Soil texture judgment based on digital experimental field

Wei Jing1,2,3,4, Dong Qiguang1,2,3,4, Sun Zenghui1,2,3,4*

1 Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an, Shaanxi, 710021, China
2 Institute of Land Engineering and Technology, Shaanxi Provincial Land Engineering Construction Group Co., Ltd., Xi'an, Shaanxi, 710021, China
3 Key Laboratory of Degraded and Unused Land Consolidation Engineering, the Ministry of Natural Resources, Xi'an, Shaanxi, 710021, China
4 Shaanxi Provincial Land Consolidation Engineering Technology Research Center, Xi'an, Shaanxi, 710021, China
5 Corresponding author’s e-mail: menglinxiyu@163.com

Abstract. At present, it is very common to use Mastersizer 3000 to detect soil texture, which can be detected by dry method and wet method. In order to distinguish the consistency of the results of the two detection methods, the dry method and the wet method were used to test 8 samples from the pot experiment, and each sample was tested repeatedly for 3 times. The results were averaged. The content of clay (< 2 μm) and sand (50-2000 μm) in dry method was lower than that in wet method in all samples. The particle size distribution of dry method and wet method was significantly correlated, with a determination coefficient R2 of 0.9222. Therefore, in this project area, the model can be used to simulate the particle size distribution range of wet method and determine the mechanical composition.

1. Background of digital experimental field and soil texture judgment

The digital experimental field is to input the basic data about the physical and chemical indexes of the experimental field plants and soil in the research area into the database constructed by the big data platform of land engineering, and regularly update the data for researchers to use. Soil particle size distribution is one of the basic data to study soil properties. It can be used to determine the mechanical composition (texture) of soil, which plays an important role in controlling the physical and chemical properties and mechanical properties of soil[1]. In recent years, the laser diffraction particle size analyzer has been widely used in the powder industry because of its convenient operation, fast analysis speed, accurate and stable results[3-6]. In the field of soil testing, the Mastersizer 3000 laser diffraction particle size analyzer is also widely used[7,8]. For the accuracy research of laser particle size analyzer and traditional detection results, the conclusions are different and controversial[9-11]. Yang Jinling et al. determined the conversion relationship between the two methods according to the data results of the laser method and the pipette method, and all of them have good linear conversion relationship, so that they can use the data of the laser method to directly classify the texture[12-13]. The Mastersizer 3000 laser diffraction particle size analyzer can provide particle size distribution test by dry and wet dispersion[14], but the consistency of the two methods needs to be verified.
2. Materials and methods

2.1 Study area overview
Yaoqu Town, Yaozhou District, is located in the north of Weihe River, with crisscross mountains, rivers and tablelands, crisscross ditches, beams and hills, and unique landform. The earth rock mixed mountainous area contains a lot of argillaceous shale weathering materials, and the soil layer is very shallow. The paleosol in this area has a heavy texture and less pore distribution, which limits the circulation of air, water and heat in the soil, and hinders the growth and extension of crop roots, and lacks of soil nutrients and trace elements. The argillaceous shale contains abundant mineral elements such as montmorillonite, which has the characteristics of bentonite. Mixing it into the ancient soil can not only improve the soil structure to a certain extent, but also increase the nutrient and trace element content in the soil.

2.2 The experimental setup
The argillaceous shale, Huangmian soil and paleosol were collected, dried, and ground for 2 mm respectively. The argillaceous shale was mixed with Huangmian soil and paleosol in a certain proportion and used for pot experiment planting. See Table 1 for specific treatment measures.

| Test processing | M(argillaceous shale): M(Huangmian soil) | Test processing | M(argillaceous shale): M(paleosol) |
|----------------|----------------------------------------|----------------|----------------------------------|
| H1             | 1:1                                    | G1             | 1:1                              |
| H2             | 1:2                                    | G2             | 1:2                              |
| H4             | 1:5                                    | G4             | 1:5                              |
| CK             | 0:1                                    | CK             | 0:1                              |

2.3 The experimental method
In April 2019, mixed soil samples of each treatment were collected, dried naturally, and grounded through a 2mm aperture sieve for future use. The Mastersizer 3000 laser diffraction particle size analyzer was used to detect the distribution range of particle size by dry method and wet method. The distribution range of particle size was graded according to the Chinese grain size system, and the mechanical composition was based on the triangular diagram of soil texture made by the US department of agriculture [15,16].

Dry Test: take proper amount of air-dried soil sample after grinding and sieving (2mm) and test it directly on the machine. WET Test: Weigh 0.4g of air dried soil sample after grinding and sieving (2mm), and put it into a triangular flask, then add 0.5mol/l sodium hexametaphosphate to soak the soil sample for 24h for dispersion; add 100ml of pure water, and put the triangular flask on the digital display constant temperature electric sand bath for heating (put funnel at the mouth of the triangular flask for reflux of distilled water when heating), then start timing and boiling for 1h after the liquid boils; after the sample cools down Sample determination on computer [17].

3. Results and analysis

3.1 Comparison of dry and wet test results
The dry and wet dispersion analysis results of 8 samples by Mastersizer 3000 laser diffraction particle size analyzer are shown in figure 1, and the measurement results are shown in table 2. It can be seen from figure 1 that the dry and wet test results of the Mastersizer 3000 laser diffraction particle size analyzer are different for the same sample. The dry test results of all samples were lower than the wet test results for clay (< 2 μm), while the sand content (50-2000μm) was higher.
**Table 2. Mastersizer 3000 dry and wet dispersion determination results.**

| Test sample number | Test processing | Clay (%) | Silt (%) | Sand (%) | Mechanical components | Clay (%) | Silt (%) | Sand (%) | Mechanical components |
|--------------------|----------------|----------|----------|----------|-----------------------|----------|----------|----------|-----------------------|
| 1                  | H1             | 8.33     | 84.34    | 7.33     | silt                  | 14.26    | 82.63    | 3.11     | silt loam             |
| 2                  | H2             | 8.79     | 80.12    | 11.09    | silt                  | 14.35    | 83.86    | 1.79     | silt loam             |
| 3                  | H4             | 7.44     | 76.05    | 16.51    | silt loam             | 13.85    | 84.94    | 1.21     | silt loam             |
| 4                  | CK             | 8.90     | 78.60    | 12.50    | silt loam             | 16.29    | 81.97    | 1.74     | silt loam             |
| 5                  | G1             | 8.94     | 80.78    | 10.28    | silt                  | 18.93    | 80.59    | 0.48     | silt loam             |
| 6                  | G2             | 8.32     | 67.24    | 24.44    | silt loam             | 16.31    | 82.65    | 1.04     | silt loam             |
| 7                  | G4             | 7.97     | 72.06    | 19.97    | silt loam             | 16.06    | 83.47    | 0.47     | silt loam             |
| 8                  | CK             | 8.19     | 85.74    | 6.07     | silt                  | 16.30    | 82.16    | 1.54     | silt loam             |

According to table 2: (1) The content range of clay (< 2 μm) is 7.44% - 8.94%, and that of powder (2-50 μm) is 67.24% - 85.74%, and that of sand (50-2000 μm) is 6.07% - 24.44%. The texture judgment results of No. 1, No. 2, No. 5 and No. 8 samples are silt, and the quality judgment results of other samples are all silt loam.

(2) By using Mastersizer 3000 laser diffraction particle size analyzer, the content of clay (< 2 μm) ranges from 13.85% to 18.93%, and the content of powder (2-50 μm) ranges from 80.59% to 84.94%, and the content of sand (50-2000 μm) ranges from 0.47% to 3.11%. The results of texture determination were all silty loam.

(3) Among the 8 samples, the texture of 1, 2, 5 and 8 samples determined by dry method is silt, while the texture of 8 samples determined by wet method is silty loam, accounting for 50.00% of the total number of samples, indicating that there are differences between the results of dry method and wet method, and the differences are obvious.
(4) The content of clay particles (< 2 μ m) detected by dry method is lower than that detected by wet method, with the minimum relative deviation of 63.25% and the maximum of 111.74%; the content of powder particles (2-50 μ m) detected by dry method is higher than that detected by wet method, with the relative deviation of 2.03%, 0.24% and 4.18% respectively; the rest are lower by dry method than that detected by wet method, with the minimum relative deviation of 4.29% and the maximum of 22.92%; sand particles (50-2000 μ m) content of dry method is higher than that of wet method, and the minimum relative deviation is 57.57%, and the maximum is 97.65%.

3.2 correlation analysis of dry and wet test results

3.2.1 T Inspection. T test shall be carried out for the results of dry method and wet method. See Table 3 for the results.

Table 3. Correlation test of particle size distribution by dry and wet methods

|                      | T   | df | Significance (double tail) | Average difference | Confidence interval of 95% difference number |
|----------------------|-----|----|---------------------------|--------------------|---------------------------------------------|
|                      |     |    |                           |                    | lower limit                                  |
| Dry Method           | 4.981 | 23 | .000                      | 33.3333            | 19.4890                                     |
| Wet Method           | 4.506 | 23 | .000                      | 33.3333            | 18.0306                                     | 48.6361

Through the correlation test of dry method and wet method particle size distribution, it can be seen from table 3 that the significance (double tail) results of dry method and wet method detection are less than 0.05, and the correlation is extremely significant.

3.2.2 Correlation analysis. The correlation analysis of the results of dry method and wet method is carried out, and the results are shown in Figure 2.

It can be seen from Figure 2 that the range of particle size distribution of dry method and wet method is highly significant, the determination coefficient R2 is 0.9222, and the primary linear relationship is: y = -2.0496 + 1.0615x

Where: y - wet method for particle size content; x - dry method to detect the particle size content.

4. conclusion and discussion

According to the above research:

(1) By using Mastersizer 3000 laser diffraction particle size analyzer to detect the soil in Yaoqu town by dry method and wet method, the results of particle size distribution are obviously different, and therefore there are differences in the discrimination of mechanical composition.

(2) The correlation between the dry method and the wet method of the master sizer 3000 laser diffraction particle size analyzer is very significant. The dry method can be used for the subsequent detection, and the wet method can be simulated by the fitting equation y = -2.0496 + 1.0615x to detect the particle size distribution, and then determine the mechanical composition.
Acknowledgments
This work was Supported by the Fund Project of Shaanxi Key Laboratory of Land Consolidation (2018-TD02).

References
[1] Laboratory of soil physics, Nanjing Soil Research Institute, Chinese Academy of Sciences. Determination of soil physical properties [M]. Beijing: Science Press, 1978:28-42
[2] Zhang Qingli, Wang Zhiming. A simple method for soil particle size determination in the United States [J]. Science and technology information of soil and water conservation, 2002 (03): 18-20
[3] Ming Julan, sun Xiaoqing, Zhang Yuefang. Application of laser diffraction in particle size analysis of ion exchange resin [J]. Thermal power generation, 2013,42 (02): 71-73
[4] Xu Jufei, Kang Jian, GuFanghong, et al. Study on factors related to wort filtration performance and malt quality [J]. Food and fermentation industry, 2014,40 (12): 83-88
[5] Wang Yiming, Shu Guocai, Yang Changlin, et al. Measurement of diesel spray particle size under high temperature [J]. Journal of internal combustion engine, 1995 (01): 53-59.
[6] Particle size analysis of cell materials by laser diffraction [J]. Electronic components and materials, 2010,29 (10): 78-79
[7] Paz-FerreiroJ , E. Vidal Vázquez, Miranda J G V . Assessing soil particle-size distribution on experimental plots with similar texture under different management systems using multifractal parameters[J]. Geoderma, 2010, 160(1):0-56.
[8] Yin Jie, Deng Yongfeng, Xu Fei. Application of laser diffraction particle size analyzer in particle analysis of Lianyungang soft soil [J]. Journal of Hehai University (NATURAL SCIENCE EDITION), 2008 (05): 379-383
[9] Tan Xiaohui, Shen mengfen, Zhang Qiang, et al. Particle analysis of clay by laser particle sizer [J]. Civil engineering and environmental engineering, 2011,33 (06): 96-100
[10] Feng Teng, Chen hongsong, Zhang Wei, et al. A comparative study on the determination of soil mechanical composition in karst area by laser particle sizer and sedimentation pipette method [J]. Agricultural modernization research, 2013,34 (01): 100-103
[11] Li Xuelin, Li Fuchun, Chen Guoyan, et al. Comparative study on the determination of soil particle size by sedimentation method and laser method [J]. Soil, 2011,43 (01): 130-134
[12] Wang Da'an, Liu Gang, Wang Xiang Ying, et al. Analysis of the difference in the composition of eroded sediment particles in the black soil area of Northeast China by the laser method and the pipette method [J]. Science of soil and water conservation in China, 2016,14 (01): 114-122
[13] Wang Bin, Zheng Fanli, an Juan, et al. Study on the difference between laser diffraction method and pipette method in the determination of soil particle size distribution in Northeast Black Soil Area [J]. Soil and water conservation bulletin, 2009,29 (02): 134-139 + 143
[14] Malvern panalco. Malvern pananalytical. Mastersizer 3000 intelligent particle size measurement [EB / OL]. Https://www.malvernanalytical.com.cn/support/product-support/mastersizer-range/mastersizer-3000. 2017-9 / 2019-9-16
[15] Huang Changyong. Soil Science [M]. Beijing: China Agriculture Press, 2005:69-77
[16] Zhang Lu, Han Jichang, Wang Huanyuan, Ma Zenghui. The change of particle size composition after the combination of arsenic sandstone and aeolian sand soil [J]. Chinese science of soil and water conservation, 2015,13 (02): 44-49
[17] GB/T 19077-2016, laser diffraction method for particle size analysis [S]. Beijing: China Standards Press, 2016