



EFFECT OF ADDING OF SYNTHETIC BENTONITE CLAY ON MECHANICAL AND PHYSICAL PROPERTIES OF RUTBA IRAQI LOCAL MOULDING SANDS

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ABSTRACT

The research studied the effects of adding industrial Iraqi bentonite clay on the mechanical and physical properties of the Iraqi Rutbah sand with a wide range moisture weight ratio ranging from 1.8 - 8.5%. Properties included green shear and compression resistance; permeability, hardness and moisture content. Samples of green sand blocks (standard sample 50 mm x 50 mm) adhered to Iraqi bentonite clay were subjected to test's properties using crash index and universal strength machines.

The results showed that the ability to improve the local sand in the Iraqi Rutbah for the purpose of renewal in the preparation of molds. The results also showed that adding industrial Iraqi bentonite improved the compressive strength of the green sand mold by about 116.2%, and the shear strength by about 37.8%. It also increased the green transmittance by 12.9% and the hardness by about 9.4%.

KEYWORDS: Sand, Bentonite, Compressive strength, bentonite-sand mixture, hydration time; mechanical behavior.

1. INTRODUCTION

The traditional base material for foundry casting is natural sand in different mineral and chemical variations, exhibiting different surface formations and different physical properties (Sobczak et al., 2005). With the progress of scientific, economic and technological development, engineering activities have been extended to extreme exploration. The requirement to reduce costs and improve the product led the design team to think of modern ways to produce castings (Rundman, 2000).

In the maintenance workshop which deal with manufacturing spare parts for different machining, it is, necessary for quality & economical reason to control the local Iraqi sand. The majority of castings are made in greensand molds, which are molds whose main ingredients are sand (usually silica, SiO_2), as clays such as bentonite, and water (Rundman, 2000).

Physical properties such as moisture by weight, dimensions (screen distribution), characteristic temperatures, density, chemical properties (pH value) as well as technological parameters (compressive strength, permeability, resistance to tensile, friability and compatibility) of a wide range of FASANDS were investigated (Sobczak et al., 2005).

The strength of greensand is always determined using a so-called "standard ramming sample", that cylindrical specimen, when pressed three times into an AFS approved as a ramming device "American Foundry Standard " which measures two inches in diameter by two inches in height. The strength of green sand depends on a number of factors including clay and water content, grain size distribution of the sand, temperature of the sand, type of clay, amount and type of additive and the degree of blending or blending. Extent of compressional sand associated with varying proportions of western bentonite (Rundman, 2000).

Two other properties of greensand briquettes that are very important and regularly measured in a working foundry are compatibility and permeability. It is a property that is very sensitive to the moisture quantity in the sand. Permeability is a measure of how easily air can pass through a sand aggregate, and it is a very sensitive property of sand size distribution, moisture's content, clay and degrees of compaction. The green compression strength can be defined as a study to determine the maximum compression strength that a mixture [tailing sand, clay and water] is capable of sustaining when prepared, rammed and tested according to standard procedure.

OM et al., (2007) in their study observed that how bentonite profile depth is related to aquifer layer around particle sand. Verifying how physical property such as moisture content affects the aquifer layer. In his study the entire investigated area is underlain with 96% of sandstone.

Hunger and Brouwers, (2009) in their study, discovered that the value of the constant thickness of the water layer around the powder particles is calculated for all powders. Examinations of a mixture of sand based on pure clay and bentonite and a mixture of sand based on hybrid bentonite made it possible to follow the evolution of permeability, compressive strength and tensile strength. in the offset zone also as the indicated compressibility of the clay contained in the mixed sand. Technological parameters and the chosen strength of artificial sand are necessary for the foundry, since they greatly affect the quality of the final casting (Kamińska et al., 2020).

The presence of bentonite is led to reduce shear shrinkage and the direction of expansion of the mixture. The cohesion of the mixture increases with increasing bentonite content and hydration time, but the angle of internal friction decreases accordingly. Wetting the bentonite on the surface of the sand particles changes the shape of the contacts between the particles. The suspension of bentonite between the pores of the sand structure also affects the mechanical behavior of the bentonite-sand mixture (Borana, 2021).

A good agreement was obtained between the experimental data and the model results for the measurements of temperature, relative humidity, water quantity and inflation pressure. It was found that a single set of thermal parameters for the insulating materials could be determined in both experiments, allowing reliable estimation of the thermal balance of the experiments. (Ballarini et al., 2017).

Adding sand will also prevent the development of swelling pressure while the damping effect becomes weak with increasing sand content. The analysis shows that the sand content must be kept below 38% and 39% to ensure that the swelling pressure is greater than 1.0 MPa and the hydraulic conductivity is less than $1.0e-12$ m/s , respectively (Rao et al., 2019).

In this contribution, the hydromechanical behavior of saturated and unsaturated bentonite sandy soils was studied in the context of the recently developed concept of double porosity (CDP). The studied terrain material was assumed to consist of an incompressible, rigid and flexible steel structure surrounded by viscous gaseous liquids and water, and connected by a network of flexible clay bridge/pillar units. The rotation and sorting of the sand component is varied (Ghadr and Assadi-Langroudi, 2018).

In order to supplement this scientific fact, standard compression, direct shear, unrestricted compressive strength (UCS) and drop head permeability tests were carried out on unreinforced and reinforced bentonite and sand mixtures. fiber (PP). As a result, the shear strength increases

during UMO contamination, while the ductility is significantly reduced. UCS is poor due to contamination and low hydraulic conductivity (Bojnourdi et al., 2020).

All B-FA blends showed UCS above the minimum for coating application, regardless of pressure condition. Not all BeS blends met the lower UCS standard at higher moisture content. The addition of FA at 50% showed the greatest increase in the strength enhancement factor (10 out of 12 cases), while for the BeS blends this factor decreased with the increase in the rate of additions (Gupt et al., 2021).

Gray colored densified silica fume (SF) and lime (L) are used. Three percentages has been used by for lime (3%, 6% and 9%) and four different percentages were used for silica fume (3%, 6%, 9% and 12%) and the optimum percentage of silica fume was mixed with the percentages of lime (Fattah et al., 2016, Fattah et al., 2018).

The apparent difference in inflation pressure can be largely attributed to the effects of residual lateral stress after compression. More interestingly, samples prepared by the Trimmed and Transferred methods followed a similar relationship of dry swelling under pressure. From this point of view, the improvised method without causing loss of mass, alteration of the bentonite content and the effect of possible technological voids was advocated rather than a trimmed method of preparation of samples in the laboratory (Su et al., 2021).

It has been found that when the dune sand around the stabilized area is injected with a lime-silica smoke slurry, there will be a reduction in erosion of about 70% for a stabilizer grout percentage of (33 % (3L: 4SF) with 67% water relative to the total weight of the mixture). The stabilizing effect increases with increasing number and depth of injection holes around the stabilized area due to increased L-SF grout. Their results showed that the swelling potential decreases with adding sand content of 14 to 2.4% by adding 50% sand to pure bentonite. (Fattah et al., 2020, Fattah et al., 2022).

Pure sand dunes and these three mixes were tested by the researcher to determine the effects of wind speed on drifting sand, cohesion, shear strength, and penetration, the second step is to determine the best results for the three mixes which previous called model mix and (2.5%, 5% and 7.5% CKD were added to the model mix, which was denoted by (m41, m42 and m43) respectively, these mixes have an aging - processing period - of (7, 14, 28) day (Rammal and Jubair, 2015). The objective of this study is to investigate the effect of adding of synthetic bentonite clay on mechanical and physical properties of rutba iraqi moulding sands

2. MATERIAL AND METHODS:

The research experimentally is measured the experimental values of the mechanical properties of mould samples associated with separate mixtures and different amounts of bentonite clay. While silica is the bulk casting medium, other sands are also used in foundries for special applications including chromite, olivine, garnet, carbonaceous (petroleum coke) sands and other refractory materials affordable (Rundman, 2000).

Silica sand is considered as one of the best raw materials using in manufacturing glass (Persson, 1969). it consisted basically from natural silicate, different type available in Iraq and distributed over larger area, classified according to its location. Table 1 show chemical properties of Rutba sand which used in this research. This type of sand which is used in this paper is called Rutba sand, containing 96.5% silicate. It has comparatively unbalanced grains distribution, angle and semi angle form of grains. Its mesh number equal to (52) and contains low clay content equal to 2.88%, low impurity equal to 2.2% (Xu et al., 2016).

It is impossible to use this type of sand in foundry application without improving its mechanical and physical properties, so for a suitable moulding operation it is necessary to add some synthetics binder like bentonite which is essentially consist of hydrated-alumina-silicon of magnesium and calcium, manufactured in Iraqi industries. It has an ability to absorb water. Table 1 shows its chemical properties.

Table 1. Chemical analysis of Rutba sand and Iraqi bentonite.

	SiO ₂	CaO	Al ₂ O ₃	MgO	Fe ₂ O ₃	SO ₃	Na ₂ O	K ₂ O	TiO ₂	Impurity	Moisture
Rutba Sand	86.5	0.42	0.52	0.02	0.57	0.07	0.12	0.03	0.1	0.34	---
Bentonite Clay	63.4	16-6	17-13	7--5	6-1.5	---	---	---	---	17-8	0.2

Therefore, it is very necessary to make an in-depth study of the preparation of this type of material in order to reduce the production cost and simplify the preparation technique. This type of binder system will meet the casting, moulding to insure ease of removal of the casting. The chemical composition of the binder system shown in Table 1 is important because this composition may contain elements associated with casting defects.

The accumulation of elements such as phosphorus, nitrogen, sodium and sulfur in the reclaimed sand - over a number of cycles - can eventually exceed acceptable levels and leads to a decrease in compressive strength (Boylu, 2011).

Macroscopic properties of casting sand such as toughness or strength, shear are driven by matrix and aggregate properties, matrix bonding behavior, bentonite, mixing water and, fines content (Hunger and Brouwers, 2009). Matrix properties and bonding behavior are dependent on a number of factors, the most important of which are the effective and reactive water to bentonite's ratio, particle shape and particle size distribution in the powder. This concept has been successfully implemented by (Hunger and Brouwers, 2009).

The purpose of adding binder is coating sand's grain, it may be forced together. The binder can be distributed by making a thin film around sands grain and relating its strength to number of grains and its coating area, so net attractive forces are generated between charged hydrate clay particles and the quartz surface (Beeley, 2001). This process can be accompanied by the generation of water films around the particles. Mechanical and physical properties of a compact green sand result from entirely a different phenomenon like types of sand, type of binder, weight moisture percentage, then due to the application of a certain amount of compacting forces (Rundman, 2000).

To study the mechanical and physical properties of Iraqi Rutba sand and improving its application in the foundry and it is led to sand management and increasing sand reclamation will enable foundries to make more profits and remain competitive. For sample preparation (15) mixture of Rutba sand prepared with different percentages of bentonite, (7 - 9) %, at the wide range of weight moisture percentage (1.8 - 8.5) %. These values agreed with the same that carried out by references (Bala, 2005, Nuhu, 2008). where the to calculate a percentage moisture content, subtract the dry weight from the wet weight, and then, divide the result by the wet weight, and multiply by 100.

3. EXPERIMENTAL PROCEDURE

The experimental procedure has been done, according to the following steps:

1. Classification of the used sand in the tests, using a soil testing machine, as shown in Fig. 1.



Fig. 1. Soil testing machine.

2. Preparing the mould and adding the synthetic bentonite clay to the sand as indicated in [Fig. 2](#).
2. Using manual compactor instrument.



Fig. 2. Manual compactor instrument (Metric standard sand rammer).

[Fig. 3](#) shows a standard sample size (50 mm x 50 mm) of the sand that prepared for the all the tests



Fig. 3. A standard sample of the sand mould (Strip block and specimen test piece).

3. Permeability ratio has been done for all the samples using a special electrical permeability meter apparatus as shows in Fig. 4.



Fig. 4. Electric permeability meter apparatus.

4. The shear test and the compression test of all the samples have been done using a universal sand strength machine as shows in Fig. 5.



Fig. 5. universal sand strength machine.

Through using the apparatuses for testing the hardness of the samples, Hold the tester firmly in one hand and lower it vertically at a constant speed, pressing it against the surface of the die. The maximum value is read immediately after contact.

4. RESULTS AND DISCUSSION:

All results when compared to previous work (Rundman, 2000, Hunger, and Brouwers, 2009, Beeley, 2001, 2008) showed that the addition of bentonite clay to mould sand mixture in the standard sample improved mechanical behavior such as compressive & shear strength, hardness and permeability. It increased green permeability by about 12.9 % and hardness by about 9.3 %. Also improved green compressive strength of sand moulds over those bonded with bentonite clay by about 116.2 % and shear strength by about 37.8 % respectively.

Typically shear strength data is about one fourth that of compressive strength results. As shown in all figures, from Figs. 6-9, the physical behavior such as weight moisture percentage has a significant effect on of all mechanical behaviors, in the beginning; they increased in a nearly linear manner due to the swelling action of the bentonite clay particles, thereby pushing the sand particle further apart.

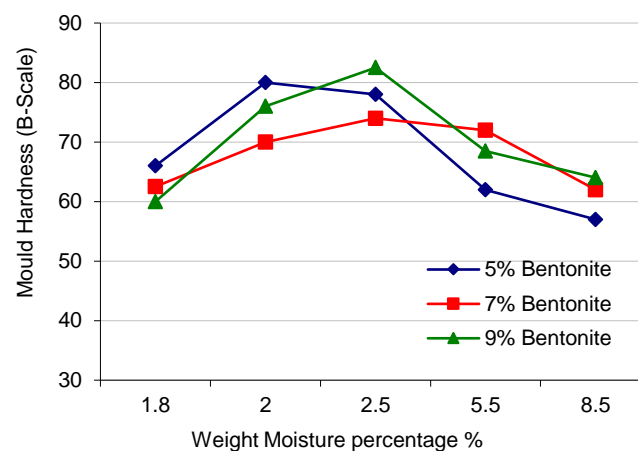


Fig. 6. Effect of percentage Bentonite % on Mould Hardness at different Weight moisture percentage.

After that when they reach the optimum value at 2.5 % weight moisture percentage decreasing in a linear manner take place, generally with increasing weight moisture percentage the value of hardness, permeability compressive and shear strength are decreased due to reducing bonding forces at contacting area of sands grain. Use a test mold with a flat test surface accompanied with an opposing surface which is also flat and parallel to the test surface.

Indeed, water molecules are known to effectively expand the hexagonal network of clays by settling between the layers of the basal plane of the structure. From the figures, Fig. 6 and Fig. 9 with increasing the amount of bentonite clay up to 9 %; the mixture give the best results for moulding hardness and shear strength, in the range of weight moisture percentage from 1.8---8.5%.

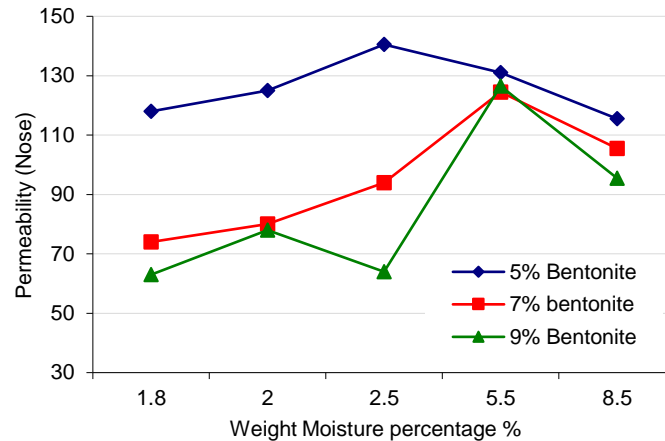


Fig. 7. Effect of percentage Bentonite % on Sand Permeability at different Weight moisture percentage.

In Fig. 7 mixture 5 % bentonite give the best results for permeability because this type of sand (Rutba Sand) contain non-uniformly graded rough grain, so with adding more bentonite clay up to 9 % all the space between these grains will be filled, and their will be no way in which air can pass through the sand aggregate. But in Fig. 8, the mixture of 7 % bentonite clay give the best results for compressive strength in the range of 1.8—8.5 % weight moisture percentage.

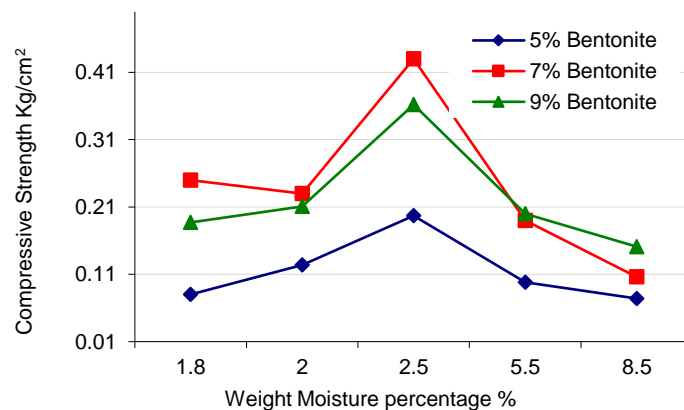


Fig. 8. Effect of percentage Bentonite % on Mould Compressive Strength at different Weight moisture percentage.

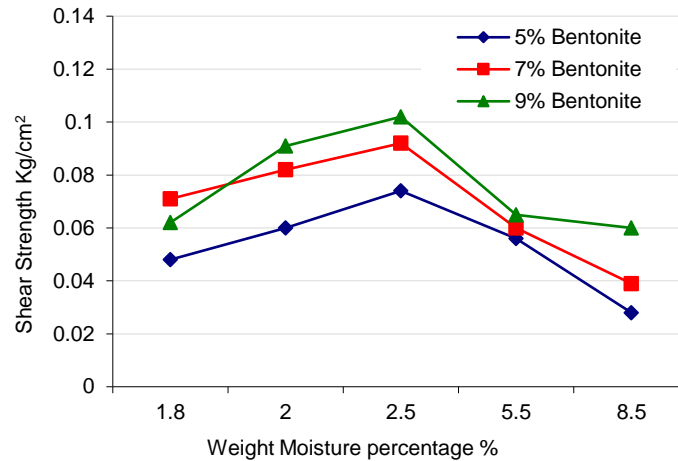


Fig. 9. Effect of percentage Bentonite % on Mould Shear Strength at different Weight moisture percentage.

5. CONCLUSION

This study can be useful for evaluation of the mechanical and physical properties of sand's element and provides a beneficial reference for water-bentonite ratio of other sand material in similar condition. Our experimental results show that:

- 1- Rutba sand showed high ability to improve their mechanical and physical behaviors for replenishment purpose in moulding preparation.
- 2- The addition of Iraqi bentonite clay improved green compressive strength of sand by about 116.2%, shear strength by about 37.8%, increasing green permeability by about 12.9% and mould hardness by about 9.4%.
- 3- Typically shear strength data is about one fourth that of compressive results, this agreed with the same that carried out by Karl B. Rundman.

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