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A curtain traveling pluviator to reconstitute large scale sand specimens

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Abstract. The preparation of repeatable and uniformly reconstituted soil specimens up to the specified conditions is an essential requirement for the laboratory tests. In this study for large samples replication, the simultaneous usage of the traveling pluviation and curtain raining technique is used to develop a new method, called the curtain travelling pluviator (CTP). This simple and cost effective system is based on the air pluviation approach, whilst reducing the sample production time, can reproduce uniform samples with relative densities ranging from 25% to 96%. In order to investigate the resulting suitability and uniformity from the proposed method, a series of tests is performed. The effect of curtain traveling velocity, curtain width, drop height, and flow rate on the parameters of the sample is thoroughly investigated. Increase in the curtain velocity and drop height leads to the increase in relative density for the sand specimen. Increase in curtain width typically resulted in the reduction of relative density. Test results reveal that the terminal drop height for the sand specimen in this study is more than 500 mm. Relative density contour lines are presented that can be utilized in optimizing the drop height and curtain width parameters. Sample uniformity in the vertical and horizontal orientation is investigated through the sampling containers. Increasing relative density tends to result in the higher sample repeatability and uniformity.

Keywords: traveling pluviation; curtain raining; sand specimen preparation; relative density; uniformity

1. Introduction

Undisturbed granular soil samples are rarely obtained due to underlying costly practical challenges. Therefore, in lieu of the rare undisturbed samples, reconstituted sand samples are widely used now-a-days in various laboratory and experimental studies. Preparation of uniform layers of repeatable sand test specimens along with the required specific gravity is a major prerequisite in order to perform reliable tests on sand samples. Different methods of sample preparation will result in dissimilar soil fabrics across the samples leading to an inconsistent stress-strain response. These inconsistencies are difficult to quantify analytically which will then jeopardize the integrity of the test results (Miura and Toki 1982, Huang *et al.* 2015).

A wide range of sample relative densities varying from loose to dense sample states are conventionally applied for specimen preparations in a typical experiment or test. Moreover, the sample void ratio must be uniform with negligible occurrence of particle segregation across the entire range of reproduced soil deposits (Kuerbis and Vaid 1988). In previous experimental studies, various methods are frequently used for sand sample preparation which include air, water or vacuum pluviation (Lo Presti *et al.* 1993, Vaid *et al.* 1999, Dixit and Patil 2013, Lagioia *et al.* 2006), vibration (Lo Presti *et al.* 1992, ASTM D4253, Bildik and Laman 2015), tamping (Konrad 1998, Boushehrian and Hataf 2003, Kaur and Kumar 2016), slurry consolidation (Brandon *et al.* 1991), chemical impregnation and freezing (Choi *et al.* 2010).

Among the mentioned methods, pluviation is widely adopted by various researchers (Wijewickreme *et al.* 2005, Camenen *et al.* 2013, Huang *et al.* 2015) due to its inherent advantage of enabling the testing of a broad range of sand bed relative densities. Furthermore, it involves relatively simple preparation methodologies wherein consistent samples can be prepared, with the ability to reliably replicate layered soils including different textures and materials. Pluviation methods typically entail the use of simple instrumentation regimes and that no particle crushing is anticipated to occur (Rad and Tumay 1987, Dave and Dasaka 2012, Gade and Dasaka 2015). In the past couple of decades, air pluviation approaches have been used to prepare different sizes of sand specimens for scaled foundation prototypes, calibration chamber, centrifuge model, shaking table, and triaxial testing (Gade and Dasaka 2015).

2. Literature review

Lagioia *et al.* (2006) introduced a sand pluviation system in water, air and vacuum with the diameter of 70 mm for triaxial sample preparation. The system is able to provide minimum density for the samples with sand raining in water (according to the minimum density proposed by ASTM D4254) and maximum density with raining in the vacuum (40% more than what is achievable according to ASTM D4253).

In an air pluviation system, sand is dropped under gravity from the end of a dedicated hopper and

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subsequently falls into a sample container. Based on the method that sand is transferred from the hopper to the sample container, air pluviation systems can be classified in the following points:

1- Pluviation using diffuser sieves in which sand is passed through one or more diffusers and is thereon distributed over the sample surface. It is worth noting that the area of diffusers are typically equal or larger than that of the sample (Cresswell *et al.* 1999, Choi *et al.* 2010, Mohammadi *et al.* 2012, Camenen *et al.* 2013).

2- Single nozzle pluviation that can be done by moving the nozzle over the sample surface in accordance to a regular pattern. Most of the research that have applied this system utilize hardware that consist of a main and fixed hopper as the sand storage, a flexible and a rigid tube with or without diffusers for sand sample reproduction (Fretti *et al.* 1995, Zhao *et al.* 2006, Chain *et al.* 2010, Dave and Dasaka 2012).

3- Curtain pluviation system in which sand is guided through an aperture and rains in the form of a thin layer called the 'curtain'. Stuit (1995) implemented this system with a fixed hopper having a rectangular opening. In the study by Stuit (1995), the sample is installed over a wheel and moved automatically in horizontal and vertical directions under the hopper. It has the ability to rebuild samples with various relative densities by changing the drop height and traveling velocity of the sample. Samples with different dimensions (2m × 0.75m, 0.6m × 0.65m, and 1.2m × 0.8m) had been prepared for plane strain testing using the curtain pluviation method (Oliveira *et al.* 2012).

The two main significant parameters that influence the relative density of the reconstituted sample are drop height and flow rate (Miura and Toki 1982, Cresswell *et al.* 1999, Wijewickreme *et al.* 2005). Drop height can be defined as the space between the hopper aperture and the top of the sand surface. Flow rate is defined as the amount of outflow sand per unit time from an arbitrarily shaped opening. The relationship between relative density, drop height and flow rate must be determined in any pluviation method. Relative density is reported to increase in the case of taller drop heights and decreased with higher flow rates (Vaid and Negussey 1984, Lo Presti *et al.* 1993, Stuit 1995, Wijewickreme *et al.* 2005, Lagioia *et al.* 2006, Zhao *et al.* 2006, Choi *et al.* 2010).

Rad and Tumy (1987) and Chain *et al.* (2010) proposed a set of instructions or methods to set up a pluviation system.

When it comes to large sample preparation, most of the introduced pluviation systems are not feasible due to several limitations. For instance, using fixed diffuser sieves is a costly exercise while the single nozzle rainer has two major limitations as follows:

1- With respect to the fact that the main hopper aperture is fixed, in the preparation of large sand samples, the slope of the flexible tube deflects towards the walls of the sample container. Consequently, the resulting sand flow is not uniform.

2- Sand particles might be accumulated over the sieves during the sand flow process, which can restrict the incessant flow of sand. Thus, the hopper opening must be efficiently designed to provide a continuous flow. Such a setback significantly increases the required time for sample preparation.

Gade and Dasaka (2015) mechanized the proposed pluviation system of Dave and Dasaka (2012).

Considering the pros and cons of different methods and practical limitations, this study aims to introduce a time effective, reproducible and reliable approach for large sand samples replication with a specific relative density. A curtain travelling pluviator (CTP), is designed and operated for filling a large circular sand sample container. The device is housed in the Center of Advanced Soil and Foundation studies at the Ferdowsi University of Mashhad, Iran. In the following sections, the device details and sample preparation procedures with different densities are described.

3. Experimental program

3.1 Used materials

The sand in the present study was chosen from natural white-yellow silica sand mines of Firoozkooh located in northeast of Tehran, Iran. This sand is massively supplied for industrial use, and the quantity of production is reliable for further repeated and future investigations. As it can be inferred from Fig. 1, the coefficients of uniformity (Cu), and curvature (Cc) of the used sand are 1.58, and 1.13 respectively, which can be categorized as poorly graded sand (SP) based on unified classification system (USCS). Other physical properties of the used sand are presented in Table 1.

3.2 Sand pluviation device

In reducing the sample preparation time, a combined system consisting of both the traveling pluviator and curtain rainer, called the curtain travelling pluviator (CTP), is introduced in this study to create sand samples with a wide range of relative density and uniform porosity. Figs. 2 and 3 illustrate details of the combined system which consists of a container, fixed funnel, mobile funnel, flexural pipe, rigid pipe and rectangular transformer opening.

The main concept driver of this research is to reproduce large samples in the most efficient time. Moving large samples is not simple and sample preparation usually takes place at or in the vicinity of the main testing location. Filling the container with tank diameter and height of 1.4 m, and 0.9 m respectively is a time-consuming process. In order to cope with this challenge, a crane or a suction pump can be used for sand discharge into the top hopper at height of 2.4 m. The maximum sand volume capacity of the funnel which dimensions are 1.1 m×1.1 m×1.1 m exceeds the sand required to fill the container in a dense state. This is a set-up consideration which if overlooked, might lead to some practical issues for any pluviation system. Sand particles are transferred via gravity from the flexural tube into a traveling hopper during the sand pluviation process. Up to 30 kg of sand can be held by the mobile hopper which is able to move around the surface of the container and provide a steady flow of sand, especially near container walls.

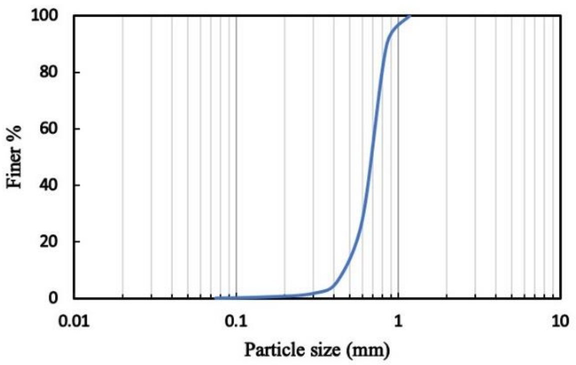


Fig. 1 Grain size distribution curve for Firouzkooh sand

Table 1 Engineering properties of the used sand

G_s	C_u	C_c	D_{10} (mm)	D_{50} (mm)	$\gamma_{d\,max}$* (kN/m^3)	$\gamma_{d\,min}$*(kN/m^3)
2.71	1.58	1.13	0.45	0.67	16.10	13.00

*Maximum and minimum dry-unit weight are achieved according to ASTM D4253 and D4254, respectively

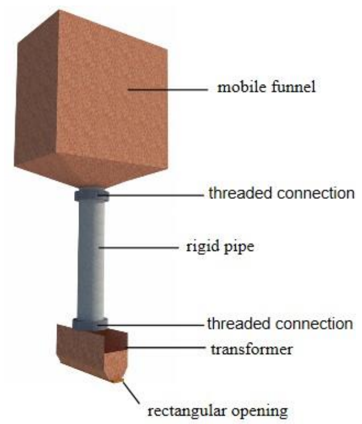


Fig. 2 transfer system from mobile funnel into rectangular opening

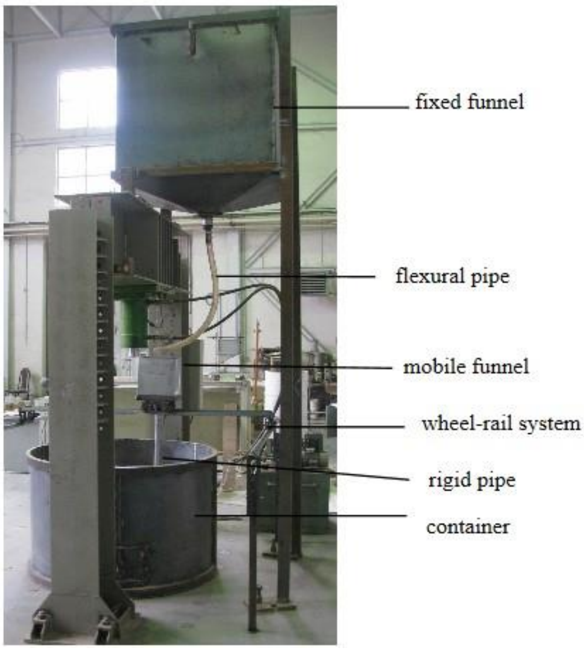


Fig. 3 The traveling curtain sand pluviator

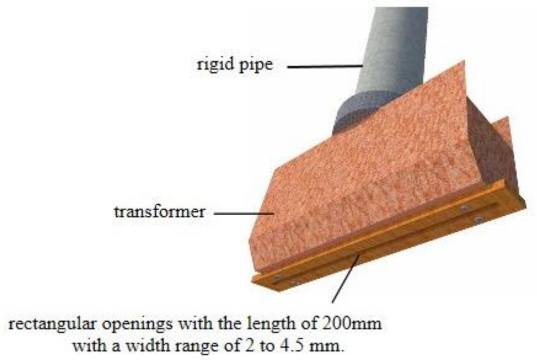
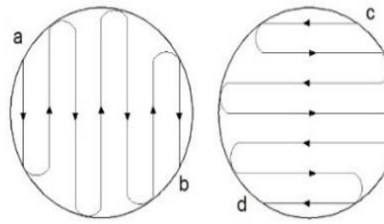


Fig. 4 Transformer between the rigid tube and rectangular opening

(a) A front view from traveling hopper over sand container



(b) Schematic view of sand pluviation directions

Fig. 5 The curtain travelling pluviator

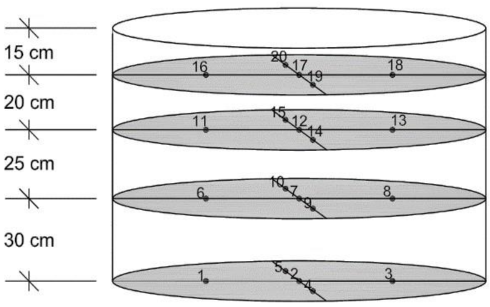


Fig. 6 Location and number of samples for local relative density investigation

A rigid tube is coupled to the traveling hopper using a threaded connection in which sand is guided to a transformer for providing uniform and constant particles out-flow over the openings. In order to control sand flow rate at the end of the pluviation path, series of plates are designed to have rectangular openings with the length of 200 mmm with a width range of 2 mm to 4.5 mm. Regarding the circular shape of the container, filling process near the walls would be problematic if more than 200 mm is used as the opening length. It must be noted that a sand storage is included in the transformer, which enables a uniform sand flow over the rectangular opening. The aforementioned opening and transformer compartment details are as shown in Fig. 4.

An integrated system of wheel-rail is utilized for effective conveyance of the traveling funnel over the entire sample surface in the circular container. According to Fig. 5, it can be observed that sand is transferred through the rigid tube into the container in two predefined paths from points A to B and subsequently from C to D which is called a passing cycle. These two directions are perpendicular, thus the opening is passed twice over the entire sample surface in each passing cycle. Choosing two perpendicular paths leads to a higher uniformity of each distributed particle layer when compared to two successive similar paths (Fretti *et al.* 1995).

The device’s jacking system and its related components are the cause of several limitations, which lead to the implementation of two-joint methods for keeping the sand rain height constant during the pluviation and sample preparation process. The combined approach is by using rigid 60mm diameter tubes with various lengths in a way that 100 mm shorter tubes are replaced after each pluviation cycle. Moreover, the wheel-rail system is set up over height-adjustable columns, which can be vertically extended up to 200 mm with 50 mm steps.

In order to evaluate the quality of the proposed pluviation method and to determine the affecting parameters on the specific gravity and relative density of the rain-outflow sand mass, tests with different drop height and deposition intensity have been performed. Relative density of the sand sample is captured by studying 20 similar samples, each with a volume of approximately 600 cm3. Location and number of samples in the sand container are shown in Fig. 6. Furthermore, one sample is positioned at the center of the circular tank in each layer and four others are evenly spaced between the wall and the center. As the control of relative density is more critical at the upper layers, the vertical spaces between the collected samples are increased along with the depth of the tank.

Tests of this study can be categorized as follows:

Section one: Evaluating the effect of deposition intensity on the relative density.

Section two: Determination of the flow rate amplitude for the proposed system.

Section three: Determination of the effect of height and flow rate on the sample relative density.

Section four: Determination of sample uniformity through the investigation of local relative density in the entire sample volume.

Tests contained in section one through three are performed for bottom layers while the fourth section addresses the entire sample volume in accordance to the depiction in Fig. 6.

4. Results and discussion

4.1 Section One: Evaluating the effect of deposition intensity on the relative density

Decomposition intensity of the rained sand is governed by following parameters:

1- The curtain velocity (V)

2- Width of the curtain (W)

It must be noted that a parametric study is required to find out how V and W affect relative density. Velocity of the curtain can be controlled through the monitoring of thickness of the outflow poured layer which is chosen to be 2.5 cm and 5 cm respectively in two distinct trials. Moreover, in each trial the rectangular opening is passed once across the entire surface of the sample (direction from point A to B as shown in Fig. 5(b)) and in forming a 10 cm layer, four and two passes is required for the first and second trial, respectively.

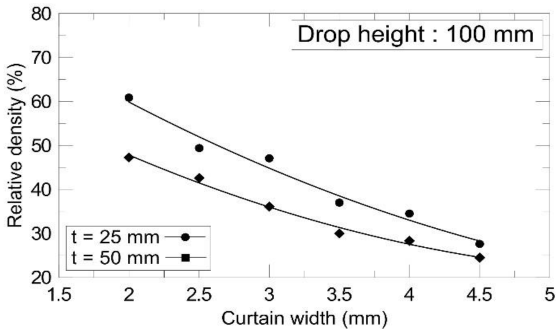
In this section, rectangular openings with the width of 2 mm, 2.5 mm, 3 mm, 3.5 mm, 4 mm and 4.5 mm are utilized, and the raining height is set at 100 mm, 150 mm, 200 mm, 300 mm, 400 mm and 500 mm. The raining height is taken as the space between the surface of the pluviated sand layer and the lower portion of the transformer compartment which is kept constant according to the aforementioned procedure of rigid tube replacement and height-adjustable columns. Fig. 7 illustrates the effect of layer thickness of 2.5 cm and 5 cm trials and pluviation curtain width on the relative density while keeping the height of fall as a constant. Generally, relative density is more sensitive to the curtain traveling velocity or layer thickness when lower drop height and smaller curtain widths are used. However, layer thickness is more influential on the relative density in the case of higher falling heights and larger curtain widths.

Based on Fig. 7, it can be seen that with an increase in the curtain width or flow rate given a constant drop height leads to decrease in relative density, which can be generally anticipated as it is independent of layer thickness. The reduction in relative density may be related to the air trapped between sand particles while falling in a large mass and resting over each other, forming layers.

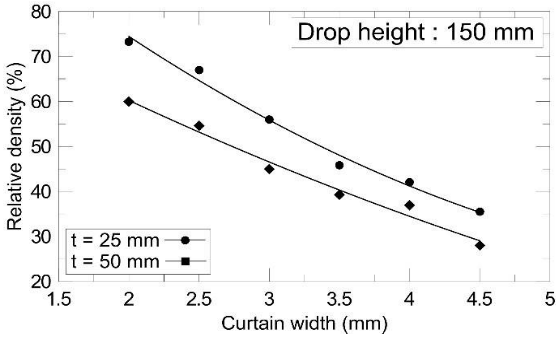
Fig. 8 illustrates the effect of curtain traveling velocity and height of fall on the relative density while curtain width is kept unchanged at 2 mm and 4.5 mm respectively. It can be inferred that given a constant curtain width, the required traveling velocity for passing over the sample surface in forming a layer with thickness of 2.5 cm is higher than that required in forming a 5 cm layer. Therefore, increasing the curtain traveling velocity results in higher sample relative density, regardless of the drop height. This is in agreement with the results reported by Lo Presti *et al.* (1993) and Stuit (1995).

Based on Fig. 9, the observed increase in relative density with higher curtain traveling velocity can be related to the compaction mechanism during pluviation. Particle compaction occurs in a very thin layer, called the energetic layer comprised of three or four grains, and higher relative density can be achieved if enough time for the formation of this layer is provided. In case that optimum time for the energetic layer formation is not allowed, maximum density cannot be achieved.

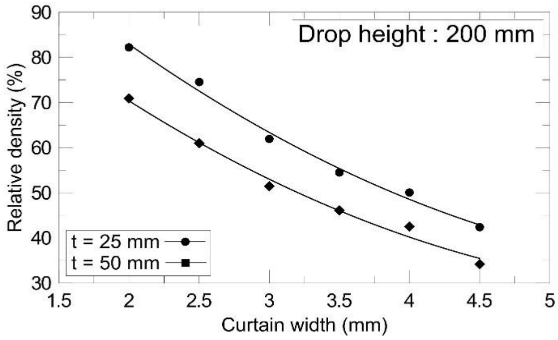
Regarding to the aforementioned observations, it can be obviously inferred that there is an inverse relationship between the relative density and deposition intensity in the proposed system.



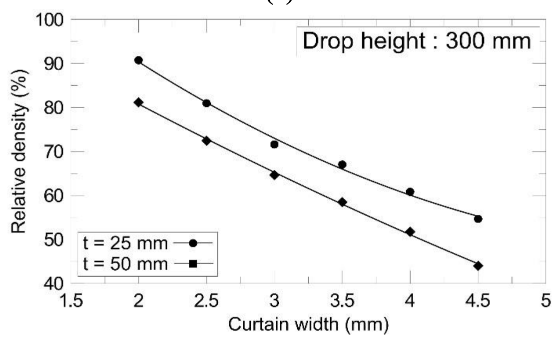
(a)



(b)

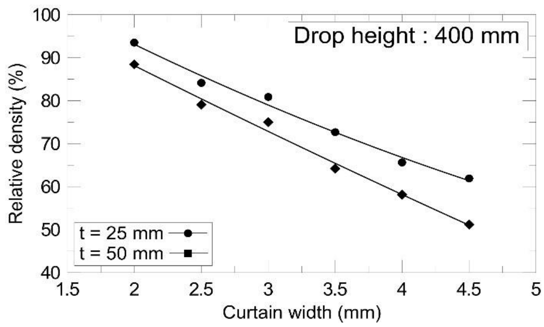


(c)

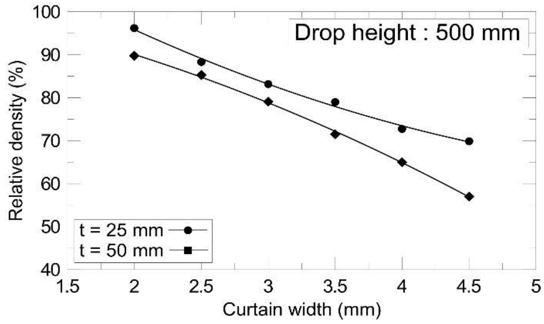


(d)

Fig. 7 Effect of layer thickness and curtain width on the relative density in constant height of fall



(e)



(f)

Fig. 7 Effect of layer thickness and curtain width on the relative density in constant height of fall

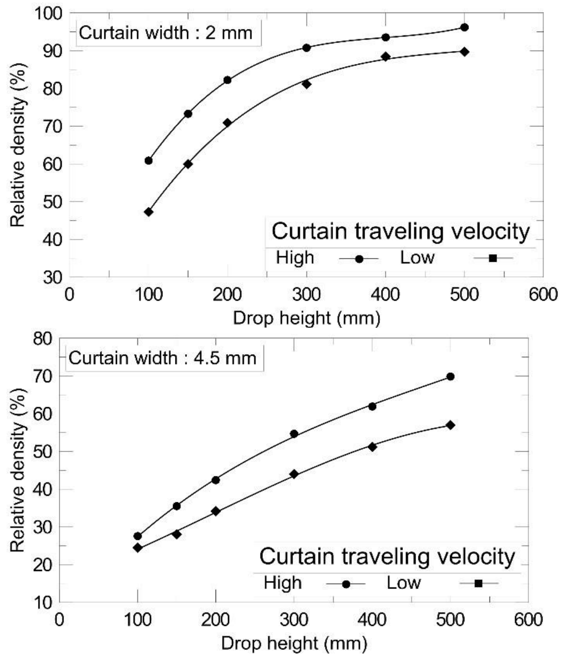


Fig. 8 The effect of curtain traveling velocity and drop height on the relative density in constant curtain width

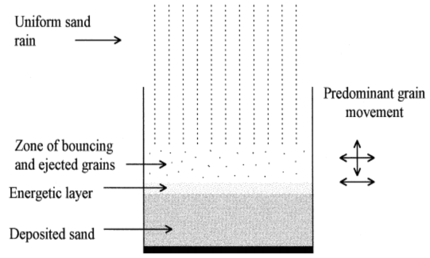


Fig. 9 Compaction mechanism during the pluviation process (Cresswell *et al.* 1999)

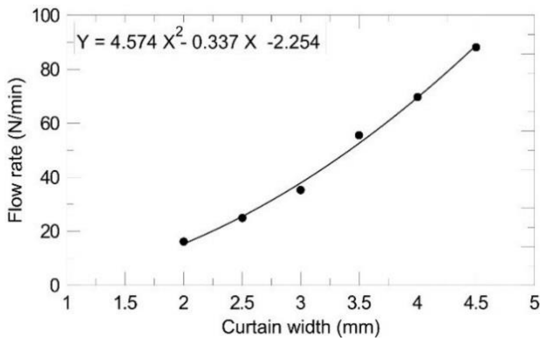


Fig. 10 Effect of the curtain width (W) on flow rate

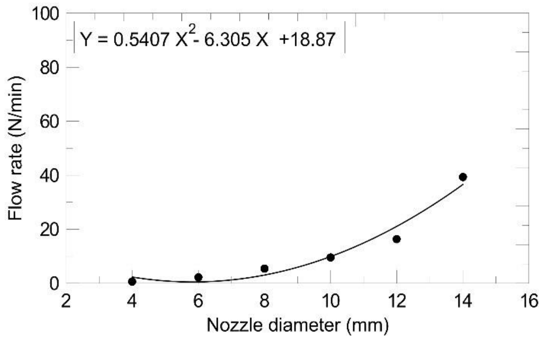


Fig. 11 Effect of the nozzle diameter on flow rate

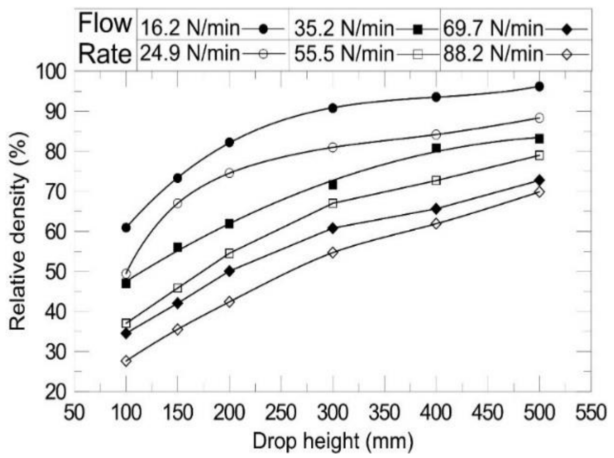


Fig. 12 Effect of the drop height and flow rate on the sample relative density for 2.5 cm layer thickness

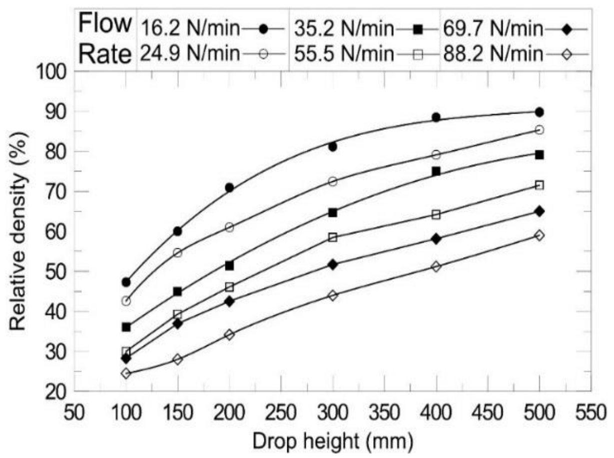


Fig. 13 Effect of the drop height and flow rate on the sample relative density for 5 cm layer thickness

4.2 Section two: Determination of the flow rate amplitude for the proposed system

Required time for sample preparation is one of the main aspects of this research, which is affected directly by the flow rate amplitude. In this context, flow rate can be defined as the mass of pluviated sand per unit time, which can be measured from the mass of outflow rained sand from each opening for one minute in a sampling container with 10000 cm^3 volume.

Flow rate of different widths for rectangular openings are varied between 16.2 N/min and 88.2 N/min for the proposed method. There is an observed nonlinear relationship in the form of a second order polynomial between the flow rate and curtain width (W) which can be seen from the presented results in Fig. 10.

For the sand used in the present study, a comparison between the time of sample preparation in the proposed method and other approaches, in which a single nozzle is used for pluviation (Dave and Dasaka 2012, Fretti *et al.* 1995), is presented in Fig. 11. This enables a holistic comprehension on the effect of outlet nozzle diameter on the sand flow rate. Figs. 10-11 highlight the acceptable flow rate values in the proposed method. Moreover, in comparing the proposed method to methods utilizing single nozzle raining, reduced sample preparation time can be clearly seen as a result of the proposed method. The required time for a complete sample preparation with 50% to 70% of relative density is approximately 4 hours.

4.3 Section three: The Effect of height and flow rate on the sample relative density

Calibration of the sample preparatory device is crucial in order to produce arbitrary and repeatable samples with a specified relative density, in experimental studies and laboratory models. According to the test results of the first section, the effects of drop height and flow rate are investigated. Calibration graphs are presented in Figs. 12-13 for the proposed system in the case of 2.5 cm and 5 cm layer thickness, as it can be observed, drop height and relative density are directly correlated. In the case of 2.5 and 5 cm layer thickness, relative densities can be varied from 29% to 96% and 25% to 90%, respectively in the developed system.

Sand particles falling velocity which reflects the grains' kinetic energy progressively approaches a terminal value with the growth in the height of the fall. The relationship can be stated as a nonlinear function and it is worth noting that the relative density remains unchanged if drop height exceeds the terminal falling height (Vaid and Negussey 1988). According to Figs. 12-13, terminal particle velocity is not achieved in the tests performed. Therefore it can be stated that if the terminal falling height is more than 500 mm it is anticipated that higher values of relative densities are possible to be attained.

Based on the achieved results, as the flow rate has been increased, relative density is consequently decreased. This can be related to the particle interactions which prevent a steady arrangement to be obtained. Moreover, higher values of the flow rate might lead to air trapping between the grains and thereon lead to lower values of kinetic energy of the falling particles.

Regarding to the required relative density, the choice of optimized and efficient parameters are important considerations for a pluviation system design. A comprehensive and practical graph has been provided herein this work with respect to the results of the 2.5 cm layer and presented in Fig. 14 in the form of a three-dimensional planar surface. It can be seen that the maximum and minimum relative density can be achieved when drop height is 500 mm and 100 mm and curtain width is 2 mm and 4.5 mm, respectively.

According to the planar surface in Fig. 14, any arbitrary relative density value can be reproduced using different combinations of drop height and curtain width. Fig. 15 is a valuable graph which depicts relative density contours. This graph can be efficiently used for the choice of pluviation parameters and plays an important role to reduce sample preparation time. For instance, reconstituting a sample with 50 percent relative density can be possible using curtain width and drop height of 2.5 mm, and 100 mm or 4 mm, and 200 mm, respectively. Before any experimental studies, the same graph can be drawn for the used sand and sample preparatory systems which lead to enhance decisions and reduction in the total time required.

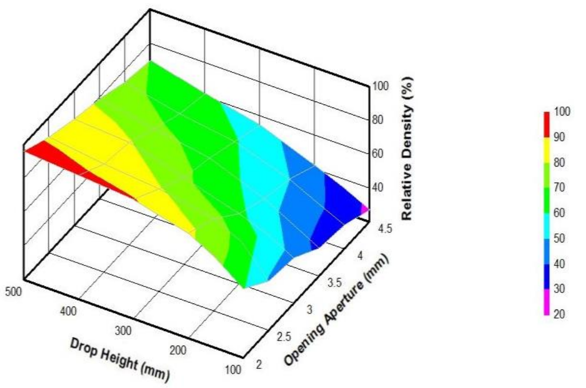


Fig. 14 Relative density variations versus drop height and opening aperture for 2.5 cm layer thickness (All dimensions are in millimeters)

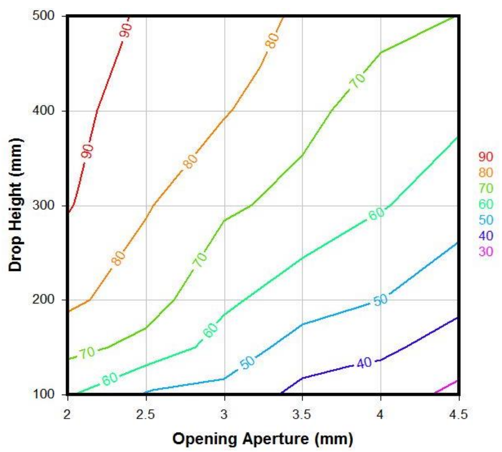


Fig. 15 Relative density contours with different combinations of drop height and opening aperture for 2.5 cm layer thickness

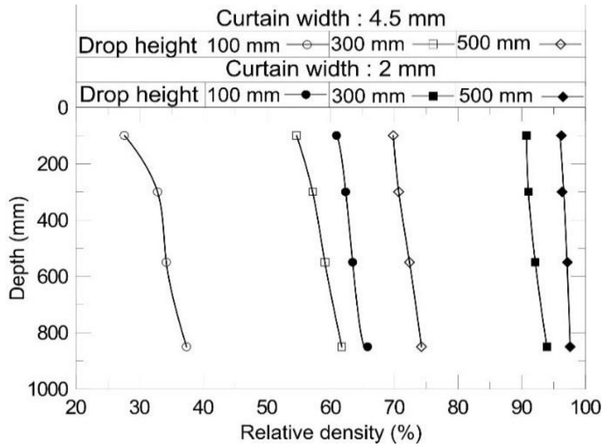


Fig. 16 Vertical variations of the sample relative density

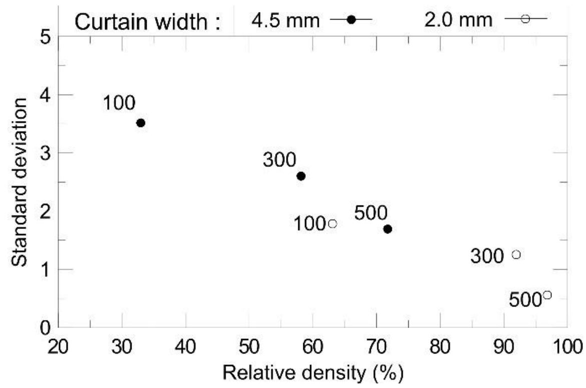


Fig. 17 The standard deviation for the sample relative density in vertical direction (drop height: 100 mm, 300 mm, 500 mm)

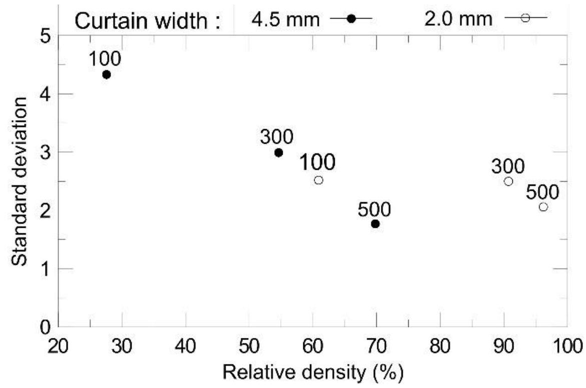


Fig. 18 The standard deviation for the sample relative density in horizontal orientation (drop height: 100 mm, 300 mm, 500 mm)

4.4 Section four: Sample uniformity analysis

A desirable trait of reproducible samples is uniformity in both vertical and horizontal orientations. This work's interpretation of this criterion has been made through different statistical methods. In this section, the sample uniformity is investigated using the relative density standard deviation and the results are compared to previous studies (Borden 1991, Zhao *et al.* 2006, Choi *et al.* 2010).

Compaction uniformity in the proposed method is studied by setting the rectangular opening width of 2 mm, and 4.5 mm and drop height of 100 mm, 300 mm, and 500 mm. Therefore, it is possible to study the effects of maximum and minimum flow rate alongside the maximum, minimum and mean relative density on the uniformity. For local relative density evaluation, five sampling containers are positioned at the bottom of the main sand tank and the pluviation is continued until the accumulated sand reaches to the designated level of 300 mm. Pluviation is then stopped and five other sampling containers are placed as shown in Fig. 6 and this process is continued until the sand tank has been filled.

Vertical variations of the relative density in the main sample are shown in Fig. 16. It can be seen that relative density in the bottom parts of the tank is higher than the upper parts and vertical uniformity is mended for higher relative density values. This outcome is in agreement with previous studies (Bellotti *et al.* 1991, Choi *et al.* 2010) and can be related to the fact that the weight of upper layers can be considered as surcharge for underneath layers and compaction is increased as a consequence.

Rad and Tumay (1987) stated a 2%-5% difference in relative density in the vertical direction for a sample with 45 cm height. Choi *et al.* (2010) reported variations ranging from 5% to 10% for a 1 m height sample. They inferred that the relative density variation between the upper and lower layers is not an appropriate measure of non-homogeneity when dealing with specimens that have different overall densities and specimen heights. Instead, the standard deviation of average values of densities measured at each layer is recommended to be used for which 2% to 5.5% variations is reported.

In this study, the average values for five retrieved samples in each layer is acquired for which the standard deviation is estimated in six different trials as shown in fig. 17. It can be seen that as the value of relative density increase, the vertical uniformity becomes more satisfactory. Given a constant drop height, vertical uniformity is amended by decreasing the curtain width.

In order to investigate the sample uniformity in its horizontal direction, the standard deviation of relative density is depicted in Fig. 18 for the five samples taken from the tank.

The standard deviation of relative density was reported to be 7 percent for the lower soil layer by Borden (1991). Zhao *et al.* (2006) reported ±4 percent of relative density variation for horizontal layers. Choi *et al.* (2010) stated that the value of relative density standard deviation for horizontal layers varies between 2% to 7% which decreases dramatically with increasing the relative density. Non-uniformity of loose to medium loose samples were studied by Lo Presti *et al.* (1993) and the coefficient of variation was reported to be between 0.5% and 7%.

Fig. 18 shows that the relative density standard deviation in the lower layer is between 2% and 4% for the developed device which is an acceptable value for horizontal uniformity.

5. Conclusions

The CTP system comprises sand transfer compartments from the main hopper to the sample container and a rectangular opening at the bottom of the hopper which controls the pluviation flow rate. The comprehensive design and calibration of the CTP system can be concluded in the following points:

• Using the proposed method is simple and cost efficient. It can easily be deployed to produce any arbitrary sample with a wide range of relative densities.

• For lower drop heights, the relative density is more affected by the layer thickness or curtain traveling velocity in the case of smaller curtain widths. However, layer thickness is observed to have a more governing effect on the relative density if higher drop heights and larger curtain widths occur simultaneously.

• There is a nonlinear and direct relationship between flow rate and curtain width. Due to obvious practical limitations, using the single nozzle for sample preparation is highly time consuming. The proposed method is more time efficient and this is also manifested in the reduction of time required for large sample preparation.

• Increasing the flow rate given a constant drop height leads to decrease in the relative density and is independent of layer thickness. Keeping constant the drop height and flow rate, higher relative densities can be achieved by increasing the curtain traveling velocity. There is a direct relationship between drop height and relative density. Terminal falling velocity is not attained in the tests performed herein. Higher relative densities are anticipated to be achieved in the case of a set-up having more than 500 mm in drop height.

• Using the graph figure containing relative density contours, different combinations of drop height and curtain width can be selected to prepare a sample with a specified target relative density.

• Relative density value for the lower layers is more than that of their upper layers. The vertical uniformity between the layers increases as higher relative density samples are prepared. Standard deviation of relative densities for the horizontal layers is between 2% and 4%. It can be henceforth stated that the performance of the proposed system is reliable and very acceptable due to high uniformity across the entire sample.

• The proposed system can be developed in the form of a fully automated and mechanized model in order to further reduce the time of sample preparation while providing more design specimen precision.

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