Pertanika J. Sci. & Technol. 21 (2): 335 - 342 (2013)

PERTANIKA JOURNALS

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Green Compression Strength of Tin Mine Tailing Sand for Green Sand Casting Mould

Azhar Abdullah[1#]*, Shamsuddin Sulaiman[1], B. T. Hang Tuah Baharudin[1], Mohd Khairol Anuar Mohd Ariffin[1] and Thoguluva Raghvan Vijayaram[2]

[1]Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[2]Faculty of Engineering and Technology (FET), Multimedia University, Jalan Ayer Keroh Lama, Bukit Beruang, 75450, Melaka, Malaysia

ABSTRACT

Tailing sand is the residue mineral from tin extraction that contains between 94% and 99.5% silica, which can be used as moulding sand. It is found in abundance in the Kinta Valley in the state of Perak, Malaysia. Adequate water content and clay in moulding sand are important factors for better strength and casting quality of products made from tailing sand. Samples of tailing sand were investigated according to the American Foundrymen Society (AFS) standard. Cylindrical test pieces of Ø50 mm×50 mm in height from various sand-water ratios were compacted by applying three ramming blows of 6666g each using a Ridsdale-Dietert metric standard rammer. The specimens were tested for green compression strength using a Ridsdale-Dietert universal sand strength machine. Before the tests were conducted, moisture content of the tailing sand was measured using a moisture analyser. A mixture bonded with 8% clay possesses higher green compression strength compared to samples bonded with 4% clay. The results also show that in order to achieve maximum green compression strength, the optimum allowable moisture content for mixtures bonded with 8% clay is ranged between 3.75 and 6.5% and for mixtures bonded with 4% clay is 3-5.5%.

Keywords: Tailing sand, clay content, moisture content, green compression strength

Article history:
Received: 19 October 2010
Accepted: 3 June 2013

E-mail addresses:
azija656@yahoo.com (Azhar Abdullah),
shamsuddin@upm.edu.my (Shamsuddin Sulaiman),
hangtuah@upm.edu.my (B. T. Hang Tuah Baharudin)
khairol@upm.edu.my (Mohd Khairol Anuar Mohd Ariffin)
*Corresponding Author
[#]Author's current affiliation
Department of Mechanical Engineering, Politeknik Ungku Omar, 31400 Ipoh, Perak, Malaysia

ISSN: 0128-7680

INTRODUCTION

Tailing sand is the residue mineral from tin extraction, which contains between 94% and 99.5% silica and is found in abundance in the Kinta Valley in the state of Perak, Malaysia (Mackay, 2000). The objective of this study was to investigate the effects of moisture content on green compression strength of tailing sand from four identified tin-mining locations in Perak State for their potential for use in making green sand casting moulds. Samples were taken from Taiping (4.8648532N, 100.7061714E), Tronoh (4.4410824N, 101.0034513E), Batu Gajah (4.447543N, 101.061044E) and Tanjung Tualang (4.2995955N, 101.0588551E) (Google Earth, 2010).

The green compression strength of the tailing sand was studied to determine the maximum compressive stress that a mixture (tailing sand, clay and water) is capable of sustaining when prepared, rammed and tested according to standard procedure by the British Cast Iron Research Association (BCIRA). This is because sufficient strength of moulding sands is required during the withdrawal of the pattern from the mould and during pouring processes where the mould must retain shape independently without distortion or collapse. Usually, green compression strength for typical moulding sands run from about 30 to 150 kN/m^2 (Loto, 1990). For instance, green sand properties for moulds prepared by jolt/squeeze machine are about 70-100 kN/m^2 at 3-4% moisture and bonded with 5-5.5% clay (Heine *et al.*, 1967).

Clay and water are the control additions in influencing the mechanical properties of moulding sand such as green compression strength. Incorrect amount of clay and water in the mould mixture can cause casting defects. When water is exposed to radiant heat from the metal, moisture is driven back from the mould surface, condensing in a wet, weak underlying layer that can easily fracture to produce expansion defects in castings such as scabs, rat-tails and buckles (Brown, 2000). Meanwhile, if clay content is higher in the mould mixture, the permeability and refractoriness of the moulding sand will decrease; thus, clay should be made in the order of 5-7% to produce moulds with better strength and higher permeability (Griffiths, 1990). Due to this fact, 4% and 8% clay was selected for this research.

Water present in the moulding sand to about 1.5% to 8%, activates the clay in the sand, causing the aggregate to develop plasticity and strength. Control of moisture in the moulding sand is necessary to develop the best properties (Heine *et al.*, 1967). Suitable water content is the principal source of the strength and plasticity of moulding sand. Water in moulding sands is often referred to as tempering water. Too little water fails to develop adequate strength and plasticity. The clay adsorbs the water up to a limiting amount. Only the water rigidly held (adsorbed) by the clay appears to be effective in developing strength. This is due to increasing thickness of the water films, causing the clay to become less stiff and the sand grains to be held further apart (Webster *et al.*, 1980). Additional water, however, can act as a lubricant, and makes the sand more plastic and more mouldable although strength may drop (Heine *et al.*, 1967). Therefore, excess moisture must be avoided as it lowers permeability and increases the chance of a blown casting and may also lead to plasticity and deformation of the mould. Low permeability and green compression strength encourage entrapment of gas and the washing away of sand by molten metal (Griffiths, 1990).

Clay will act as a binder agent where it mixes with water to bind the sand particles and should be controlled due to the fineness of the particles. Clay can thus be made in the order of 5-7% to produce moulds with better strength. Increase in strength occurs because as the clay content of the moulding sand increases, its binding strength (properties) also increases which leads to increase in strength (Olasupo, 2009). The development of bond strength depends upon hydration of the clay; the green strength of a moulding mixture increases with water content up to an optimum value determined by the proportion of clay. Beyond this value, additional free water causes the green strength to diminish (Beeley, 2001).

Fig.1 shows the relationship between clay content and addition of water on green compression strength for green sand casting moulds.

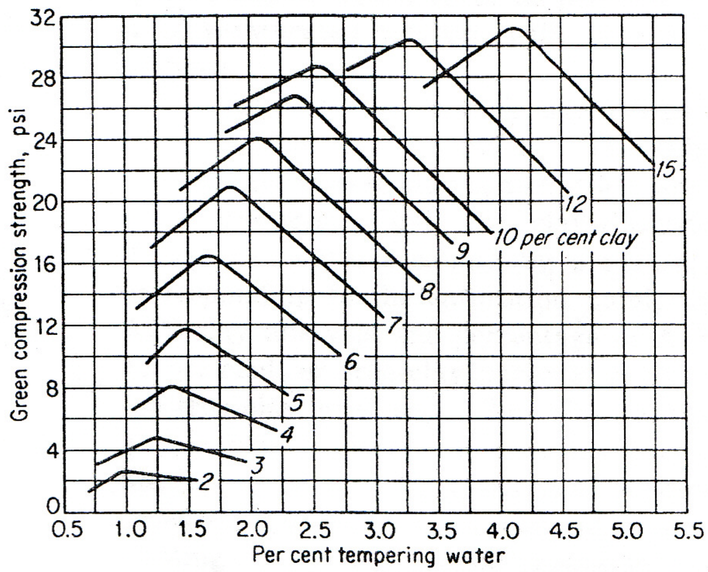

Fig.1: Relationship of clay content and percentage of tempering water on green compression strength from R. E. Grim and F. L. Cuthbert (Heine *et al.,* 1967)

MATERIALS AND METHODS

A mixture was prepared by mixing 1000g of dry sand with 4% of bentonite clay by weight, and milled for 5 minutes. Then, water was added to the mixture starting with 20ml (approximately 2% moisture). The mixture was milled approximately for 3 minutes and then a sample was tested for moisture using a moisture analyser as shown in Fig.2.

The moulding sand mixture was tested for moisture using a moisture tester as shown in Fig.2. Approximately 10g of sand mixture was weighed out and put on the plate inside the tester. Then, the mixture was heated up and a reading was obtained within 3 minutes depending on moisture content of the mixtures.

A test piece of Ø50 mm×50 mm in height was prepared by weighing out specimens ranging from 138g to 150g depending on the sand/clay/water ratio. The mixture was then transferred to the Ridsdale-Dietert Metric Standard Rammer as shown in Fig.3 to form the test piece and was stripped using a strip block as shown in Fig.4. The test piece was then tested with a Ridsdale-Dietert universal sand strength machine as shown in Fig.5. After the readings were obtained, an addition of 20ml water was added until the moisture content reached approximately 9%, where the mixture became too wet and unmouldable. The procedure was repeated for a mixture bonded with 80g clay.

Fig.2: Equipment for foundry sand testing. Moisture analyser(top left), Ridsdale-Dietert metric standard rammer (top right), strip block (bottom left) and Ridsdale-Dietert universal sand strength (bottom right)

RESULTS AND DISCUSSION

The results of the tests on the green compression strength and moisture content of the tailing sand-clay mixture are presented in graphs in Fig.3 to Fig.6.

The results of the tests carried out showed that the green compression strength for all samples bonded with 4% and 8% bentonite clay increased incrementally with the increasing percentage of water added. The reason for this is that when the dried mixture (sand and clay) was mixed with water, the presence of water activated the clay, causing the aggregate to develop plasticity and strength. The strength had increased when the clay adsorbed the water up to its limiting amount. After reaching the maximum strength at 3.0-5.5% moisture for a mixture bonded with 4% clay and 3.75-6.5% moisture for a mixture bonded with 8% clay, the strength started to decrease. The was due to the additional water which acted as a lubricant and increased the thickness of the water films so that the clay became less stiff and was unable to hold the sand grains apart, thus making the mixture more plastic and causing the strength of the mixture to drop.

The results also show the comparison of green compression strength for mixture bonded with 4% clay and 8% clay. Mixture bonded with 8% clay had greater strength compared to mixture bonded with 4% clay. This can be observed from Fig.3 to Fig.6, where the strength curve for mixture bonded with 8% clay is higher than for 4% clay. This is because when the mixture contains more clay, more particle-bonding agent exists in the mixture, and this will increase the strength of the mixture when water is added.

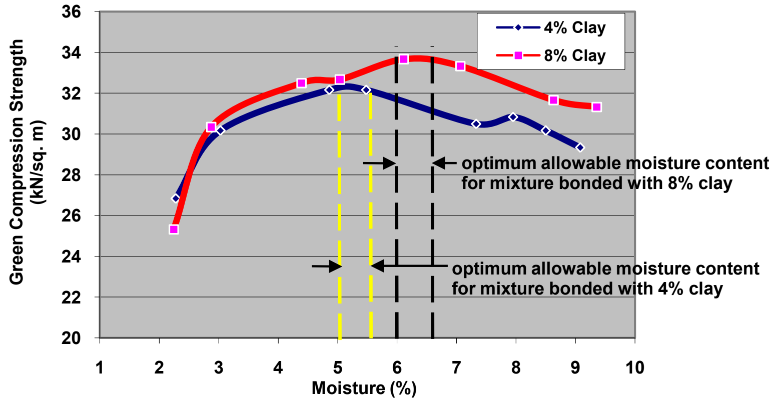

Fig.3: Effect of moisture on green compression strength and optimum allowable moisture content for tailing sand mixture from Batu Gajah bonded with 4%and 8% of clay

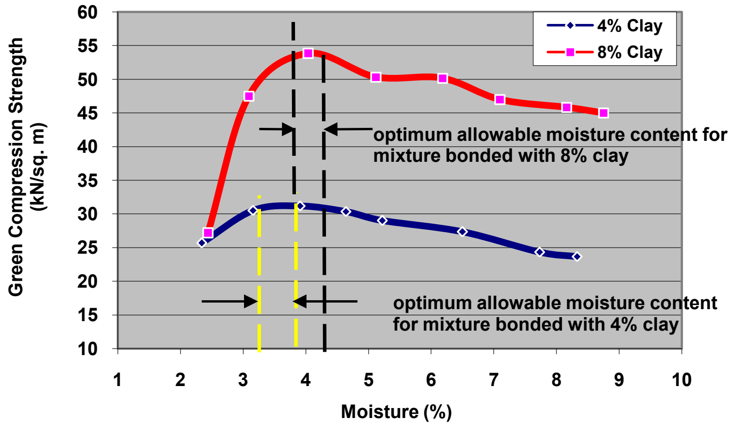

Fig.4: Effect of moisture on green compression strength and optimum allowable moisture content for tailing sand mixture from Taiping bonded with 4% and 8% of clay

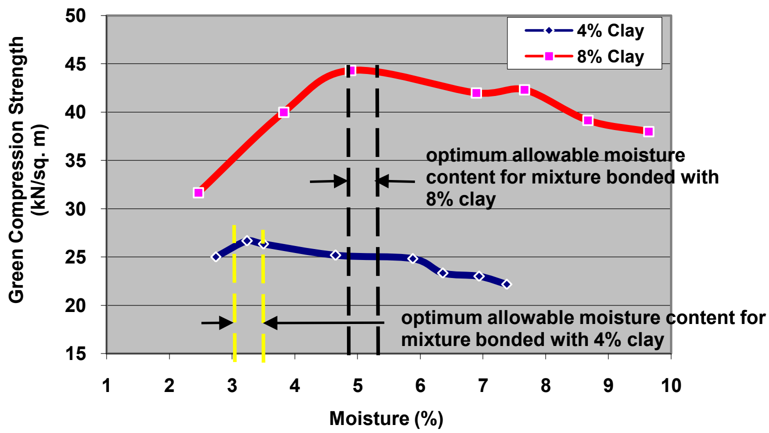

Fig.5: Effect of moisture on green compression strength and optimum allowable moisture content for tailing sand mixture from Tronoh bonded with 4% and 8% of clay

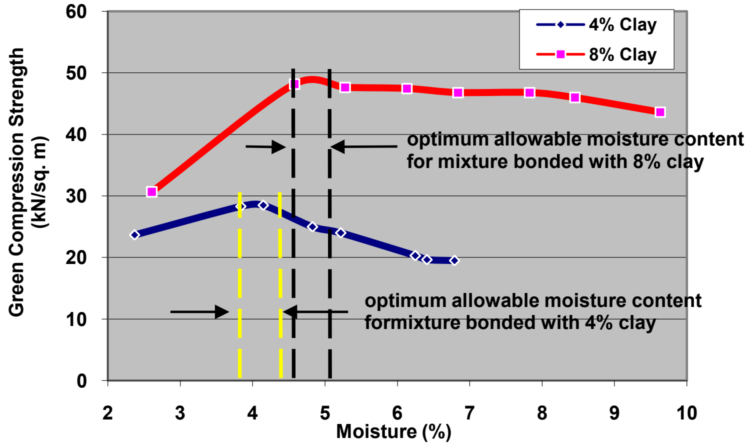

Fig.6: Effect of moisture on green compression strength and optimum allowable moisture content for tailing sand mixture from Tanjung Tualang bonded with 4% and 8% of clay

The result indicates that the optimum allowable moisture content to achieve maximum strength for a mixture bonded with 8% clay is higher than for a mixture bonded with 4% clay, as shown in Fig.3 to Fig.6. The reason is that when a mixture has more clay, more water is required to develop maximum strength. The optimum allowable moisture content for mixture bonded with 4% clay is 3.0-5.5% moisture and for samples bonded with 8% clay it is 3.75-6.5% moisture. These results are within the requirement for foundry sand, where moisture content is in the range of 1.5% to 8% to develop green compression strength.

CONCLUSION

The results indicate the influence of moisture on green compression strength for tailing sands bonded with 4% and 8% bentonite clay. The mixture bonded with 8% clay was found to have higher green compression strength and needed more water to achieve maximum green compression strength compared to a mixture bonded with 4% clay. The optimum allowable moisture content for a mixture bonded with 4% clay is 3-5.5% and for a mixture bonded with 8% clay is 3.75-6.5% moisture, and this is acceptable. Too little or too much water will have an effect on the strength of moulding sand as well as on permeability. Therefore, a test on permeability is necessary to determine the working range and the potential for tailing sand as aggregates for making green sand casting moulds.

REFERENCES

Beeley, P. (2001). The moulding material. *Foundry Technology*. 2nd Ed. (p.202-205). Elsevier Ltd.

Brown, J. R. (2000). Sand and Green Sand. *Foseco Ferrous Foundryman's Handbook*. 11th Ed. (p.152-153). Elsevier Ltd.

Foundry Sand Testing Equipment Operating Instructions. Ridsdale & Co. Ltd.

Google Earth, (2010). *Google Map*. Retrieved on July 2010 from http://maps.google.com.my. Accessed in July 2010

Griffiths, J. (1990). Minerals in Foundry Casting, Investment in The Future. *Industrial Minerals* (p. 39-51). London.

Heine, R. W., Loper, C. R. Jr., & Rosenthal, P. C. (1967). Moulding Sands. *Principle of Metal Casting* (p. 86-89). New York: McGraw-Hill Book Company.

Loto, C. A. (1990). Effect Of Cassava Flour And Coal Dust Additions On The Mechanical Properties Of Synthetic Moulding Sand. *Journal of Applied Clay Science* (p. 249-263). Elsevier Science Publisher B. V., Amsterdam.

Mackay, IMC., & Schnellmann. (2000). Final Report Of Mineral Processing Consultancy Silica Sand. (p. 6-12). *International Mining Consultants Limited*. Kuala Lumpur.

Olasupo O. A., Omotoyinbo, J. A. (2009). Moulding Properties of A Nigerian Silica–Clay Mixture for Foundry Use. *Journal of Applied Clay Science* (p. 244-247). Elsevier Science Publisher B.V., Amsterdam.

Webster, P. D. (1980). Sands and Binders. *Fundamentals of Foundry Technology* (p.116). Surrey: Portcullis Press.