moisture content, soil compaction in
accordance with the wet bulk density and
moisture content in case of the three test
measurements of wet bulk density, we
can determine the degree of compaction
of fill D and optimum moisture content
w0p wf moisture and filling the margin
(w0p-wf). Three-click method is the
principle of:

Soil dry bulk density at maximum
γdmax and optimum moisture content of
wet bulk density at the time of w0p for γd
max(1+w0p), be divided by (1+w0p)/(1+
wf), can be transformed into γdmax(1+
wf). W arbitrary moisture content of the
wet bulk density of the sample for the
γd(1+w), divided by (1+w)/(1+wf) to
change the same for the γd(1+wf).

On where, when wf=0 when, Z=w,
the representative of the moisture content;
when wf>0, the ws-style in the dry
weight for the sample.

Determination of the site will fill
compaction density of the soil samples
into the same weight three, respectively,
with different weight of water (without
holding), is suspected in the attack hit it
with a standard feature, measured after
tamping the wet bulk density for γd(1+
w), respectively, divided by (1+Z), was
transformed into the γd(1+wf), be in the
wet bulk density and wet bulk density for
the transformed vertical coordinates, Z is
the abscissa of the graph, draw γd(1+
w)~Z and γd(1+wf)~Z two curves.
From γd(1+wf)~Z curves for the
ordinate the only variables γd, so the
same curve of the maximum ordinate γ
dmax(1+wf).

3 Three-phase soil and soil
maximum dry density

3.1 Territories of the three-phase

Natural soil is a three-phase system,
namely, solid-phase, liquid and gas;
unsaturated soils is a two-phase system,
namely, solid-phase and liquid phase; dry
soil is also a two-phase system, namely,
solid-phase and gas. The soil is
compacted by the three-phase line.

3.2 The density of soil

By the compaction of soil through
different methods of sampling measured
the quality of unit volume, are
three-phase system is measured.
Measuring moisture content through the
conversion of the unit volume of dry soil
quality, are two-phase system, is ideal for
the value of the conversion. Density of wet soil - soil dry density per unit volume is the quality of soil moisture, this part of the share volume of water if filled with dry soil, that is, the theory of soil maximum dry density, when the soil is still two-phase line.

4 Principle of the number of solution

4.1 Theoretical value of maximum dry density

Department through the territories of three-phase analysis, the maximum dry density of soil under the type that can be used:

$$\rho_{d,\text{max}} = \rho_d + \frac{(\rho_{\omega} - \rho_d) \times \rho_d}{\rho_{\text{water}}}$$

(1)

The density of water by 1 terms, it was simplified for the type

$$\rho_{d,\text{max}} = \rho_d + (\rho_{\omega} - \rho_d) \times \rho_d$$

(2)

Theory of the largest degree of compaction:

$$D = \frac{\rho_d}{\rho_{d,\text{max}}} = \frac{1}{1 + \rho_{\omega} - \rho_d} \times 100\%$$

(3)

On the type (2) obtained the largest number of solution is the theoretical maximum dry density, click it to five and three-click method is the maximum dry density obtained too, taking into account the actual and theoretical maximum is in the construction can not be achieved, according to soil compaction, that is reactive in the same compaction, the soil dry density of soil moisture content with the change, when the maximum dry density at moisture content as the corresponding optimum moisture content, Based on this, it is conceivable that in the actual construction, soil moisture content or greater than the optimum moisture content or less than optimal moisture content, optimum moisture content equivalent to the probability is very small, and Turkey when the actual construction of the water content equivalent to the most excellent moisture will reach the maximum when the dry density of compaction, degree of compaction to 100%. Therefore the construction of the maximum dry density should be in the optimal soil moisture content when the dry density.

4.2 Construction of maximum dry density

Solution According to the principle of the wet soil density - density of dry soil per unit volume is the quality of soil moisture, this part of the share volume of water if filled with dry soil, that is, the theory of soil maximum dry density, then the optimal soil moisture content when rate greater than the actual moisture content of soil, the soil in the maximum dry density at optimum moisture content - the actual construction of China and Turkey is the moisture content per unit volume to achieve maximum dry density of soil when the moisture content of the
poor, the share of this part of the water If the volume filled with dry soil, and Turkey is the construction of the maximum dry density. In contrast, when the actual soil moisture content is greater than the optimum moisture content of soil, the construction of the actual moisture content of China and Turkey - the maximum dry density of soil at the optimum moisture content per unit volume is the maximum dry density of soil when the moisture content more rate, as the soil moisture content is the quality of the soil moisture content and dry soil mass ratio of the percentage, the conversion and construction in order to simplify the maximum dry density:

$$\rho_{d_{\text{max}}} = \rho_d + \frac{\rho_{\text{water}}}{\rho_d} \times (\omega_o - \omega) \times \rho_d$$  \hspace{1cm} (4)

With the maximum dry density, the density is like 1, the maximum dry density for the simplified formula:

$$\rho_{d_{\text{max}}} = \rho_d + (\rho_o - \rho_d) \times (\omega_o - \omega) \times \rho_d$$  \hspace{1cm} (5)

In this way, calculating the degree of compaction is very convenient:

$$D = \frac{\rho_d}{\rho_{d_{\text{max}}}} = \frac{1}{1 + (\rho_o - \rho_d) \times \mid \omega_o - \omega \mid} \times 100\%$$  \hspace{1cm} (6)

On where, D for the degree of compaction, $\rho_d$ to the measured dry density, $\rho_{d_{\text{max}}}$ for maximum dry density, $\rho_w$ to the measured wet density, $\omega_o$ for optimum moisture content, $\omega$ as measured moisture content, $\rho_{\text{water}}$ the density of water.

5 Project

The following table is an example of a project out of the measured moisture content and wet density, by the standards of indoor test, the optimal soil moisture content = 18%, blow dry density is the largest law 1.72g/cm$^3$, for the purpose of calculating the value of other data. Table theoretical maximum dry density according to formula (2), the number of solution of maximum dry density according to formula (5), the number of degree of compaction method based on formula (6), the degree of compaction tamping method in accordance with the indoor test obtained maximum dry density and dry density measured.
The number of tamping method statistical comparisons of degree of compaction method

<table>
<thead>
<tr>
<th>Pilot project</th>
<th>Optimum moisture content = 18%. Tamping method of maximum dry density 1.72g/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content (%)</td>
<td>16.1 16.6 16.7 16.8 17.6 19.0 24.1 28.6</td>
</tr>
<tr>
<td>Wet density (g/cm³)</td>
<td>2.100 2.070 2.050 1.990 1.980 1.990 2.068 2.110</td>
</tr>
<tr>
<td>Dry density (g/cm³)</td>
<td>1.809 1.775 1.757 1.704 1.684 1.672 1.666 1.641</td>
</tr>
<tr>
<td>Theoretical maximum dry density (g/cm³)</td>
<td>2.336 2.298 2.272 2.191 2.183 2.204 2.336 2.411</td>
</tr>
<tr>
<td>Maximum dry density of the number of solution (g/cm³)</td>
<td>1.819 1.783 1.763 1.710 1.686 1.678 1.707 1.722</td>
</tr>
<tr>
<td>Degree of compaction tamping method (%)</td>
<td>105.03 103.27 102.24 99.14 98.08 97.01 96.84 95.23</td>
</tr>
<tr>
<td>The number of degree of compaction method (%)</td>
<td>99.45 99.59 99.62 99.66 99.88 99.68 97.61 95.26</td>
</tr>
</tbody>
</table>

Examples from the table, the project can be seen, the number of degree of compaction method in the calculation of the optimal moisture content near 18 percent, in the optimum moisture content of 18% moisture content on both sides with the increase or decrease the degree of compaction decreases with the test of the basic law. Test and calculated degree of compaction moisture content of 16.1 percent from 28.6 percent to the increase in degree of compaction was reduced to 105.03% from 95.26%. Strap test does not match the basic law. Generate the possible reasons for this situation first test of the optimal moisture content did not identify, and the other is the source material (including gravel volume) changes in third test of the hit Shigong and construction features of RCC not comparable.

6 The number of solution compared with the traditional method

In the quality control of soil compaction, the commonly used indicator of degree of compaction, which is due to the uneven soil coefficient small, small particle size range, the dry density of soil compaction and soil than the maximum dry density. However, the values of maximum dry density, there are many variable factors, specifically manifested in:

1) Indoor 5-click method is by adjusting the moisture content is an ideal state, to determine the maximum dry density in the vicinity of the optimal
moisture content of some change;

2) construction is not the optimum moisture content of moisture, but moisture may be the scope of construction;

3) Indoor 5 clicks with real law and the construction of the soil samples there may be changes in the volume of gravel, resulting in compactness often greater than 100% of the cases, which is chosen distortion of the maximum dry density;

4) the number of solution of the maximum dry density obtained is the same type of soil, which is equivalent to point-to-point test, and the authenticity of a unique, on-site need for test, just the source of material for optimal soil moisture test;

5) the number of three-point method with a rapid strike law is similar, but more than three points a few fast solution method tamping it easier to understand, the application is more convenient, the impact of the construction progress of the smaller.

7 Conclusion

Construction of soil moisture on the soil for better, higher or lower than the optimal range of soil moisture are difficult to compaction, construction project must scramble to prevent the sun or rain; the shop at the same time soil material thickness small, low production, quality inspection required part of a long time and can save time in test is part of enhanced production. In this paper, the number of compacted soil solution for the maximum dry density and degree of compaction innovative thinking, in theory, is a major breakthrough in testing can greatly save time in the projects to promote the value of a certain.