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LOCAL SOIL IMPROVEMENT WITH BENTONITE TO MAKE CRICKET PITCH SPEEDY AND BOUNCY

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ABSTRACT

Soil in Indian subcontinent is generally silt and clay type and its plasticity index is low. This study will present a way to change soil's various properties to make it more suitable for using while preparing speedy and bouncy cricket pitches with local soil. Soil sample was collected from different locations of Bangladesh. Hydrometer test and Atterberg limit tests were performed to determine silt, clay content, and plasticity index of soil samples. Comparing this with Australian pitches soil sample which is used to prepare their cricket pitches which is more speedy and bouncy than Bangladeshi cricket pitches. For this, local soil sample which is used to prepare cricket pitches is needed to increase clay content as well as improve its plasticity index is required to make speedy and bouncy like Australian pitches. From laboratory analysis, it's been shown that after using bentonite admixture in local soil increase clay content from 6% to 27% (sample 1) and 13% to 37% (sample 2), lowering silt content from 44% to 24% (sample 1) and 47% to 29% (sample 2), and organic matter are lowering near 5% for both samples. Liquid limit and Plastic limits for both samples are decreased after improvement with bentonite and plasticity index are increased from 4.39% to 4.53% (sample 1) and 1.22% to 3.82% (sample 2). Coefficient of restitution is increasing with decreasing moisture content. Four models have been developed two are with bentonite and another two are without bentonite and compare the speed and bouncy property of these four samples. Finally, it was found that improved soil model behaving more similarly with Australian cricket pitches. Therefore, with this improved soil sample speedy and bouncy cricket pitch in Bangladesh can be prepared as like as Australian cricket pitches.

Keywords: *Local soil, Bentonite, Silt and clay content, Plasticity index, Speed and bouncy test.*

1. INTRODUCTION

Cricket is one of the most popular sports in Bangladesh. People are delighted to watch this game as it is representing our country at the international level as well as the Bangladesh National Cricket team is doing well in this game. In Cricket, various factors are important to be concerned. Among them, weather, playing surface, ground conditions vary from country to country. The playing surface is known as Cricket Pitch. The cricket pitch consists of the central strip of the cricket field between the wickets. It is 22 yards (20.12 m) long and 10 feet (3.05 m) wide (Eudoxie & Nagassar, 2012). The surface is flat and normally covered with extremely short grass though this grass is soon removed by wear at the ends of the pitch. Cricket pitches are categorized according to their behavior. Fast and slow are the common categories of pitches. "Fast" pitches quite commonly are "Bouncy" pitches as well while "Slow" pitches tend to be "Low", dusty and conducive to "Spin"(Nawagamuwa, Senanayake, Silva & Sanjeewa, 2009). Most of the subcontinent pitches are slow and low even though it has been attempted, the creation of fast and bouncy pitches in the subcontinent has eluded. This study deals with the problem of creating fast and bouncy pitches by investigating how some of the physical property of a cricket pitch varies with soil used to make the pitch. Pace, bounce, spin, consistency, and deterioration are the significant behavior of cricket pitches (Baker, Cook & Adams, 1998). Pace describes how fast delivery will come at the batsmen after bouncing and it depends on the horizontal velocity component of the ball and the horizontal velocity retained after bouncing (Robinson & Robinson, 2016). Spin defines the cricket ball with rapid rotation so that when it bounces on the pitch it will deviate from its normal straight path, thus making it difficult for the batsman to hit the ball cleanly. The speed the ball travels is not critical and is significantly slower than that for fast bowling. A typical spin delivery has a speed in the range 70–90 km/h (45–55 mph) (Robinson & Robinson, 2016). Bounce describes the steepness of the path of delivery after bouncing and its governing factor is vertical velocity gained by the ball after impact with the pitch. Consistency means batsman's better predictability about the path of delivery as the highly inconsistent pace will make batting almost impossible while inconsistent bounce will be dangerous to the batsman. Deterioration describes the length of time a pitch is likely to maintain a certain level of pace and bounce (James, Carré & Haake, 2005). Cricket pitches are mainly categorized into 3 types: Dead pitch, Dusty pitch, Green pitch. Most of the dead pitches are mainly found in Indian subcontinents. ODI and T20 matches are mainly played in this type of pitches. As these wickets have nothing for bowlers the batsmen continue to put runs on the scoreboard leaving the bowlers in a state of trouble. But the game played in these wickets is very much interesting because of the huge maximums from the batsmen. Green pitches having green grass on it makes it less abrasive on the ball and helps the ball to swing easily (Ball & Hrysomallis, 2012). Along with swing, the bounce in these wickets is unpredictable. Even if these pitches seem to help the seam bowlers but serve absolutely nothing for a spinner. These types of pitches are found in western countries of the globe and mainly preferred for test cricket. The surface of the dusty pitch is soft and unrolled which creates a great help for the spin bowlers. These pitches are easier to bat as compared to the other two because in this wicket the bounce of the ball can be predicted by the batsmen. Dusty pitches are mostly found in subcontinents. These wickets are not that difficult to score as the deliveries normally stay low which can be easily faced by the batsmen (Gopinath, 2017). But spinners with great skills can pick up a bunch of wickets in these pitches. In the subcontinent, the dead pitch is prepared for ODI and T20 format whereas dusty pitches are prepared for longer version as this pitch have low pace and bouncy behaviour whereas Green pitches are prepared in Australia, England, and South Africa because of its high speedy and bouncy behaviour for all types of version. According to experts, Bangladeshi pitches differ from Australian, English and South African pitches in three of the above characteristics. They are namely pace, bounce and deterioration. Bangladesh's pitch has a slower pace and bounce and also deteriorates much faster.

The soil in Bangladesh is generally silt and clay type and its plasticity index is low (Payton et al., 2003). There are Seven Soil Tracts of Bangladesh and these are Madhupur Tract, Barind Tract, Tista Silt, Brahmaputra Alluvium, Gangetic Alluvium, Coastal Saline Tract, and Chittagong Hill Tract

(Payton et al., 2003). And considering the climate as the most active pedogenic factor, Bangladesh was divided into three zones: Humid, Semi-Humid, and Feebly Arid.

Cricket pitches of different locations in Bangladesh are usually made by local soil according to the location of the stadium. Cricket pitches are consisting of an aggregate mixture of coarse sand, fine sand, silt, and clay together by a strong binding agent. Silts are non-cohesive soil particles that reduce cohesiveness of soil, as a result, pitches become dusty (Gopinath, 2017). Higher organic content in soil reduces the binding strength of the soil and so reduces pace and bounce. Pitches of the subcontinent have higher silt and organic content that's why these pitches are slower and spiny. On the other hand, Pitches in Australia, England, and South-Africa have high clay content with a minimum percentage of silt and high plasticity index (Harwood, King & Yeadon, 2017). Because of these reasons, the behaviour of pitches in those countries is fast and bouncy. The objectives of this study are to improve soil properties by using bentonite admixture as it reduces organic content, silt content of soil and increases clay content, plasticity index which will help to create fast and bouncy cricket pitch. As Bangladesh is a tropical country, here most of the time temperatures are higher than English condition that's why heated bentonite was used to improve soil sample which increase plasticity index (Widjaja & Nirwanto, 2019). It was hypothesized that reducing the silt content, organic content and improving the plasticity by the introduction of Bentonite (a clay type with very high plasticity) into the soil would produce a faster and bouncier pitch of similar character to those in Australia, England, and South Africa (Nawagamuwa et al., 2009). Since bentonite is used to transform cohesion less soil into cohesive soil and this happens due to rearrangement of soil grains, decreasing the void between the grains and increasing the density of the soil.

2. METHODOLOGY

An experimental program was conducted to investigate the behavior of soil samples before and after improving with bentonite admixture (30% of soil sample weight). Two soil sample was collected from two different locations which were used to prepare four different model pitches. Among them, one was before improvement and the other one was after improvement. There are two types of bentonite is possible one is swelling type and other is non-swelling types. Here non-swelling type calcium bentonite was used at heated temperature of 120˚C temperature.

2.1 Sample Location and Testing

Figures 1 and 2 show that Soil samples 1 were collected from Mymensingh and soil sample 2 were collected from Kishoreganj respectively. Both of them are in the semi-humid zone.

Figure 1: Soil Sample 1 from Mymensingh

Figure 2: Soil Sample 2 from Kishoreganj

Atterberg limit test, Hydrometer analysis, and organic matter content of two soil samples before and after improvement were performed to determine silt content, clay content, organic matter content, and plasticity index of the soil samples. Laboratory analysis of collected soil samples was done. Figures 3 and 4 representing the oven drying of soil samples and Atterberg limit test respectively.

Figure 3: Oven drying of soil sample

Figure 4: Atterberg Limit Test

2.2 Model Pitch Preparation and Testing

Four different model pitches were prepared by two soil samples before and after improvement having dimensions of 3 X 3 ft. and thickness of 6 inches. The sample pitch having thickness 6 inches where 3 inches of soil layer, 0.5 inches of metal plate and 2.5 inches of founding materials (stone chips). Each sample pitches were constructed into three layers with hammering and rolling. Figure 5 and figure 6 indicates the model pitch 1 with and without bentonite whereas figure 7 and figure 8 shows model pitch 2 with and without bentonite.

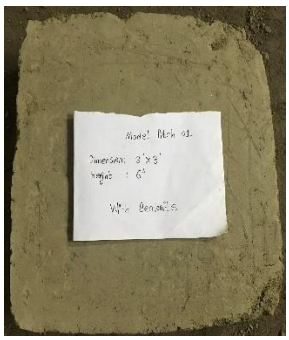

Figure 5: Model Pitch 1 with Bentonite

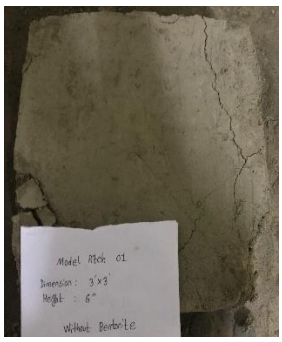

Figure 6: Model Pitch 1 without Bentonite

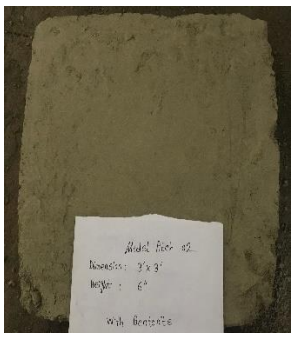

Figure 7: Model Pitch 2 with Bentonite

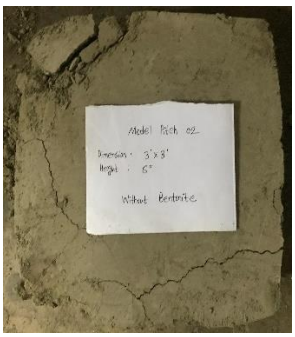

Figure 8: Model Pitch 2 without Bentonite

2.3 Speed Test

Figure 9 represents the experimental setup to determine the speed value of the model pitch by identifying the release point of the ball, impact point of the ball on pitch and bouncing point of the ball after impact on pitch with an android app called speed clock which helped to determine the speed value of each point above mentioned. Regular Cricket ball was used during this speed test.

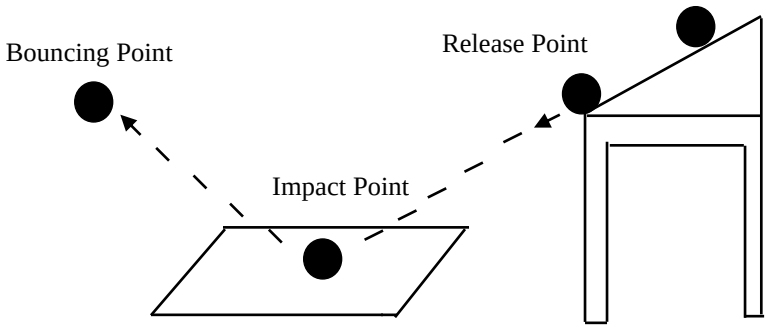

Figure 9: Experimental setup for Speed test

2.4 Bounce Test

Figure 10 shows that the experimental setup of bouncy test of the model pitches where the ball was released from a certain height 'H' with a definite velocity on the model pitch and after impacting rebound height 'h' was measured. Through this process and from the simple mechanic's coefficient of restitution of surface was determined. Bouncy property of cricket pitch will increase with increasing value of the coefficient of restitution.

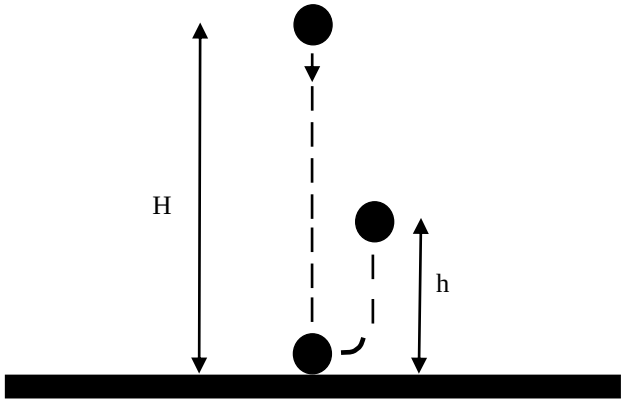

Figure 10: Experimental setup for Bounce test

3. RESULTS AND DISCUSSIONS

3.1 Soil Components and Atterberg Limit Test

Table 1 represents the comparison between soil properties of Australian pitches and local soil samples from Mymensingh and Kishorganj. Soil components of Australian Pitches represent that their clay contents are too high, silt content is low and organic content is near about 5%. Because these pitches are too fast and bouncy whereas local soil samples showing exactly opposite behavior. Improving soil samples with Bentonite admixture, it's been clearly indicating that the clay content was increased whereas silt content was decreased. Since non swelling types calcium bentonite after heating 120˚C temperature was used, liquid and plastic limit of soil samples were decreasing but plasticity index was increased. And the most significant part is organic matter were decreased and its numerical value went down to almost 5%. This is a clear indicator that, the pitch with this improved soil will be faster and bouncier than before.

Table 1: Comparison between soil components of Australian pitches and local Soil Sample

Soil	Brisbane*	Perth*	Soil Sample 1		Soil Sample 2	
			Before Bentonite	After Bentonite	Before Bentonite	After Bentonite
Clay	68	82	6	27	13	37
Silt	6	6	44	24	47	29
Organic Matter	5.5	2.1	7	5.4	8	4.8

(*NZSTI Guide to Cricket Pitch Preparation)

It has been clearly shown from Table 2 that improving soil samples with Bentonite lowering the liquid and plastic limit value but increasing the plasticity index. This indicates that preparing a pitch with this improved soil will be more compacted and it will decrease the chance of crumbling.

Table 2: Atterberg limit of local Soil Sample

Soil	Soil Sample 1		Soil Sample 2	
	Before Bentonite	After Bentonite	Before Bentonite	After Bentonite
Liquid Limit	29.6	25.25	26	24.50
Plastic Limit	25.21	20.72	24.78	20.68
Plasticity Index	4.39	4.53	1.22	3.82

Figure 11 represents the comparison of soil components of different local soil samples with Australian pitches soil samples and figure 12 shows the Atterberg limits variation before and after improving soil with Bentonite.

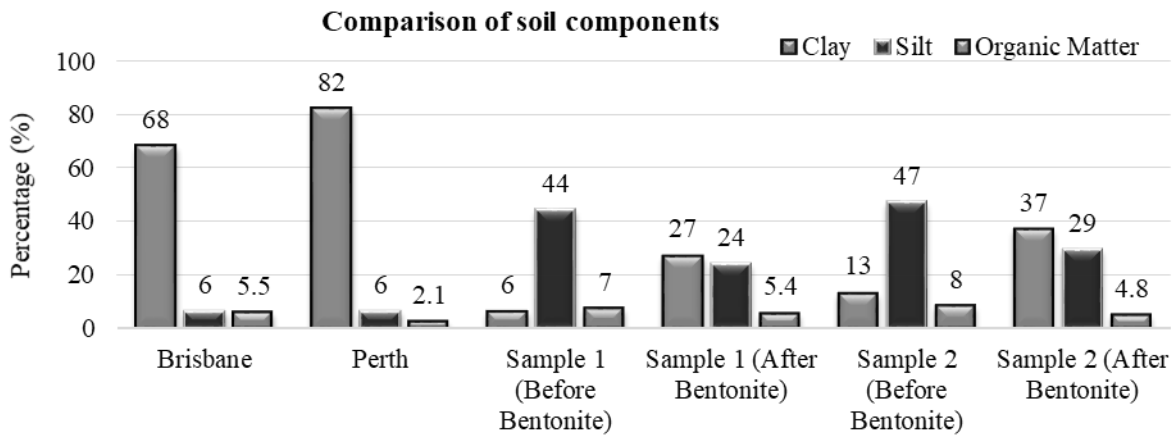

Figure 11: Comparison of soil components of different local soil samples with Australian pitches soil samples.

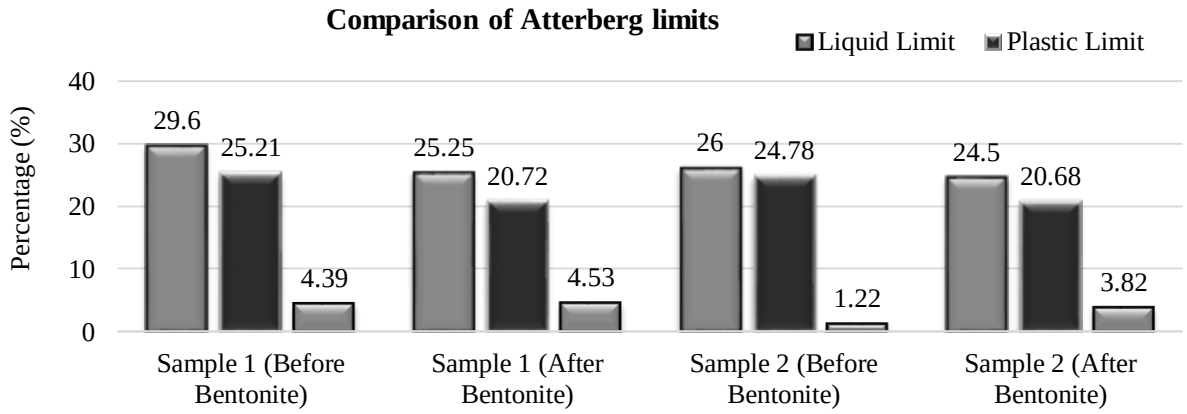

Figure 12: Comparison of Atterberg limits of different local soil samples before and after improvement.

Equations:

From simple mechanics, equations of coefficient of restitution can be determined and it shown below,

$$v_i = \sqrt{2gH} \quad (1)$$

$$v_o = \sqrt{2gh} \quad (2)$$

$$e = \frac{v_o}{v_i} = \sqrt{\frac{h}{H}} \quad (3)$$

Where, v_i= incoming velocity, v_o= outgoing velocity, e= coefficient of restitution

3.2 Speed Test

Cricket ball was thrown at a constant speed of 85 Kph on four different pitch models. In model Pitch 1 and 2 without Bentonite, speed was increased after the impact of ball on the pitch from 85 Kph to 94 Kph and 96 Kph respectively. Whereas Model Pitch 1 and 2 with bentonite, speed was increased from 85 Kph to 107 Kph and 111 Kph respectively. Table 3 represents the speed variation of cricket ball on different pitch models.

Table 3: Variation of Speed on different Pitch Models

	Model Pitch 1 (without Bentonite)	Model Pitch 1 (with Bentonite)	Model Pitch 2 (without Bentonite)	Model Pitch 2 (with Bentonite)
Releasing Point speed (Kph)	85	85	85	85
Bouncing Point speed (Kph)	94	107	96	111

3.3 Bouncy Test

Table 4 and 5 represents that cricket ball was released freely on Pitch models from 60 inches above in different moisture condition 5 %, 10%, 15% sequentially. As moisture content were increasing, rebounding heights were decreased. From equation (3) it calculated that the coefficient of restitution was decreasing with the increase of moisture content.

Table 4: Bounce Test Results for Model Pitch 1

	Moisture (%)	H (inch)	h (inch)	e
Model Pitch 1 (Before Bentonite)	5	60	20	0.577
	10	60	16	0.516
	15	60	11	0.428
Model Pitch 1 (After Bentonite)	5	60	22	0.606
	10	60	17	0.532
	15	60	13	0.465

Table 5: Bounce Test Results for Model Pitch 2

	Moisture (%)	H (inch)	h (inch)	e
Model Pitch 1 (Before Bentonite)	5	60	24	0.632
	10	60	21	0.592
	15	60	17	0.532
Model Pitch 1 (After Bentonite)	5	60	28	0.683
	10	60	22	0.606
	15	60	19	0.563

Comparison between moisture content (%) and the coefficient of restitution (e) of Model Pitch 1 and 2 are shown in Figures 13 and 14 respectively.

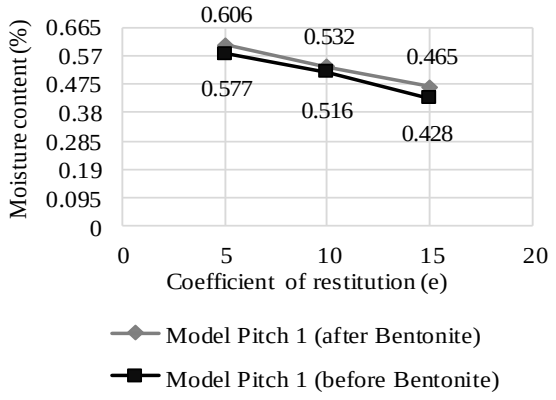

Figure 13: Moisture Content (%) vs. Coefficient of restitution(e) of Model Pitch 1

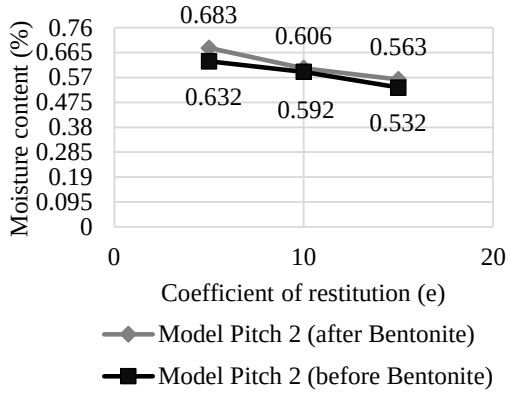

Figure 14: Moisture Content (%) vs. Coefficient of restitution (e) of Model Pitch 2

4. CONCLUSIONS

From this study, it observed that model pitch 1 and 2 without bentonite had comparatively low and slow characteristics than model pitch 1 and 2 with Bentonite. Compare with Australian pitches conditions with model pitch 1 and 2 with bentonite had achieved better results than the model pitch 1 and 2 without Bentonite. From the value of the coefficient of restitution, it analyzed that bounce of the ball in model pitches with improved soil has better bouncy behavior and in case of speed, it also showed from the table that model pitches with improved soil made speedy pitches than model pitches without improved soil. Though model pitches with improved soil cannot reach the level of Australian Cricket pitches, it gives a clear indication that if pitches with an improved soil sample of Bentonite admixture are prepared, it can be faster and bouncier than the regular cricket pitches of Bangladesh.

Also, here, the amount of Bentonite was 30% of the weight of soil sample if it increases up to 60-80% then more convenient results of prepare faster and bouncier pitches in Bangladesh are possible but there is a possibility of severe cracking. So, Model pitches with improved soil of Bentonite admixture have a greater possibility to construct much higher speedy and bouncy cricket pitches in Bangladesh.

REFERENCES

Baker, S. W., Cook, A., & Adams, W. A. (1998). Soil characteristics of first-class cricket pitches and their influence on playing performance. *Journal of Turfgrass Science*.

Ball, K., & Hrysomallis, C. (2012). Synthetic grass cricket pitches and ball bounce characteristics. *Journal of Science and Medicine in Sport*. https://doi.org/10.1016/j.jsams.2011.10.010

Eudoxie, G., & Nagassar, D. (2012). Influence of cricket pitch preparation on resulting pitch surface hardness. *Tropical Agriculture*.

Gopinath, R. . . . P. B. (2017). Utilization of Lateritic Soil to Make Fast and Bouncy Cricket Pitches. *International Journal of Science and Research (IJSR)*.

Harwood, M. J., King, M. A., & Yeadon, M. R. (Fred). (2017). The influence of cricket pitch length on ball release by junior bowlers. *ISBS Proceedings Archive*.

James, D. M., Carré, M. J., & Haake, S. J. (2005). Predicting the playing character of cricket pitches. *Sports Engineering*. https://doi.org/10.1007/bf02844162

Nawagamuwa, U. P., Senanayake, A. I. M. J., Silva, S. A., & Sanjeewa, D. M. l. (2009). Improvement of Local Soils in Order to Make "Fast & Bouncy" Cricket Pitches. *Engineer: Journal of the Institution of Engineers, Sri Lanka*. https://doi.org/10.4038/engineer.v42i4.7033

Payton, R. W., Barr, J. J. F., Martin, A., Sillitoe, P., Deckers, J. F., Gowing, J. W., … Zuberi, M. I. (2003). Contrasting approaches to integrating indigenous knowledge about soils and scientific soil survey in East Africa and Bangladesh. *Geoderma*. https://doi.org/10.1016/S0016-7061(02)00272-0

Robinson, G., & Robinson, I. (2016). Spin-bowling in cricket re-visited: Model trajectories for various spin-vector angles. *Physica Scripta*. https://doi.org/10.1088/0031-8949/91/8/083009

Widjaja, B., & Nirwanto, A. F. (2019). Effect of various temperatures to liquid limit, plastic limit, and plasticity index of clays. In *IOP Conference Series: Materials Science and Engineering*. https://doi.org/10.1088/1757-899X/508/1/012099