Research on structure design of soil hardness penetrameter

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Abstract. Aiming at the shortcomings of the current field measurement of soil hardness, such as complicated operation and low measurement accuracy, this paper designs a penetrometer for measuring soil hardness. The penetrometer comprises a lifting part, a peripheral windproof part and a control part. It solves the problems of low measurement accuracy, inconvenient carrying in the field, large manpower demand and complicated experimental operation. The experimental efficiency and the accuracy of experimental data are improved.

Keywords: field work; Soil hardness; Penetration meter; Structure design.

1. Introduction

In the field measurement soil hardness test, there is a special data measurement method, this data measurement specific operation requires a weight of 265g of awl from a certain height of free fall into the soil, and then measure the depth of insertion [1-2]. At this stage, there is no equipment design for this data measurement and the experiments .

In the wild, the soil hardness is measured at the penetration depth. The cycle and working time of field experiments are long, if the structure of experimental equipment is too complex and bulky, it will not be conducive to field work. So first of all, the instrument should be concise and portable in structure. Secondly, the experimental equipment should meet most of the needs of the experimental process, minimize the number of operators, the smaller the number of operators, the less the factors affecting the experimental data, thereby improving the accuracy of the experimental data and reducing the error. Finally, in terms of materials, try to choose a lighter and reasonably priced material, and the design of the penetration meter will comprehensively consider the above content and meet as much as possible, and can meet the measurement of the hardness of the wild soil.

2. Penetrameterdesign

2.1. Problem analysis

The main purpose of this design is to solve the defects and demands in the test, and the defects and demands of the penetrameter in the existing experiment are analyzed as follows:

1) The experiment progress is sluggish.

2) The experimental process is troublesome.

3) The accuracy is bad.

4) Multiple people are required to participate at the same time.

5) Experimental data is unstable, and it is difficult to ensure the stability of experimental data by human operation of awls, which affects experimental analysis.

2.2. Design principles

In order to solve the above problems and needs, the designed penetrameter has the following advantages: to meet the penetrameter can arbitrarily control the height of the cone; let the cone be able to complete a certain height of free fall movement without interference; the structure is simple, convenient for field work. The specific structural design is shown in Figure 1.

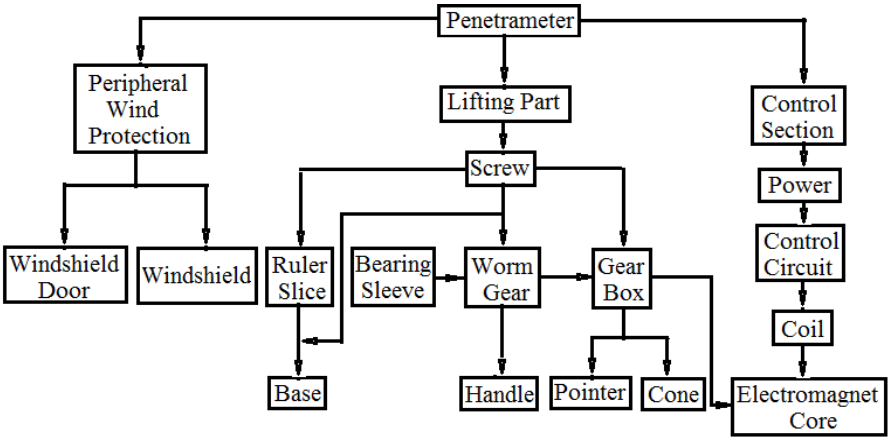

Figure 1 Structural design of penetrameter

3. Overall structural design

The structure of the penetrameter includes the lifting part, the peripheral wind protection part and the control part. The lifting part is used to adjust the height of the cone, the peripheral wind protection part of the penetrameter is used to prevent the wind from affecting the experimental error caused by the free fall of the cone, and the control part is used to control the cone to do the free fall movement. The structural composition is: ruler lices (two pieces), gearbox (upper and lower), windshield, windshield door, base, taper, lead screw, handle, turbine, worm, pointer, bearing, axle sleeve and various types of screws and bolts. The structural design and material selection of these components are designed according to the needs of experiments and penetration. Figure 2 below is the appearance of the penetrameter and its A-A cutaway view, Figure 3 is a schematic diagram of the structure of the penetrameter, marked in the figure as: 1 gearbox (including the box cover and box), 2 dust cover, 3 cone, 4 cylindrical roller bearing (upper), 5 turbine, 6 cylindrical roller bearing (bottom), 7 windshield door, 8 worm, 9 pointer, 10 deep groove ball bearing (rear), 11 deep groove ball bearing (front), 12 screw, 13 handle, 14 wind shield, 15 long ruler slice (left), 16 long ruler slice(right), 17 base, 18 foot pad.

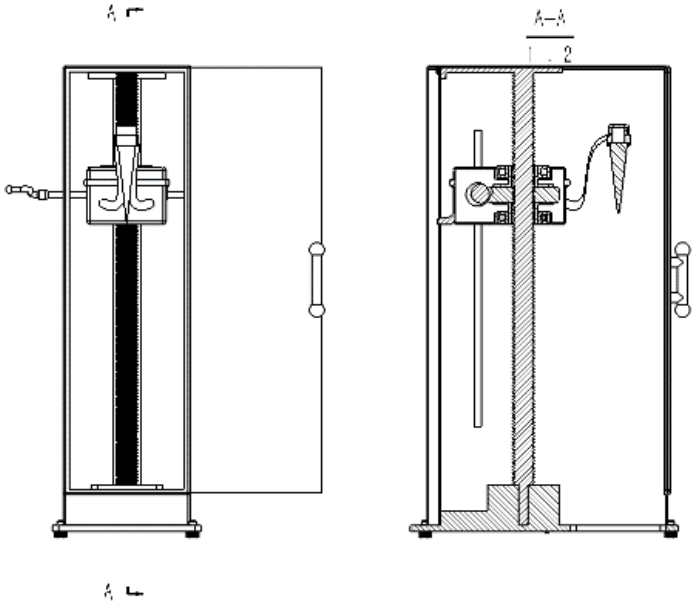

Figure 2 Appearance of penetrameter (left) and its A-A sectional view (right)

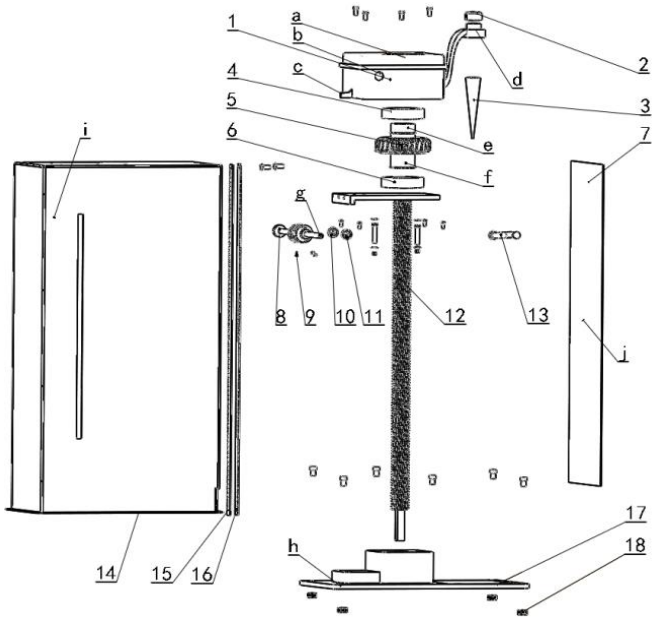

Figure 3 Structure diagram of penetrameter

3.1. Lifting part

This section, including gearbox, turbine (with upper and lower bearing sleeves), worm, lead screw, base, handle, long left and right ruler slices, pointer and dust cap. The main feature is that the matching screw sleeve of the lead screw is discarded, the thread of the screw sleeve is machined in the center of the turbine, and the turbine is regarded as a screw sleeve and a screw. The turbine worm is limited to the lead screw so that it can complete the function of lifting normally, in order to make the handle rotate the turbine more labor-saving, install the rear deep groove ball bearing and the front deep groove ball bearing at the two holes connected to the gearbox and the worm, fixing the outer ring of the rear deep groove ball bearing and the front deep groove ball bearing with the gearbox and the inner ring with both ends of the worm, which makes it easier to shake [3]; Install the long left ruler and the right ruler slices, the pointer, convenient to control the height when experimenting with this penetrameter.

3.2. Peripheral wind protection part of penetrameter

Peripheral wind protection of the penetrameter, including the windshield, the windshield door, the lower end of the windshield and the base are connected with screws, the upper end of the windshield and the horizontal plate at the upper end of the lead screw are connected with screws, and the windshield door is connected with the windshield, and the windshield door is used to push and pull left and right, mainly to solve the problem of experimental error caused by the wind when the cone is free fall.

3.3. Control section

The control part refers to the control of the free fall movement of the cone, specifically the coil of the electromagnet core and the iron core is placed in the dust cover (as shown in figure 3 of d), and then use its magnetic force to absorb the cone below, design the wired control in the dust cover, let the coil pull out to connect the power supply, there is an outer circuit switch to control the disconnection and connection of the power supply, control the work of the electromagnet, and then control the fall of the cone below, and complete the free fall of the cone.

4. Key part design and material selection of penetrameter

Some of the part details and material descriptions of this design are described below:

4.1. Turbine (with shaft sleeve), worm, lead screw

Turbine intermediate processing with threaded holes and lead screws to complete the entire ascent process, the top of the lead screw processing a one-sided bent rectangular plate, used to fix the left long ruler and the right long ruler slices and the top of the windshield, materials, considering that these three parts are threaded and toothed transmission parts, to prevent its deformation and wear and other effects on the penetrameter work, choose cast alloy steel as the material of these three parts.

4.2. Windshield and windshield door

The role is to prevent the wind from affecting the cone to do free fall movement, increase the experimental error, the windshield structure is determined according to the entire penetration meter structure, and the left and right sides are cut out of two rectangular holes (as shown in figure 3 of i) to cooperate with both ends of the worm, so that the lifting function of the penetration gauge can be carried out normally, the windshield door and the windshield are push-pull with the windshield door, the windshield door is equipped with a handle (as shown in J in Figure 3), the windshield and the windshield door need to take into account the high transparency, High hardness and reasonable price of the material, so choose a kind of plexiglass, referred to as PMMA.

4.3. Deep groove ball bearings and front deep groove ball bearings

Select a deep groove ball bearing with an inner diameter of 10 and an outer diameter of 19 (code: GB/T276-94 deep groove ball bearing 61800-ZN). Upper cylindrical roller bearings and lower cylindrical roller bearings are cylindrical roller bearings with an inner diameter of 50 and an outer diameter of 90 (code: GB/T283-94 cylindrical roller bearing nH210E). In terms of materials, SUJ2 of JIS steel used in general bearings is used.

4.4. Gearbox, dust cover, handle, foot pad

when choosing the same material in the material, they all need to take into account the factors of light material, high hardness and wear resistance and low cost, and choose polymsj's EH series nylon material.

4.5. Cone, base

This design uses iron with a general density of 7.874g/cm^2 as the material, the cone chooses this material because it is convenient to determine the size of the cone according to the required weight and density, convenient for processing, the base chooses this material because the design has low requirements for the base material, so the choice is more economical.

4.6. Pointer

The use of a triangular design, the material selection of transparent plastic, the color is red, this is the best design of this penetration meter in the reading, the material choice is the same as the windshield, all choose a kind of plexiglass, referred to as PMMA.

4.7. Long rulers

Stainless steel was chosen as the material because it is necessary to prevent the scale of the long ruler from being worn.

5. Conclusions

The structure of the penetrameter is designed for the problems and needs of soil hardness measurement, including a lifting part, a peripheral wind protection part, and a control part. The lifting part is used to control the height of the vertebral body, the peripheral wind protection part is used to

reduce the error caused by the wind, and the control part is used to control the free fall of the vertebral body, so the design is very in line with the requirements of the equipment structure design.

1) The penetrameter can be adjusted at will to the desired height, and the flexibility is high, allowing for more selectivity in the experiment.

2) This penetrameter has a high degree of accuracy in adjusting the height. The height of the scale pointer of the long ruler and the height of the lower end of the cone are very accurate, which reduces the error of the experiment a lot, and the error will be much lower than when there was no penetrameter before.

3) The structure of the penetrameter is very stable, and the experimental error will not be caused by the instability of the penetration meter during the experiment.

4) The experiment is very convenient, only one person is required to complete the experiment during the experiment, before that, such experiments require two or three people to complete, too many people, which will increase the error of the experiment and consume manpower.

5) The data obtained by the experiment is more reliable, and the experimental data is more reliable than when the penetrameter was not available before.

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