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RESEARCH PAPER

Sand Ranking Method to Evaluate Beach Soccer Ground Coverage

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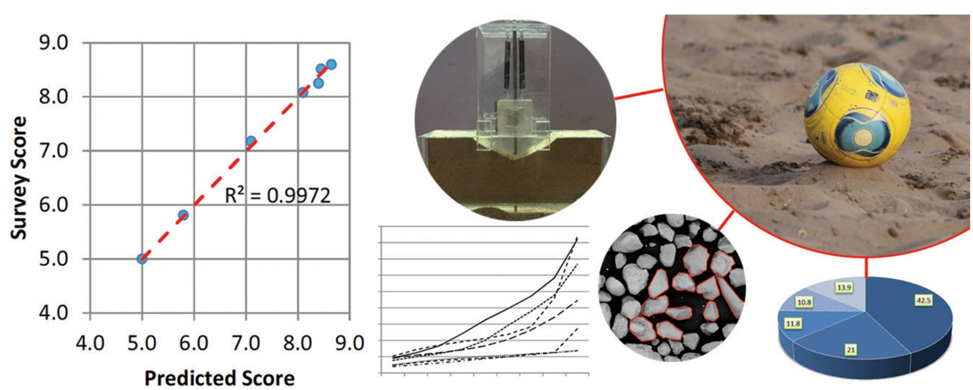
Abstract

Beach soccer is one of the world's growing sports, particularly since FIFA began to promote and organize it. In this game, the ground surface is covered with sand. FIFA presented some criteria for selection of appropriate sand. However, these criteria are not precise enough; hence, it seems reasonable to introduce a method for standardization of beach soccer grounds and ranking different sands for the purpose of ground surface coverage. In this study after conducting several tests, survey and gathering climate data, a simple yet reliable method for ranking sands used in beach soccer ground coverage is presented. The method can accurately predict the score of each sand sample using the input data of gradation test, roundness test and climate data. According to the level of the match, a score for sand can be specified. In such a manner, the grounds of beach soccer can be standardized using presented ranking method. In addition, results are analyzed and discussed to provide specific information about appropriate sand for beach soccer competitions.

Graphical Abstract



Keywords Beach soccer · Sand quality · Ranking method · Gradation · Roundness

1 Introduction

Beach soccer or beach football is a variant of football, played on a sand covered ground or a beach. In 1992, the rules of the game were established and a pilot tournament was held in Los Angeles. The first professional beach soccer matches were held in the following year in Miami Beach, and in 1995 the first World Beach Soccer Championship was organized. This sport was incorporated into the FIFA structure in 2004 and the first Beach Soccer World Cup was held on Copacabana beach Brazil in 2005 (Castellano and Casamichana 2010).

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The quality of sand covered playing surface has an important impact on quality of the beech soccer matches. There are some criteria presented by FIFA to select the appropriate sand. However, these criteria are relatively rough. The requirements of sand according to FIFA (2006, 2015/2016) are as follows:

The surface should be composed of sand, which is level and free of pebbles, shells and any other objects which could injure the players. For international competitions, the sand must be fine and at least 400 mm deep. It must be sifted until suitable for play, must not be rough or contain pebbles or any other dangerous elements; however, it must not be so fine as to cause dust that sticks to the skin.

It can be shown that many different sands with different mechanical properties can fall in FIFA-acceptable range. Therefore, each game ground has its own specifications and the beach soccer players experience different conditions in different grounds. Therefore, it seems reasonable to introduce a method for standardization of beach soccer grounds and ranking different sands for the purpose of ground surface coverage.

In this study, a comprehensive investigation is conducted to explore a simple yet reliable method for the purpose of ranking and selection of an appropriate sand to cover the ground of beach soccer. This study is mostly based on geotechnical and soil mechanics concepts and methods and consists of two main steps:

- To conduct a survey, as the basis of the study, and;
- To conduct several tests and analyses for gathering the required data. Using these data, a relationship is suggested to rank different sands to predict which sand is appropriate for coverage of the surface of beach soccer ground.

Through the following sections, each of the above-mentioned steps is explained in more detail and a relation is presented to evaluate different sands for coverage of beach soccer ground surface. Finally, results of tests and survey are discussed to provide specific information about suitable material for ground surface of beach soccer competition.

2 Literature Review

There are numerous studies on engineering properties and mechanical behavior of sands. These studies are concentrated mainly on geotechnical aspects of sands. They have studied the effect of grain size and shape, gradation, friction angle, etc., on engineering properties of sand, such as shear strength of sand. For example, see Yong and Warkentin (1975), Koerner (1970), Bishop (1948), Zelasko (1966), Zelasko et al. (1975), Edil et al. (1975), Cho et al. (2006) and Bareither et al. (2008).

There are also a few studies on sands used to cover sport grounds. For example, Crum et al. (1997) studied the engineering properties of high-sand-content soil used in golf putting greens and sport fields. They focused mostly on bearing capacity, porosity and gradation of such soils. Some data were presented for a number of fields, but there was no clear conclusion.

In the past studies, any method for evaluation or ranking of sand for its utilization to cover sports ground surface, especially beach soccer ground surface is not presented. Therefore, the authors decided to do a comprehensive study on sand properties to find an evaluation method for sands used to cover beach soccer ground.

3 Survey

In the first step, the authors have conducted a survey. Ten players of a national beach soccer team filled the questionnaires about the quality of sand in 7 beach soccer grounds from different countries (70 questionnaires totally). Each questionnaire consists of 9 questions that are related to sand excessive roughness (coarse sand), sand excessive fineness (to sticks to the player's skin), dust, early fatigue, quick reduction of ball speed, excessive unevenness of ground surface (ball detour), low stiffness of ground surface, high stiffness of ground surface and general quality of sand, respectively. Questions 1–8 are related to unwanted properties of sands, and question 9 shows general acceptability of sand or sand quality. The players have assigned a score between 0 and 10 to each question.

Table 1 shows average scores for each question and each sand sample. Equation 1 is developed to explain the relationship between the scores of questions 1–8 and general acceptability of sand. Higher coefficient for a question shows higher importance of corresponding factor. According to Eq. 1, the importance of different factors of a sand sample can be classified as follows:

- High importance: high or low stiffness, evenness of ground surface
- Medium importance: sand fineness, early fatigue
- Low importance: sand roughness, dust, ball speed reduction

The values predicted using Eq. 1, are also shown in Table 1.

$$\mathrm{Q9} = 22.2-(0.21\mathrm{Q}_1+0.36\mathrm{Q}_2+0.11\,\mathrm{Q}_3+0.41\mathrm{Q}_4+0.11\mathrm{Q}_5+0.49\mathrm{Q}_6+0.56\mathrm{Q}_7+0.66\mathrm{Q}_8) \quad (1)$$

Table 1 Average scores (70 questionnaires)

	Q. 1	Q. 2	Q. 3	Q. 4	Q. 5	Q. 6	Q. 7	Q. 8	Q. 9	Eq. 1
Sample 1	2.10	3.10	2.70	6.65	6.80	6.30	6.60	2.50	8.65	8.44
Sample 2	6.40	3.10	3.60	6.75	6.40	6.15	5.80	3.80	7.10	7.10
Sample 3	3.60	6.00	4.90	7.00	4.60	6.60	7.50	4.10	5.00	5.23
Sample 4	1.60	8.55	1.60	8.65	3.50	3.50	4.85	2.80	8.45	8.40
Sample 5	5.50	4.90	6.60	6.90	7.15	7.05	5.95	1.45	8.10	7.20
Sample 6	6.10	3.80	3.80	5.80	5.90	6.50	4.90	6.30	5.80	6.02
Sample 7	5.60	4.60	3.90	3.40	3.70	4.80	5.60	5.40	8.40	8.09

In this paper, the split-half method is used to estimate the reliability of questionnaires. Considering that for each sand sample, 10 questionnaires are prepared, so the questionnaires are split in two halves (two groups of 5 questionnaires). For each half and for each question, a unique score is calculated by summing the scores of that question. Then the scores of one half are correlated with the scores of the other half using Eq. 2. Spearman–Brown formula (Eq. 3) is also used to convert the calculated reliabilities of the halves to the reliability of all questionnaires. In such a manner, the reliability of the questionnaires is estimated, as shown in Table 2.

$$r = \frac{\sum_{i=1}^{n} (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\left[\sum_{i=1}^{n} (X_i - \bar{X})^2\right]\left[\sum_{i=1}^{n} (Y_i - \bar{Y})^2\right]}} \tag{2}$$

$$\rho = \frac{2r}{1+r} \tag{3}$$

where r is reliability, ρ is modified reliability according Spearman–Brown formula, X_i and Y_i are the scores of question i in the first and second halves, respectively, $\bar{X}$ and $\bar{Y}$ are average of X_i and Y_i, respectively, and n is the number of questionnaires.

It should be noted that the validity of questionnaires is obvious. Because the aim of the survey is gathering data about the acceptability of sand samples, different aspects of sands acceptability are questioned directly.

4 Testing Program

4.1 Direct Shear Test

Direct shear test is a simple geotechnical test to measure shear strength of soils. A direct shear test is a laboratory test used by geotechnical engineers to measure the shear strength properties of soil (Bardet 1997). By use of this test, the friction angle of sand samples can be determined. The friction angle represents mechanical strength of granular soils. More detailed explanation on this test is presented in ASTM D3080. The results of this test for 7 sand samples are shown in Table 3. From data mentioned in Table 3, it can be seen that the friction angles of sand samples belong to a narrow range of 25–31 degree.

4.2 Gradation Test

One of the most important factors that leads to different behaviors of sands is gradation. It shows distribution of particle sizes, i.e., the percentage of each size in sand samples. For more details, see ASTM C136-06. The results of gradation test are demonstrated in Table 4 and Fig. 1. As can be seen, the sand samples have completely different gradations. In Fig. 1, D10, for example, is the size (diameter) that 10% of sand particles are finer. Curvature and uniformity coefficients and classification type for each sample are listed in Table 5. All samples are classified as poorly graded sand (SP) according to ASTM D2487.

4.3 XRF[1] and XRD[2] tests

XRF and XRD tests are both conducted to determine the chemical composition of sand samples. The results are shown in Table 6. From the data listed in Table 6, it can be seen that the samples have different chemical compositions. For example, in samples 1, 3, 4, and 5 the main composition is SiO_2 (quartz with mineral hardness 7) but in samples 2, 6, and 7 the main composition is CaO (lime with mineral hardness 3.5).

4.4 Roundness Test

The geometry or the shape of sand particles is an important factor affecting sand behavior. The roundness test was carried out for sand samples. Using this test, a number between 0 and 1 is assigned to each sand sample that shows average degree of roundness of sand particles in each sand sample (Krumbein 1941). The basic concept of this test is shown in Fig. 2, and the microscopic images of sand samples are demonstrated in Fig. 3. Observed values of roundness are summarized in Table 7.

[1] X-ray fluorescence analysis.

[2] X-ray diffraction analysis.

Table 2 The reliability of questionnaires

	Samp. 1	Samp. 2	Samp. 3	Samp. 4	Samp. 5	Samp. 6	Samp. 7
R	0.993	0.890	0.949	0.991	0.982	0.855	0.895
P	0.997	0.942	0.974	0.995	0.991	0.922	0.945

Table 3 Friction angle

	Friction angle (°)
Sample 1	29
Sample 2	28
Sample 3	31
Sample 4	28
Sample 5	27
Sample 6	26
Sample 7	25

4.5 Air Moisture

Moisture is another factor that can affect the physical properties of sands. In fact, moisture causes the sand to show a small cohesiveness, because of linking between particles. It can change the quality of sand, slightly. Sand moisture content is defined as the ratio of the weight of water phase to the weight of solid phase in a sand sample. The moisture content of the beach sand increases due to factors such as rising level of sea water, ground water or atmospheric precipitation including rain or snow. On the other hand, the moisture content decreases with evaporation process.

The evaporation rate is determined from the field meteorological data such as relative humidity or solar radiation. Relative humidity is the ratio of the partial pressure of water vapor to the equilibrium vapor pressure of water at a given temperature. An increase in relative humidity decreases the evaporation rate and vice versa. Evaporation ceases when the vapor pressure at the sand

Table 4 Gradation test

	D10	D20	D30	D40	D50	D60	D70	D80	D90
Sample 1	0.079	0.100	0.124	0.149	0.176	0.200	0.224	0.249	0.274
Sample 2	0.206	0.286	0.343	0.385	0.424	0.474	0.569	0.918	1.679
Sample 3	0.186	0.247	0.331	0.483	0.650	0.793	0.944	1.167	1.641
Sample 4	0.155	0.199	0.239	0.291	0.401	0.585	0.759	0.955	1.337
Sample 5	0.099	0.135	0.165	0.187	0.204	0.218	0.233	0.250	0.275
Sample 6	0.096	0.126	0.151	0.169	0.184	0.198	0.233	0.252	0.545
Sample 7	0.182	0.218	0.248	0.283	0.333	0.412	0.530	0.684	0.889

D_x diameter that x% of sand particles are finer, mm

Fig. 1 Gradation test

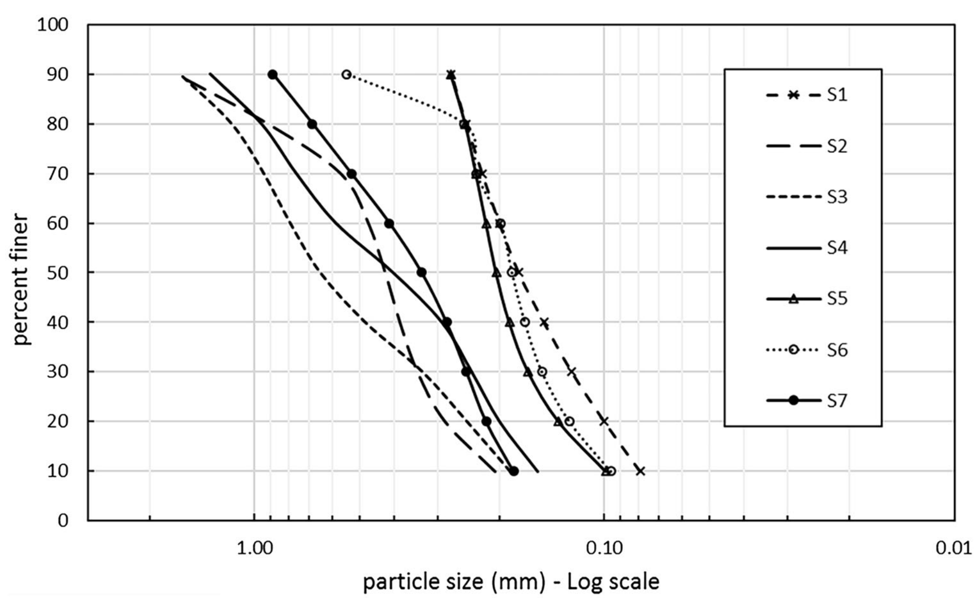

Table 5 Gradation coefficients and classification of samples (ASTM D2487)

Sample	Cu	Cc	Classification
Sample 1	2.53	0.97	SP
Sample 2	2.3	1.2	SP
Sample 3	4.26	0.74	SP
Sample 4	3.77	0.63	SP
Sample 5	2.2	1.26	SP
Sample 6	2.06	1.2	SP
Sample 7	2.26	0.82	SP

surface becomes equal to that of air (Song et al. 2013). Therefore, high relative humidity of the air causes moisture to remain in the sand. The regional air moisture for samples is shown in Table 8.

The primary factor that affects the evaporation is solar radiation. As soon as the sun radiation reaches the surface of a beach sand, evaporation starts from the top few centimeters of sand, and the surface of sand becomes dry rapidly. After drying of the sand surface, the evaporation zone (EZ) moves downward to a lower depth from dried sand (DS) (Wang 2015). This process continues until the whole of 400 mm sand becomes dry.

4.6 Special Tests

In addition to the above-mentioned tests, the authors designed two special apparatus to simulate real conditions of contact surface between the player's foot and ground surface of the beach for soccer. The apparatus are shown in Figs. 4 and 5. Test 1 simulates the condition in which the

Table 6 Chemical composition of sand samples (%)

	Qurtz SiO_2	Lime CaO	Corundum Al_2O_3	Hematite Fe_2O_3	Loss on ignition L.O.I	Other
Sample 1	51.5	–	12.6	7.6	7.21	21.09
Sample 2	5.4	50.9	–	–	37.35	6.35
Sample 3	97	–	–	–	–	3
Sample 4	97.7	–	–	–	–	2.3
Sample 5	42.5	10.8	11.8	21	–	13.9
Sample 6	14.7	42.4	–	–	32.5	10.4
Sample 7	11.9	46.6	–	–	35.23	6.27

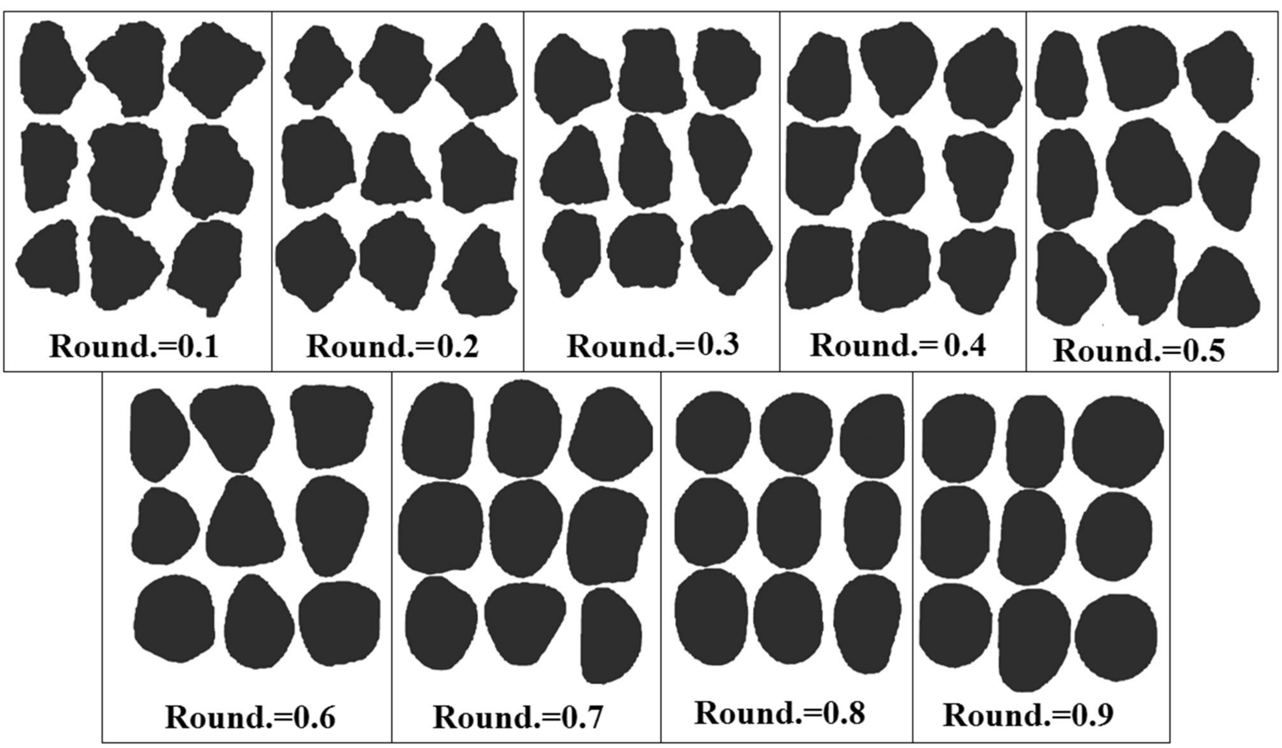

Fig. 2 Roundness values based on shape of particles. Reproduced with permission from Krumbein (1941)

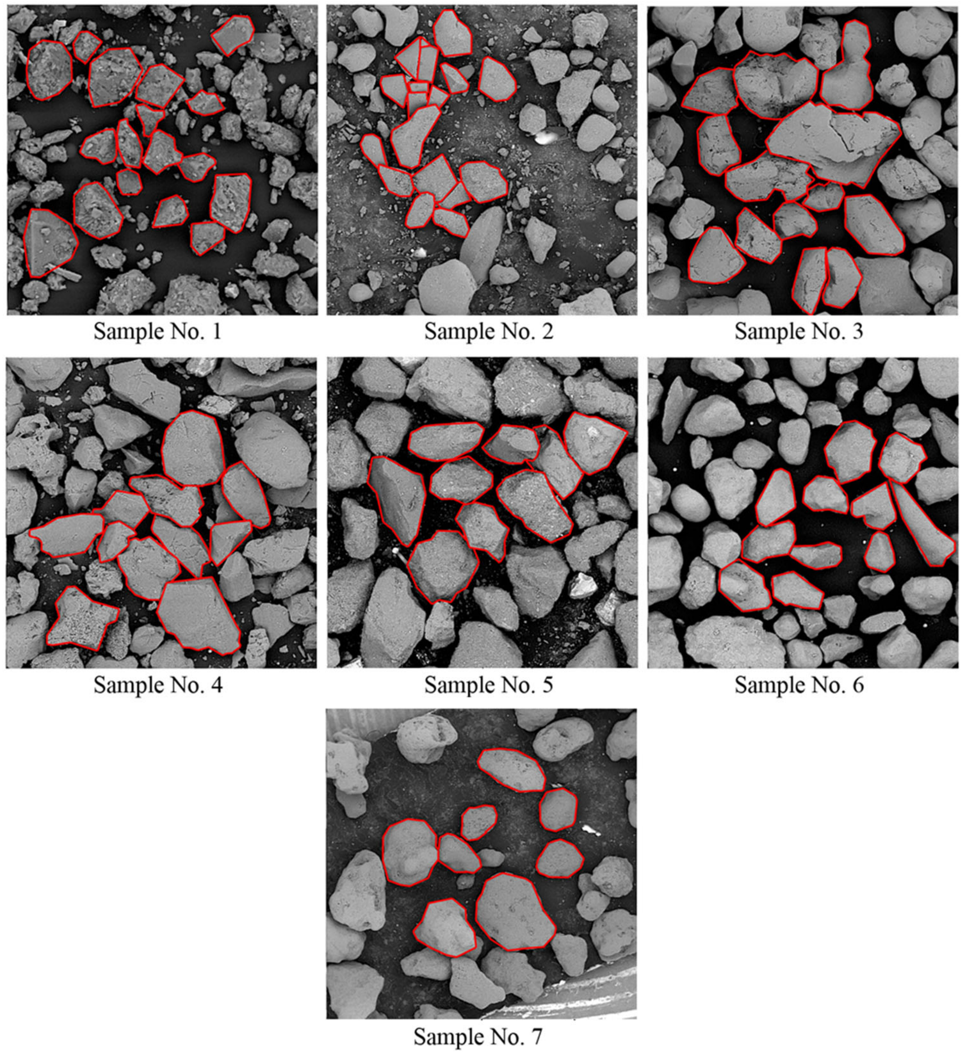

Fig. 3 Microscopic image of particles

Table 7 Roundness of sand samples

	Roundness
Sample 1	0.2
Sample 2	0.2
Sample 3	0.1
Sample 4	0.3
Sample 5	0.4
Sample 6	0.4
Sample 7	0.6

Table 8 Regional average air moisture (weatherspark.com)

	Moisture (%)
Sample 1	0.74
Sample 2	0.49
Sample 3	0.76
Sample 4	0.70
Sample 5	0.29
Sample 6	0.56
Sample 7	0.51

players put their foot on ground surface and in test 2, the condition in which the players lift their foot is simulated. The output of test 1 is a force–displacement diagram, and from test 2 the width and depth of hole is measured. The results of tests 1 and 2 are presented in Fig. 6 and Table 9, respectively. It is observed that there is a correlation between the results of these two tests and the results of direct shear test (friction angle).

5 Results and Discussion

In Fig. 6, the results of special test 1 are presented for samples No. 1 and 3. Samples 1 and 3 have highest and lowest sand quality among 7 sand samples. Considering the results presented in Fig. 6, it can be observed that the load–displacement curve of the sample 1 (high-quality sand) has a relatively small slope for load less than 250 kN and a

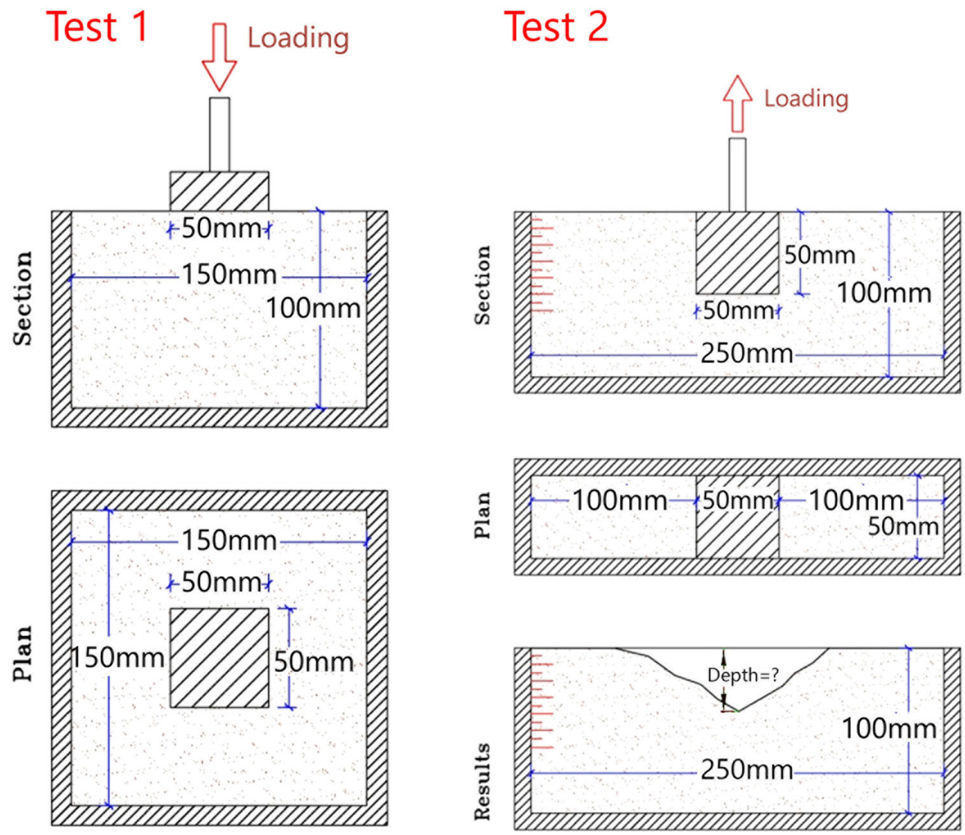

Fig. 4 Scheme of test 1 and 2

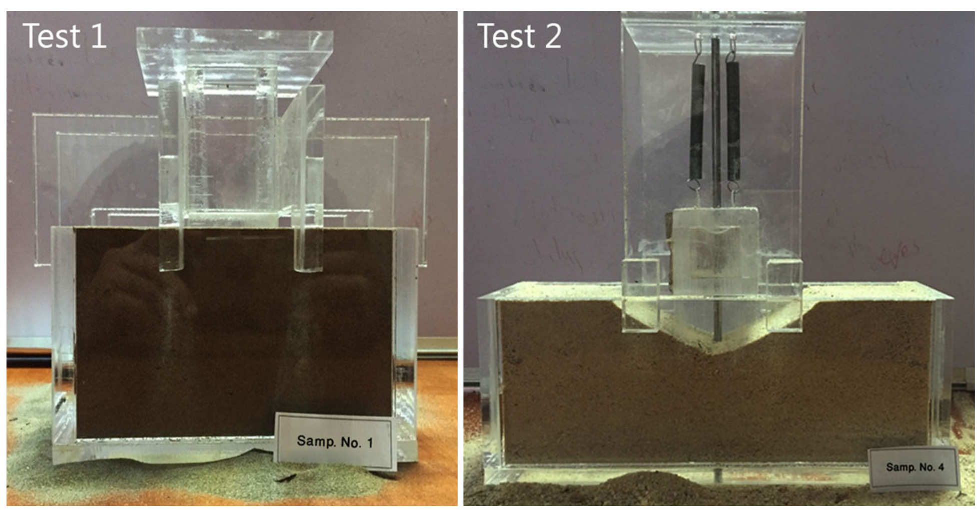

Fig. 5 Apparatus of test 1 and 2

sharp slope for load greater than 250 kN. In other words, by increasing load to 250 kN, displacement increases and sand is compacted gently, and with increasing load to a value greater than 250 kN, stiffness of sand increases due to compaction. Players describe this sample as a very good sand, because sand behaves gently when they put their foot on the sand and it supports strongly the start of next step for running, i.e., lower stress is applied on player's foot and player needs lower energy to run. However, load–displacement curve of sample No. 3 (low-quality sand) has a sharp slope for load less than 270 kN and a very small slope for load greater than 270 kN. In this sand with increasing load to 270 kN, high stiffness of sand causes an impact on foot and by increasing load to a value greater than 270 kN, stiffness of sand decreases rapidly and does not support the start of next step for running. Therefore, players described this sample as a not good sand. It can be concluded that for a high-quality sand it is expected that the slope of load–displacement curve is relatively small

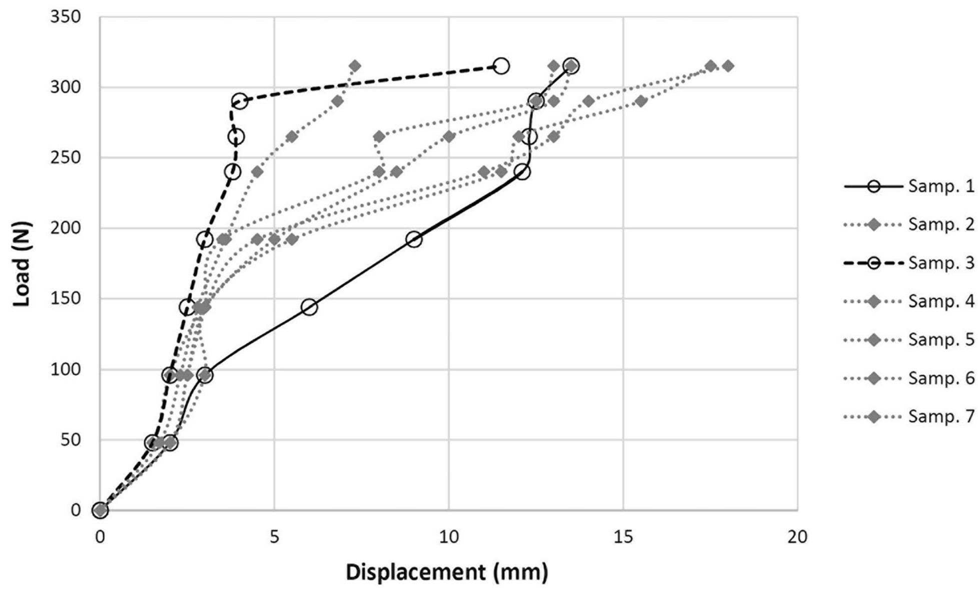

Fig. 6 Load–displacement curve for each sample from test 1

Table 9 Observed width and depth of the hole in test 2

	Width (mm)	Depth (mm)	Length (mm)	Volume (mm^3)
Sample 1	111.0	32.0	50.0	88,800
Sample 2	127.0	31.0	50.0	98,420
Sample 3	128.0	33.0	50.0	105,600
Sample 4	128.0	32.0	50.0	102,400
Sample 5	129.0	28.0	50.0	90,300
Sample 6	132.0	30.0	50.0	99,000
Sample 7	140.0	29.0	50.0	101,500

before load of putting the foot on the ground and remains stiff during start of next step.

Considering the results of special test 2, presented in Table 9, it can be observed that the volume of the hole in sand surface differs for samples 1–7. The lowest and highest values of the hole volume correspond to samples 1 and 3. We know from previous steps that the sand samples 1 and 3 have highest and lowest quality among 7 sand samples. It can be generally concluded that for a high-quality sand the volume of the hole in test 2 is minimum, and in other words, the sand surface remains smoother comparing with other samples, and vice versa.

In Table 7, roundness values for sample 3 with lowest quality for players are minimum in comparison with other samples. On the other hand, roundness of sample 7 which has an acceptable quality is maximum. It is obvious that sands with spherical particles provide appropriate and smooth ground surface cover for beach soccer. It is therefore recommended that shape of sand particles be rounded or sub-rounded and not be acquired from a crushed rock.

Considering grain size distribution curve of Sample 1 with highest quality for players in Fig. 1, it can be observed that sample 1 consists of the finest particles that the variation range of particle diameter is from 0.075 to 0.2 mm, i.e., particle size range for fine sand. Furthermore, it can be observed that sample 1 has relatively uniform gradation curve. On the other hand, particle diameter of sample 3 varied from 0.2 to 2 mm, i.e., range for medium sand. In sample 3, variation of particle size is more than sample 1. It can be found that uniform fine sand is more suitable for beach soccer ground surface. Uniformity of particle size makes the voids between particles increase and then particles have more space to move. In such circumstances when putting the player's feet on sand, particles move easily and when removing the feet, particles are displaced and holes are filled; hence, the surface becomes smooth again. Note that in samples 4 and 3 the particles mineral is mainly quartz (SiO_2); however, particle sizes in sample 3 are larger than sample 4 and sample 3 has a lower value of roundness than sample 4. Thus, quality of sample 3 is lower than sample 4 for players as observed in Table 1. Therefore, sand with rounded or sub-rounded uniform fine particles is more suitable for beach soccer ground than samples with angular or sub-angular coarse or medium particles.

Sandy ground of Beach soccer should be dry. However, in practice 1 percent moisture can be considered as maximum value for moisture content of sand. In order to measure the sand moisture content, instruments can be used. Time domain reflectometry (TDR) is an instrument that sends an electrical signal through steel rods placed in the sand and measures the signal return to estimate sand moisture content. Wet soil returns the signal more slowly than dry soil. The main advantages of TDR over other sand water content measurement methods are: (i) superior accuracy; (ii) calibration requirements are minimal, in many cases soil-specific calibration is not needed; (iii) lack of radiation hazard; (iv) TDR has excellent spatial and temporal resolution; (v) measurements are simple and fast, and (vi) requires little to no maintenance (Jones et al. 2002).

5.1 Proposed Ranking Method

All tests explained in the previous sections are conducted to investigate the effective parameters for selection of an appropriate sand to cover a beach soccer ground. The methods presented here can be used to rank different sand samples, to evaluate them for coverage of the beach soccer ground and to standardize the beach soccer grounds. After analyzing all gathered data of sand samples and regional conditions, it was decided that among all of them, the gradation and roundness test results and the average air moisture can be used to predict simply and effectively the quality of a sand to be used for coverage of the beach soccer ground.

For the purpose of using gradation data, it is necessary to scale the data first using Eq. 4. In Eq. 4, X =10, 20 … 90 and i is column No. in gradation table (i =1, 2 … 9). The "new" and "old" subscripts are related to Tables 10 and 4, respectively. In this study, gradation data of samples is scaled so that $D10$ and also $D90$ in Table 4 reduce to zero, as shown in Table 10. The positive sign is used for all calculated values. Two parameters are defined using this table to be used in presented ranking equation. $D_{\max}$ in Eqs. 5 and 6 is the maximum number in each row in Table 10.

$$D_{Xnew} = \left| D_{Xold} - \left(\frac{9-i}{8}\right) D_{10} - \left(\frac{i-1}{8}\right) D_{90} \right| \tag{4}$$

$$\text{Parameter 1}: \quad A = |0.62 D_{\max} - D_{20}| \tag{5}$$

$$\text{Parameter 2}: \quad B = |0.66 D_{\max} - D_{30}| \tag{6}$$

Equation 7 is the suggested ranking formula resulted from this study. This formula covers accurately the scores of all 7 sand samples according to player's survey. Using this formula, a score can be determined that shows the quality of each sand sample for the purpose of using it to cover the beach soccer ground. The results for proposed ranking method for all samples are presented in Fig. 7. It is obvious from the presented data that Eq. 7 can predict the scores of sand samples successfully, with an error close to zero.

$$S = 8.67 - 25.56A - 5.22B - 0.45C + 0.98D + 0.62E \tag{7}$$

where parameters of A, B, C, D and E are shown in Table 11. The calculated values of these parameters for samples are shown in Table 12.

According to the level of the match, a score for sand can be specified. In such a manner, the grounds of beach soccer can be standardized using presented ranking method. The authors suggest a score, according to Eq. 7, for each level of beach soccer match in Table 13. In order to determine and standardize sand quality for beach soccer grounds applying Table 13, following steps can be followed:

- To prepare a sand sample
- To do gradation and roundness tests
- Gathering climate data (average air moisture)
- To calculate parameters A, B, C, D and E (Table 11)
- To calculate sand quality; S (Eq. 7)
- Selecting minimum acceptable sand quality according the level of the matches from Table 13.
- To decide which matches can be held in which beach soccer grounds by comparing the results of two previous steps or planning for improvement of the quality of sand in a specified beach soccer ground.

Table 10 Scaled gradation data

	D10	D20	D30	D40	D50	D60	D70	D80	D90
Sample 1	0.000	0.036	0.033	0.021	0.003	0.008	0.005	0.004	0.000
Sample 2	0.000	0.266	0.403	0.493	0.550	0.579	0.566	0.386	0.000
Sample 3	0.000	0.329	0.397	0.339	0.288	0.276	0.261	0.200	0.000
Sample 4	0.000	0.342	0.470	0.513	0.462	0.345	0.271	0.197	0.000
Sample 5	0.000	0.117	0.155	0.134	0.092	0.045	0.008	0.011	0.000
Sample 6	0.000	0.171	0.273	0.359	0.425	0.474	0.462	0.483	0.000
Sample 7	0.000	0.193	0.307	0.366	0.379	0.339	0.256	0.146	0.000

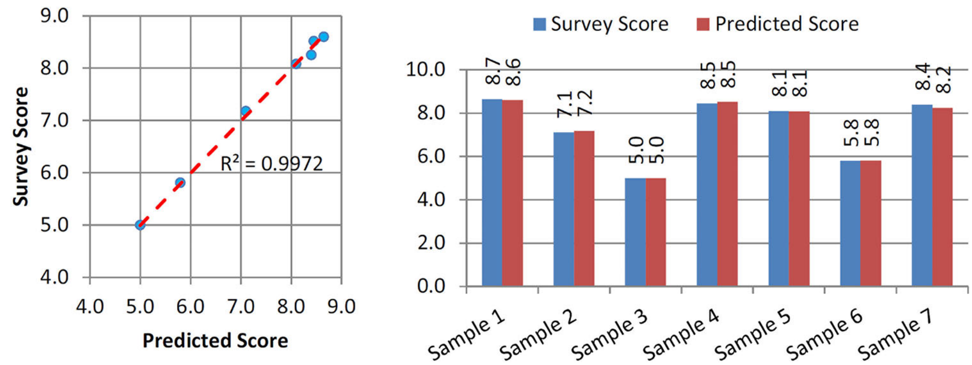

Fig. 7 Predicted score versus survey score

Table 11 Selected parameters for sand ranking formula

Parameter	Definition	Unit
A	Equation 5	mm
B	Equation 6	mm
C	$\frac{D_{50}}{\text{Roundness}}$, Tables 4 and 7	mm
D	*D*90, Table 4	mm
E	Average regional moisture	–

Table 12 Values of selected parameters

	A	B	C	D	E
Sample 1	0.014	0.009	0.881	0.274	0.74
Sample 2	0.093	0.021	2.118	1.679	0.49
Sample 3	0.083	0.135	6.501	1.641	0.76
Sample 4	0.024	0.131	1.336	1.337	0.70
Sample 5	0.021	0.053	0.510	0.275	0.29
Sample 6	0.129	0.046	0.460	0.545	0.56
Sample 7	0.041	0.057	0.554	0.889	0.51

Table 13 Suggested sand quality versus match level

Level of match	Suggested sand quality
World cup	$S \geq 8$
Continental	$S \geq 7$
National	$S \geq 6$
Regional	$S \geq 5$
Training	$S \geq 3$
Inacceptable	$S < 3$

6 Conclusions

The beach soccer game was originally played in the sandy beaches. Nowadays, the beach soccer matches are held in the grounds covered by sand. There are many different sands with different properties to be used in beach soccer grounds. The sand can be selected according some criteria presented by FIFA. These criteria are not too precise. In other words, many different sands with different properties can fall in FIFA-acceptable range. Hence, it seems reasonable to introduce a method for standardization of beach soccer grounds and ranking different sands for the purpose of beach soccer ground surface coverage.

In this study at first, a survey was conducted in which players of a beach soccer team answered the questionnaires about the quality of sand in different beach soccer grounds. Samples were graded according to desired quality of players. Subsequently, laboratory testing of gradation, direct shear test, XRD and XRF test and roundness test were carried out. Results of these tests indicated that uniform fine sand with rounded or sub-rounded particles is suitable for beach soccer ground. Furthermore, moisture content of sand for beach soccer ground was suggested to be less than 1 percent. Also, to measure moisture content of sand TDR as a simple, fast and accurate instrument was introduced for use in beach soccer ground. Two special tests were designed to simulate real conditions of contact surface between the player's foot and the sand surface. The results of these two tests show important properties of the high-quality sands:

- It can be observed from the results of test 1 that for the high-quality sand the slope of load–displacement curve is relatively small before load of putting the foot on the ground. For this type of sand with increasing load, the slope of load–displacement curve increases due to compaction of sand.
- From the results of test 2, it can be generally concluded that for the high-quality sand, the volume of the hole in test 2 is minimum, and in other words, during beach soccer match, the sand surface remains smoother comparing to other samples.

Finally, a novel ranking method is introduced on the base of some conducted tests and the climate data. This method can be applied to determine the quality of each sand sample using the input data of gradation test, roundness test and climate data. Using this method, a score can be calculated for each sand sample, which shows the sand quality. The ranking method is adjusted so that the results of survey are closely covered. Furthermore, a minimum sand quality is specified considering the level of the beach soccer match, on the basis of personal experiences of the players and referees of beach soccer matches.

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