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NEW IDEA USEFUL FOR CONSTRUCTION OF WATER WELL DESIGN

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ABSTRACT: *Grain size distribution analysis that is one of the base properties of aquifer materials gives idea about water well design. Particle size distribution of aquifer materials through mechanical sieving gives results in terms of cumulative values of angles. The method proposed in this paper can be used effectively to replace the retained and passing weights. The results of the research indicated that the size of particles significantly affecting in grain size distribution for the each angle, and it's being fast and accurate results for estimating slot size of screen and gravel pack size. Determination of grain size distribution derived from mechanical analysis method (circle) is give a new idea and useful for predict theoretically through the angle value for any particle grain size predominant. A new novel for measuring the particle size distribution of aquifer was conducted to compare the results obtained from sieve analysis depending on old methods (retained and passing).*

KEYWORDS: New novel, grain size distribution, image model, aquifer materials.

INTRODUCTION

In the past, groundwater was easily extracted through large diameter wells since water tables were very near to the ground surface. However, starting from the early sixties, groundwater abstraction rates accelerated rapidly and the use of submersible pumps became necessary to cope with the falling water tables (Rashed, and Abduljawad, 2013). Grain size characteristics are fundamental role in hydrological, geomorphological and sedimentological studies (Friedman and Sanders, 1978), and (Goudie, 1981). The grain size distribution was determined using the standard sieving technique as described by the American Society of testing and materials (ASTM) (1995), and (Tanner and Balsillie, 1995). Grain size analysis is primarily used for aquifer materials classification and provided a first order estimate of slot size of screen and gravel pack size. A considerable range of percentage of gravel pack to be retained by the screen is suggested in both the theoretical and technical literature (Johnson technical bulletins, 1975). The usual rule is that at least 90 percent of the gravel pack should be retained where the pack and aquifer is uniform; however, values as low as 40 percent have been suggested if there is bad uniformity (Johnson, 1975). A gravel pack is typically placed in the annular space (the space between the well casing and the wall of the drilled hole) outside the screen casing but within the drilled borehole. The gravel pack consists of sand or gravel that has been designed with grain size finer than the screen slot size. The gravel pack acts as a filter to prevent sediment from entering the well, and also to manage the velocity of the water passing through the aquifer and into the well. High speed water velocity, due to excessive pumping or improperly sized gravel pack, may result in erosion of the aquifer as sediment is pulled into the well.

Design of well screen:

The success of water well mainly depends on the performance of the screen it's that part of well through which water moves from the aquifer into the well. One of the most important

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items in the successful design of a well finished with a natural filter pack is the proper selection of slot opening in relation to the sizes of aquifer materials (Mehaysen, and Mahasneh, 2015). The purposes of the blank well casing between and above the well screens are to prevent fine and very fine formation particles from entering the well, to provide an open pathway from the aquifer to the surface, to provide a proper housing for the pump, and to protect the pumped groundwater from interaction with shallower groundwater that may be of lower quality (Thomas, 2003).

The studied determine that the filter pack must be many times more permeable than the aquifer material, but the filter pack must not be coarse enough to allow the fine particles of the aquifer material to continue to wash through the pack (Terzaghi, 1951). To determine of screen slot size depends on fine sediments particle size of aquifer or gravel pack can be retained. The slot size shall be selected to retain from 90 to 100 percent of the formation material in artificially filter packed wells, and from 50 to 100 percent of aquifer material in naturally packed wells.

MATERIAL AND METHODS

The main purpose of this test is performed to determine the angle value of different grain sizes contained within aquifer materials. The mechanical or sieve analysis is performed to determine the distribution of the coarser, larger-sized particles, and the hydrometer method is used to determine the distribution of the finer particles.

The objective of the well design is to create model, allows groundwater to move effortlessly and prevents fine sand particles (all sediments) from moving from the aquifer formation into the well, and prevents bacterial growth and material decay in the well. The proposed particle size estimation technique using circle image processing is discussed in the following steps and shown in (Fig. 1). During the analysis the particle size distribution of the sample, they are several particle sizes were used to accurately describe the size distribution of the sample. The aims of this paper are to investigate the effect of particle size and to determine the more accurate circle method for slot size and gravel pack computation. For this purpose, more aquifer samples with different shapes and sizes are used. The results from the research were compared with old methods (retained and passing) produced different curves of grain size distribution (Figs. 2 and 3).

Experimental Procedure:

For the sieve analysis record the weight retained on the data sheet (Table 1), and after that applicable of the circle method, as following;

1- Calculate the angle value of retained on each sieve by multiplying the weight retained on each sieve by 360° and dividing by the original sample (total weight) by using the following equation:

$$A_v = \frac{W_r x 360^{\circ}}{W_T} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots . (1)$$

Where,

A_v= the angle value of retained on each sieve.

W_r= the weight retained on each sieve (g).

W_T= the original or total sample weight (g).

2- The value of the angle of the retained weight or the passage of each sieve is extracted separately, where the larger angle shows the value of the dominant of the type of geological formation.

3- The value of the angle of the retained weight is calculated clockwise, while the value of the angle of passing weight is found in the opposite direction of the clock (counterclockwise).

4- The value of the size of the sieve slot (granular size) is derived from the circle and is calculated from the sum of the cumulative angle values starting from the 360° angle after applying the equation below:

$$slot\ size\ (d_{50}) = 360^{\circ} x 0.5 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

5- To extract the value of the effective size d_{90} and the uniformity coefficient U_c of the retained weight were respectively by the following mathematical equations as:

$$d_{90} = 360^{\circ} x 0.9 = W_t x 0.9 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots...(3)$$

$$U_c = \frac{d_{40}}{d_{90}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(4)$$

$$d_{40} = 360^{\circ} x 0.4 = W_t x 0.4 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

6- To extract the value of the effective size $d_{10}$and the uniformity coefficient U_c of the passing weight respectively and also calculated by the following mathematical equations as:

$$d_{10} = 360^{\circ} x 0.1 = W_t x 0.1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(6)$$

$$U_c = \frac{d_{60}}{d_{10}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(7)$$

$$d_{60} = 360^{\circ} x 0.6 = W_t x 0.6 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(8)$$

Example (1):

Using the information in the table below, computing the items as the following:

- The slot size of the screen.

- The values of the effective size and the uniformity coefficient.

Table (1): The results of the design of well.

Slot size (mm)	Weight of retained (g)	Cu. W. R. (g)	Value of angle	Cu. values of angles
2.00	85	85	95.6°	95.6°
1.00	65	150	73.1°	168.7°
0.50	55	205	61.9°	230.6°
0.250	45	250	50.6°	281.2°

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0.125	35	285	39.4°	320.6°
0.0625	24	309	27.0°	347.6°
0.03125	7	316	7.9°	355.5°
0.0	4	320	4.5°	360°
Total	320			

Cu. W. R.= Cumulative weight of retained.

Solution:

Firstly: The method of retained weight:

- The slot size of the screen is calculate from the total values of the cumulative angles starting from the angle (360°) or zero angle as in (Fig. 1) or from table (1), which is depending on equation (2).

$$Slot\ size(d_{50}) = 360^{\circ} x0.5 = 180^{\circ} = 0.9\ mm$$

- The values of effect size $d_{90}$and the uniformity coefficient $U_c$for the retained weight respectively (the cumulative values of the angles) are extracted after applied the equations (3, 4 and 5) and from table (1).

$$d_{90} = 360^{\circ} x0.9 = 324^{\circ} = 0.123\ mm\ \ or\ \ 360^{\circ} - 324^{\circ} = 36^{\circ}$$

$$d_{40} = 360^{\circ} x0.4 = 144^{\circ} = 1.4\ mm\ \ or\ \ 360^{\circ} - 144^{\circ} = 216^{\circ}$$

$$U_c = \frac{d_{40}}{d_{90}} = \frac{1.4}{0.123} = 11.2$$

Secondly: The method of passing weight:

- The slot size of the screen from the circle is calculate from the sum of the angle values starting with angle (360°) or zero angle (counterclockwise) as shown in (Fig. 1), which is depending mainly on equation (2).

$$Slot\ size(d_{50}) = 360^{\circ} x0.5 = 180^{\circ} = 0.9\ mm$$

- The value of effective d_{10} and the coefficient of uniformity U_c of the passing weight continuously are extracted from table (1).

$$d_{10} = 360^{\circ} x0.1 = 36^{\circ} = 0.123\ mm\ \ or\ \ 360^{\circ} - 36^{\circ} = 324^{\circ}$$

$$d_{60} = 360^{\circ} x0.6 = 216^{\circ} = 1.4\ mm\ \ or\ \ 360^{\circ} - 216^{\circ} = 144^{\circ}$$

$$U_c = \frac{d_{60}}{d_{10}} = \frac{1.4}{0.125} = 11.2$$

All the values are calculate from the first and second steps equal the values of retained and passing weight methods respectively.

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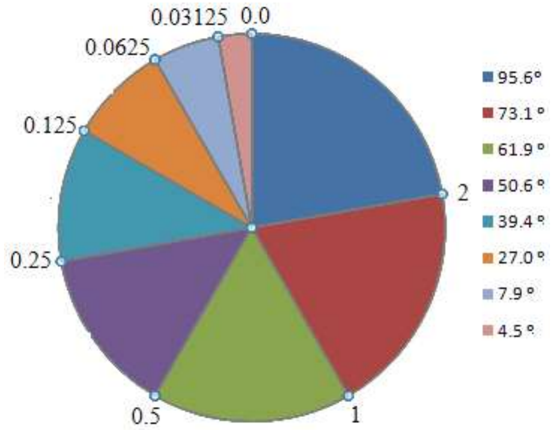

Figure (1):- The value of the angle and the size of sieve slot in millimeters is shown for all types of granules of different sizes.

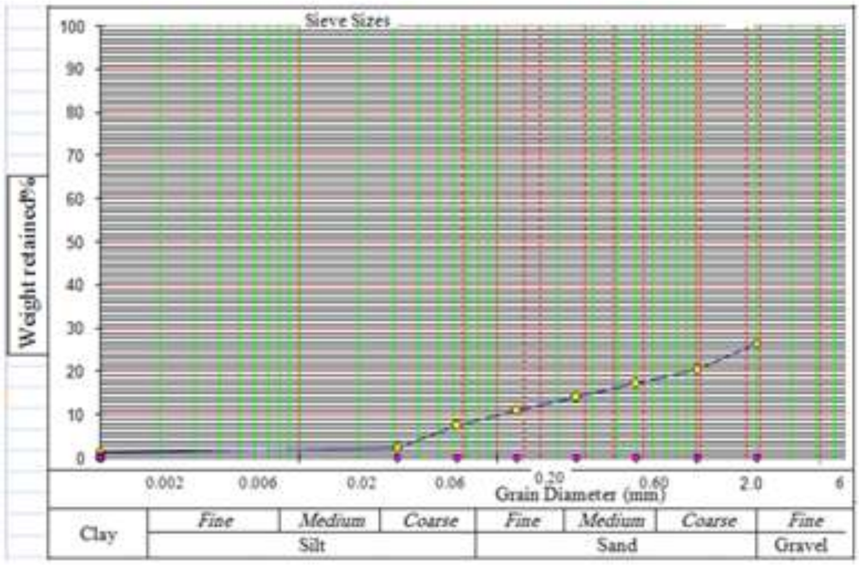

Figure (2):- Shows the size of the sieve slot against the percentage of the weight retained.

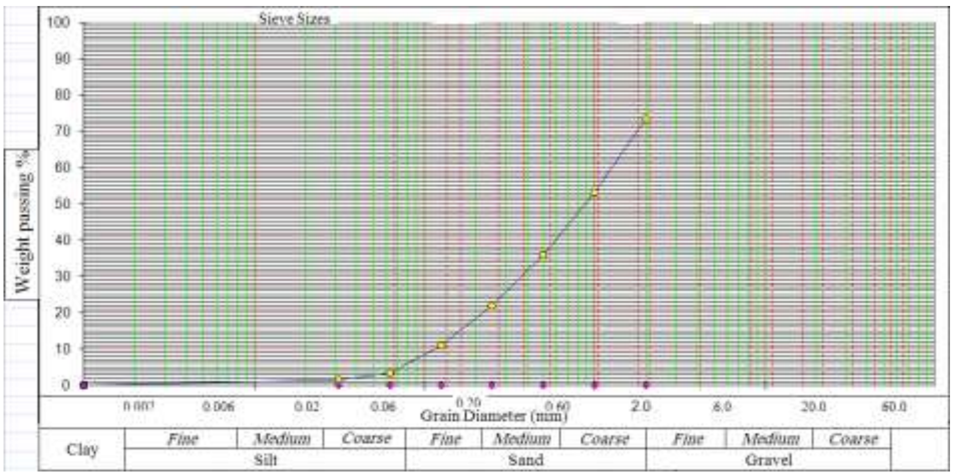

Figure (3):- The value of the size of the sieve slot versus the percentage of the passing weight.

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RESULT AND DISCUSSION

The technique of sieving and the analysis of the result are deceptively simple and sieving sorts the sediment grains by shape and by size. The new novel gives a clear idea of the most granular types of geological formation through the value of the angle in the different size. The results of circle value analysis and curve analysis of particles are presented as the same values. The curves of mechanical analysis are performed by using the cumulative weight (mass) of particles retained or passing percent, but the analysis of circle method is performed by using the values of angle. However, the classifications do not change. Thus, it could be said that the difference between two analyses results are insignificant.

CONCLUSION

In this paper, a new novel was developed for make the best well design, which depending on estimating the slot size, effective size, uniformity coefficient and hydraulic properties of the aquifer, depending mainly on particle sieve-size distribution using the circle method processing, while the retained and passing weights are considered to be the primary methods to quantify significant particle size distribution. The method discussed above not only gives a fast and easy way to estimate particle size, and also produces up to accurate particle size distribution.

The classification of soils according to the mechanical (sieve) analysis do not change and the difference between results of circle and curves methods are insignificant (negligible). In this sense, the circle analysis is considered to be a significant technological advancement towards grain size distribution of aquifer materials. It should also be pointed out that further studies on the determination of slot size and gravel pack by using circle method are needed to make more reasonable judgments for utilization of circle analysis in hydrogeology and civil engineering.

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