Experimental Study on Effect of Initial Moisture Content on Compressive Property of Compacted Loess Like Silt

Étude expérimentale des caractéristiques de compression des lœss compactés

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ABSTRACT: Compacted soil, which widely exists in many sorts of engineering projects, is commonly unsaturated soil; and its physico-mechanical characteristics are great influenced by soil moisture content. To investigate the effect of intial moisture content of the soil on its compressive property, the numbers of oedometer tests are conducted to the specimens with various initial moisture contents and compacted under various compacting energies. The test results show that for the compacted loess like silt, when the compacting energy is same, the compressive modulus decreases with the increased initial moisture content of the specimen, but at the same initial moisture content , the compressive modulus is not monotone increased with the compacting energy increasing, the maximum compression modulus is reached under a particular compaction energy when the water content is exactly the optimum water content corresponding to the compaction energy. Therefore the initial moisture content of compacted loess like silt is one of the most important control indexes for the compaction quality control. To get a high quality of loess like backfill, the initial moisture content of the backfill must be strict controlled when the dry density meets the design requirement.

RÉSUMÉ : Les caractéristiques physico-mécaniques des lœss compactés ont un effet direct sur la qualité du compactage de ceux-ci. Elles sont aussi des éléments importants à prendre en compte quand on utilise des lœss pour réaliser des fondations et des couches de forme. Des essais en laboratoire ont été effectués pour déterminer la loi de variation des caractéristiques de compactage des lœss en fonction des teneurs en eau et d'énergies de compactage différentes. Les résultats des essais montrent que le module de compressibilité est plus grand quand la teneur en eau augmente. Pour la teneur en eau optimale correspondant à une énergie donnée de compactage, le module de compressibilité est alors le plus petit. Par ailleurs, la résistance au cisaillement baisse avec l'augmentation de la teneur en eau. De même, cette dernière change en fonction de l'énergie de compactage et elle est aussi étroitement liée à la teneur en eau optimale correspondant à une énergie donnée. Par conséquent, un contrôle strict de la teneur en eau est très important pour améliorer la qualité de compactage des fondations et des couches de forme réalisées des lœss. Par ailleurs, il faut faire attention à l'influence de l'énergie utilisée quand on retient le taux de compactage comme critère pour contrôler la qualité de compactage des lœss, et ceci afin de justifier l'application de ce taux.

KEYWORDS: loess like silt, compaction energy, moisture content, compression modulus.

1 INTRODUCTION

Filling technique is widely used in backfill foundation projects of buildings, railways, highways and other subgrades. Usually, backfill refers to the accumulated soil by human activities. The backfill which is compacted in layers is called as compacted backfill. It must be compacted under the certain standard of the material composition, density, water content. The compaction quality of compacted backfill is directly related to the strength and stability of backfill foundation and subgrade (Wang, 2004). With the development of industrialization, the decreasing availability of proper construction sites has led to the increased use of mountain area, where the compacted backfill may be used. Loess like silt is the one of widely used backfill materials.

China has an extensive deposit of loess, which is mainly found in northwestern China. In this region, loess has been widely used as backfill material. The study of machenical and physical properties of natural loess has been reported by many scholars (Assallay et.al. 1997, Guo et.al. 2000, Xie 2001). However, the study of machenical and physical properties of compacted loess is still in its begining stage, the relative reports are rarel. Therefore, it is necessary to study the mechanical property of compacted loess like silt.This paper reports the experimental results about the compressive property of loess like silt compacted, which may be referred in design and construction for loess like silt compacting.

2 EXPERIMENT

2.1. *Material*

Table.1 Basic properties of tested soil

Particle size distribution (%)		Special density	2.7
0.25~0.075 mm	1.3	Plastic limit (%)	16.1
0.075~0.005mm	82.2	Liquid limit (%)	26.0
<0.005 mm	16.5	Plastic index	9.9

The soil used in this program is taken from a loess site in Luliang city, Shanxi province, China. The basic properties of the soil are listed in Table 1. According to the Chinese Code, GB/T50 123-1999 , Standard for soil test method, it is defined as silt soil.

2.2. *Test procedure*

The test program are divided into 3 steps as follow:

Step 1, determination of the maxium dry density and optimum moisture content under given compacting energy.

The three groups of remolded loess like silt specimens were compacted under compacting energies of 2684.9kJ/m^3, 1208.2 kJ/m^3 and 592.2 kJ/m^3, respectively. For each group, there were 5 speciemans made at various initial moisture contents to get a completely moisture vs. density curve, in turn, the maximum dry density and optimum moisture content under given compacting energy are determined.

Step 2, produce the compacted loess like silt specimens. Three moisture contents of 11.5%, 13.5% and 15.5% were selected to be the initial moisture contents of compacted soil for further experiment. At each moisture content, 4 compacting energies of 671.2 kJ/m^3, 1208.2 kJ/m^3, 2013.7 kJ/m^3 and 2684.9 kJ/m^3 were used. In total, there are 12 specimens to be produced.

Step 3, the oedometer test was conducted on each compacting specimen. The compressive pressures was 25, 50, 100, 200, 300, 400, 600, 800, 1600 kPa, respectively, and the correspoding final settlement was recorded. Each loading stopped when the settlement less than 0.01mm/hour.

3 TEST RESULTS AND ANALYSIS

3.1 Maximum dry density and optimum moisture content

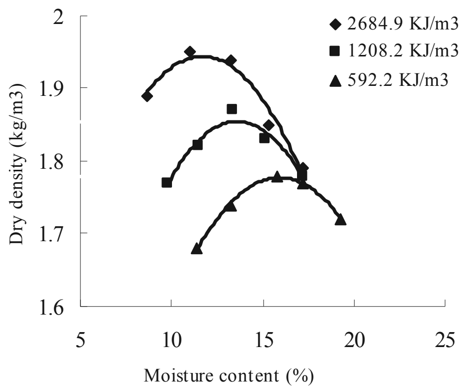

Fig. 1 Moisture content vs. Dry density

The completely moisture content vs. dry density curve is drown out for compacting energy of 592.2, 1208.2 and 2684.9 kJ/m^3 respectively, shown in fig. 1. Table 2 lists the maximum dry density and corresponding optimum moisture content for given compacting energy. Based the testing data, it can be concluded that the maximum dry density is increasing and the

Table 2 Maximum dry density and optimum water content under different compaction energy

Compacting energy E(KJ/m^3)	592.2	1208.2	2684.9
Optimum moisture content w_{op} (%)	15.8	13.4	11.0
Maximum dry density ρ_d (g/m^3)	1.78	1.87	1.95

corresponding optimum moisture content is decreasing with the increment of compacting energy. This conclusion agrees with that of other scholars.

3.2 Compressive property for same initial moisture content

The oedometer tests are conducted on the compacted loess like soil specimens which were produced with 3 different initial moisture contents and compacted under 4 different compacting energies respectively as described in section 2.2.

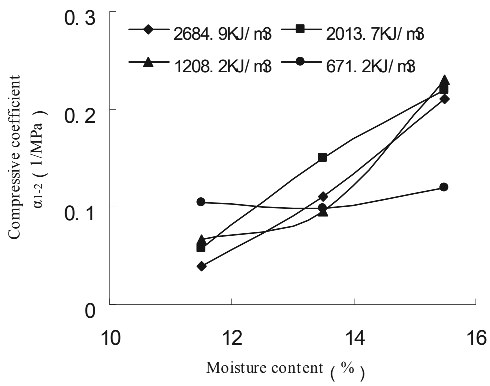

Fig. 2 Moisture content vs. Compressive coefficient under same compacting energy

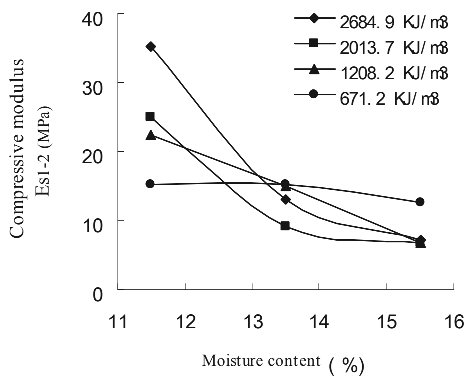

Fig. 3 Moisture content vs. Compressive modulus under same compacting energy

Fig.2 shows the relationships of compressive coefficient and moisture content for 4 different compacting energies. Fig. 3 is the curves of compressive modulus vs. moisture content for 4 different compacting energies.

From figs. 2 and 3, it can be seen that for the compacted loess like silt, the compressive coefficient increases, while the compressive modulus decreases with the increased initial moisture content of the specimen, when the compacting energy is same.

When the compacting energy is smaller, like 671.2 kJ/m^3, the compressive coefficient and modulus change with the initial moisture content, but the changes are smaller, the change ratio is less than 0.25. But, when the compacting energy is greater than 671.2 kJ/m^3, the changes are obviously, and the change ratio increses with the increment of compaction energy , shown in figs.4 and 5. The maximum change ratio is as high as 4. This may imply that the compressive property of compacted loess like silt is sensitive with the initial moisture content when the compaction energy is greater than 671.2kJ/m^3 . The greater of the compaction energy is, the more sensitive the soil to initial moisture content.

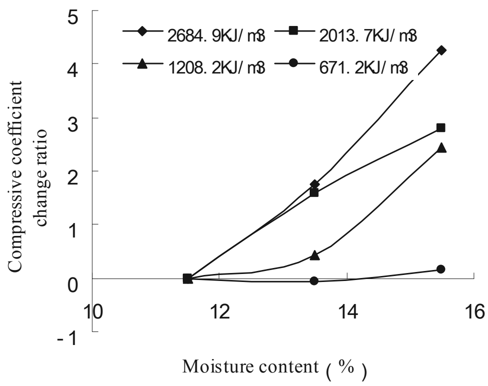

Fig. 4 Change ratio of compressive coefficient vs. initial moisture content under same compacting energy

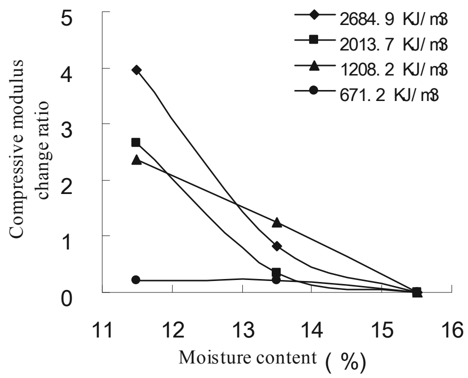

Fig. 5 Change ratio of compressive modulus vs. initial moisture content under same compacting energy

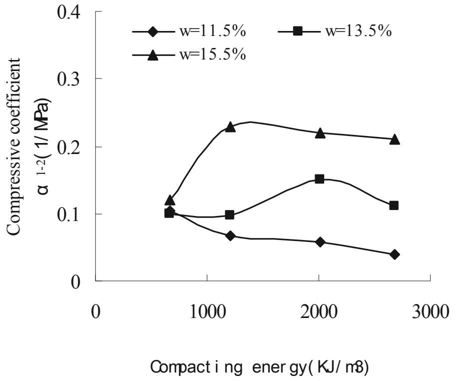

Fig.7 Curves of compacting energy vs. compressive coefficient at same initial moiture content

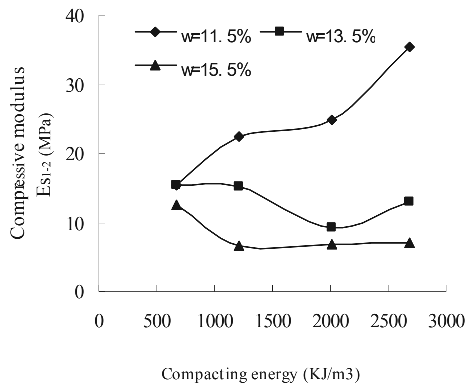

Fig.8 Curves of compacting energy vs. compressive modulus at same initial moisture content

3.3 *Compressive property for same compacting energy*

At the same initial moisture content, the compressive coefficient is not monotone decreasing and the compressive modulus is not monotone increasing with the compacting energy increasing, seen figs. 6 and 7.

When the initial moisture content equals to 11.5%, the compressive coefficient is the minimum and the compressive modulus is the maximum at the compacting energy of 2684.9 kJ/m^3. When the initial moisture content equals to 15.5%, the compressive coefficient is the minimum and the compressive modulus is the maximum at the compacting energy of 671.2 kJ/m^3. Similarly, when the initial moisture content equals to 13.5%, the compressive coefficient reaches the largest value and the modulus dose the smallest value at the compacting energy equal to 1208.2 kJ/m^3.

Considering the data in table 2, it can be seen that the maximum compression modulus, meanwhile, the smallest compressive coefficient is reached when the initial moisture content is equal or closed to the optimum moisture content under a particular compaction energy. This emphasises that the initial moisture content is a very important index for obtaining a maxmum dry density for given compacting energy. The dry density represeants the dense condition and degree of compaction of backfill. Therefore the initial moisture content of compacted loess like silt is one of the most important control indexes for the compaction quality control. To get a high quality of loess like silt backfill, the initial moisture content of the backfill must be strict controlled when the dry density meets the design requirement.

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4 CONCLUSIONS

In the present study, the following conclusions can be made about the compressive property of compacted loess like silt.

The maxmum dry density increases and the optimum moisture content decreases with the increment of compaction energy.

When the compacting energy is same, the compressive modulus decreases and compressive coefficient increases with the increment of initial moisture content.

When the initial moisture content is same, the compressive iparameters are not monotone changing with the compacting energy increasing. The maximum compression modulus (or the minmum compressive coefficient) is reached under a particular compaction energy when the water content is exactly the optimum water content corresponding to the compaction energy.

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