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The Variation of Compressive Strength of Silica Sand with Different Types of Binders

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Abstract: **Metals are cast into different shapes by pouring molten metal into mould cavities and removing the mould material after the metal has solidified as it cools. The mould material commonly used is sand with necessary amount of binders, additives and moisture. Different types of binders will affect characteristics like strength of mould, permeability and refractoriness. This paper elaborates the work of trying various binders with respect to compressive strength as it affects the ability of the mould to take the load of flowing molten metal and the solidified cast.Silica sand is mixed with different binders. A standard specimen is prepared for each and their compressive strength is tested with the help of universal sand testing machine. The results of these tests have been discussed in the paper.**

Keywords:- Casting, binder, green sand, universal sand testing machine, ramming machine, compressive strength.

I.INTRODUCTION

With a constant use of foundry in manufacturing process, it becomes highly necessary to use the most optimal products to get the best results. The most used combination in green sand moulding is Silica sand + moisture + binders + additives. The use of binder affects the properties of the mould the most as it produces the cohesion to bind the sand particles imparting strength to the sand. When the molten metal is poured into the sand mould, it is being subjected to various types of forces: tensile, compressive and shear. The reason to concentrate mainly on compressive strength is because the stability of cast is high if the compressive strength of the mould is high. The question about which binder will give the highest value of compressive strength made us to perform the tests regarding it.

India is known as the country of industries and the initial step for any of these industries is foundry[1]. Foundry is the most used manufacturing process to produce intricate parts with low cost compared to other manufacturing process, majorly during mould preparation using green sand clay[3]. Binders are the materials used to exhibit their binding properties in sand moulding, commonly used binders used in industries are clay, bentonite, sodium silicate etc. Metal casting is one of the earliest metal shaping method known to human kind. As time passed on there is drastic change in casting the metal, by using more waste products[4]. The binders have certain properties like binding the sand particles of the mould as soon as possible. The harden the mould in a very less time. [5]

II. LITERATURE SURVEY

Aman Singh , Jinendra Singh Chauhan , Pushpendra Kumar Jain (2018) [1] noted that fly ash from thermal and graphite industries are very effective for dry sand molding.They compared the structure of ash and river sand and determined that the permeability and compressibility results are good.

H Srividya Kulkarni , Srivishnu Bharadwaj , Sricharan sudarshan S , Akshay S and Ghaleppa (2018) [2] in their experimental study show that fly ash of type F can replace shell sand by 18% by weight and, fly ash of class C can replace shell sand to 15% by weight without compromising on quality of the casting.

Anca Duta,Cristina Cazan,Mihaela Cosnita (2011) [3] researched about fly ash as a reinforcement agent in developing composites based on recycled rubber and plastics.It shows that using a low amount of fly ash in composites increases the compression by almost three times.

P. Munusamy,R. Balaji,C. Sivakandhan (2017) [4] in their experimental analysis show that the compression strength of the green sand with fly ash increases up to 14 % and for the clay it increases with the increase in the addition of clay,also aluminium casting components of moderate surface finish are obtained.

P. Karunakaran, C. Jegadheesan, P. Dhanapal, and P. Sengottuvel (2014) [5] found out that several physical properties of sugar industry fly ash and molding sand were similar,their study revealed that 24% fly ash addition to molding sand produced satisfactory surface finish of castings.

Warid Wazein Ahmed Zailaini, Mohd Mustafa Al Bakri Abdullah, Mohd Remy Rozainy Mohd Arif Zainol, Rafiza Abd. Razak, and Muhammad Faheem Mohd Tahir (2017) [6] researched strength of fly ash based geopolymer mortar. It showed that fly ash based geopolymer mortar with 0.5 ratio has a very high strength.It showed observations to prove good binding between sand and geopolymer binder.

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Professor Jerry Sobczak, Mr. Robert M purgert, Balinski andrzej,Darlak Pawel, Stole Maciej, Dr. Natalie Sobszak(2002) [7] have prepared a report on use of fly ash as an aggregate for foundry sand mold and core production. This shows that fly ashes when added upto 20% gives castings of satisfactory quality.

Dr S L Patil, J N Kale,S suman(2012) [8] researched on compressive strength of fly ash concrete.it showed that workability of cement concrete mix increased from 25mm for 0% fly ash to 120mm for 25% fly ash. This research shows that cement having high proportions of fly ash can be near to properties of pure concrete.

III. METHODOLOGY

Objective :To test different types of binders and obtain the binder that gives the maximum compressive strength.

- The different binders used for the test are-
  - Cement
  - Clay
  - Bentonite
  - All purpose flour
  - Furnace ash

Step 1 - The required amount of silica sand, moisture and the binder are taken and mixed properly.

Step 2 - 150 grams of the mixture is taken into the mixing jar.

Step 3 - The mixing jar is placed below the ramming machine and rammed properly (5 times) to get the required shape of the specimen.

Step 4 - The specimen is placed between the compressive shackles of the universal sand testing machine.

Step 5 - The hand wheel is rotated till the specimen gets destroyed and the compressive strength values are noted.

VI. EXPERIMENTAL RESULTS

A. Sand+ moisture+ cement – The required amount of sand is mixed with a required percentage of cement and moisture. The mixture is rammed and then tested. The following are the results obtained. The maximum compressive strength obtained is 260 g/cm^3. The variation of the percentage of binder and moisture gives us different results.

Sand (grams)	Moisture (%)	Moisture (ml)	Cement (%)	Cement (grams)	Compressive strength (g/cm^3)
168	6	12	10	20	1.8 x 100 = 180
158	6	12	15	30	2.2 x 100 = 220
148	6	12	20	40	2.4 x 100= 240
164	8	16	10	20	2.2 x 100 = 220
154	8	16	15	30	2.4 x 100 = 240
144	8	16	20	40	2.6 x 100 = 260

Table 4.1: Sand + moisture + cement

1) **Graph:**Variation of compressive strength of sand with cement as a binder with 6% moisture (as shown in blue line) and 8% moisture (as shown in orange line).

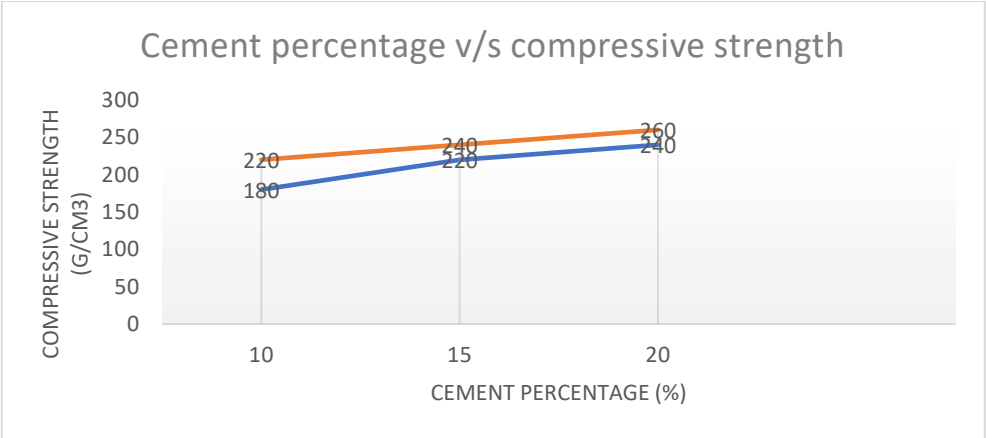

Figure 4.1 Graph between cement percentage and compressive strength

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B. Sand + moisture + furnace ash - The required amount of sand is mixed with a required percentage of ash and moisture. The mixture is rammed and then tested. The following are the results obtained. The maximum compressive strength obtained is 720 g/cm^3. The variation of the percentage of binder and moisture gives us different results.

Sand (grams)	Moisture (%)	Moisture (ml)	Ash (%)	Ash(grams)	Compressive strength (g/cm^3)
168	6	12	10	20	3.8 x 100=380
158	6	12	15	30	4.4 x 100=440
148	6	12	20	40	7.2 x 100=720
164	8	16	10	20	2.8 x 100= 280
154	8	16	15	30	4 x100 = 400
144	8	16	20	40	6 x 100 = 600

Table 4.2: Sand + Moisture + furnace ash

1) Graph: Variation of compressive strength of sand with ash as a binder with 6% moisture (as shown in blue line) and 8% moisture (as shown in orange line)

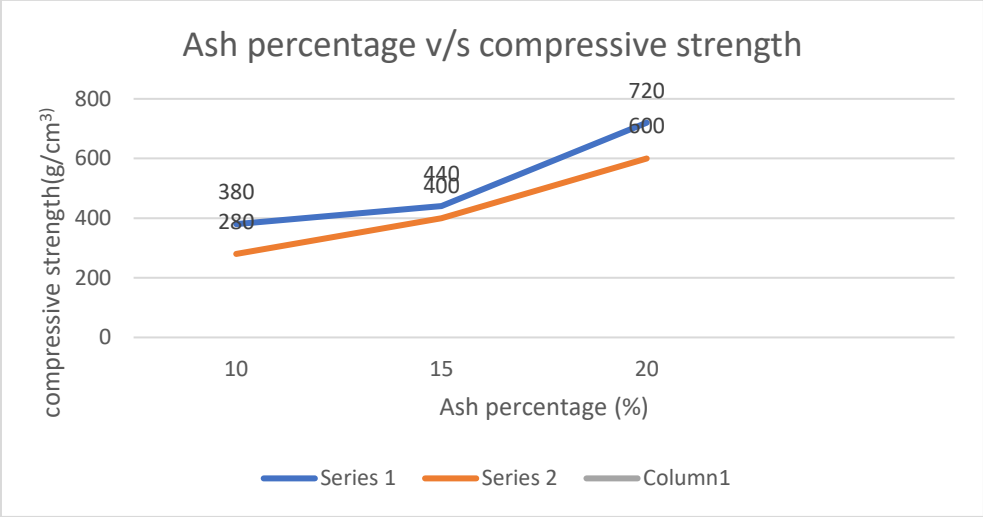

Figure 4.2. Graph between ash percentage and compressive strength

C. Sand + moisture + all purpose flour - The required amount of sand is mixed with a required percentage of all purpose flour and moisture. The mixture is rammed and then tested. The following are the results obtained. The maximum compressive strength obtained is 460 g/cm^3. The variation of the percentage of binder and moisture gives us different results.

Sand (grams)	Moisture (%)	Moisture(ml)	Maida(%)	Maida (grams)	Compressive strength (g/cm^3)
168	6	12	10	20	3 x 100= 300
158	6	12	15	30	3.6 x 100=360
148	6	12	20	40	4.6 x 100 = 460
164	8	16	10	20	3 x100 = 300
154	8	16	15	30	4.2 x 100= 420
144	8	16	20	40	4.4 x 100 = 440

Table 4.3 Sand + Moisture + All purpose flour

1)Graph : The variation of sand with all purpose flour as a binder with 6% moisture (as shown in blue line) and 8% moisture (as shown in orange line).

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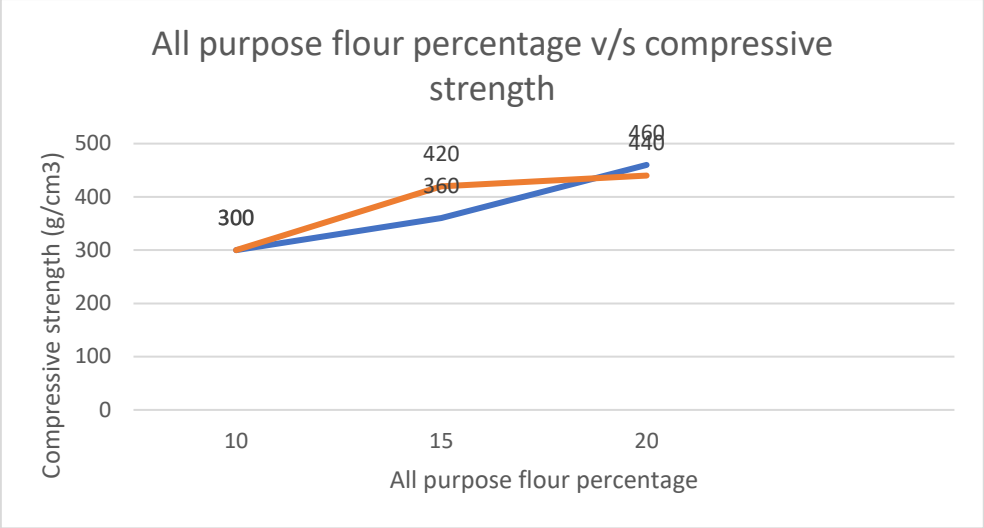

Figure 4.3. Graph between all purpose flour percentage and compressive strength

D. Sand+ moisture+ bentonite : The required amount of sand is mixed with a required percentage of bentonite and moisture. The mixture is rammed and then tested. The following are the results obtained. The maximum compressive strength obtained is 260 g/cm^3. The variation of the percentage of binder and moisture gives us different results.

Sand (grams)	Moisture (%)	Moisture(ml)	Bentonite(%)	Bentonite(grams)	Compressive strength (g/cm^3)
168	6	12	10	20	1.4 x 100=140
158	6	12	15	30	1.8 x 100=180
148	6	12	20	40	2.4 x 100=240
164	8	16	10	20	2.4 x 100=240
154	8	16	15	30	2.6x 100=260
144	8	16	20	40	2.4 x 100=240

Table 4.4: Sand + Moisture + Bentonite

1)Graph: The variation of compressive strength of sand with bentonite as a binder with 6% moisture (as shown in blue line) and 8% moisture (as shown in orange line).

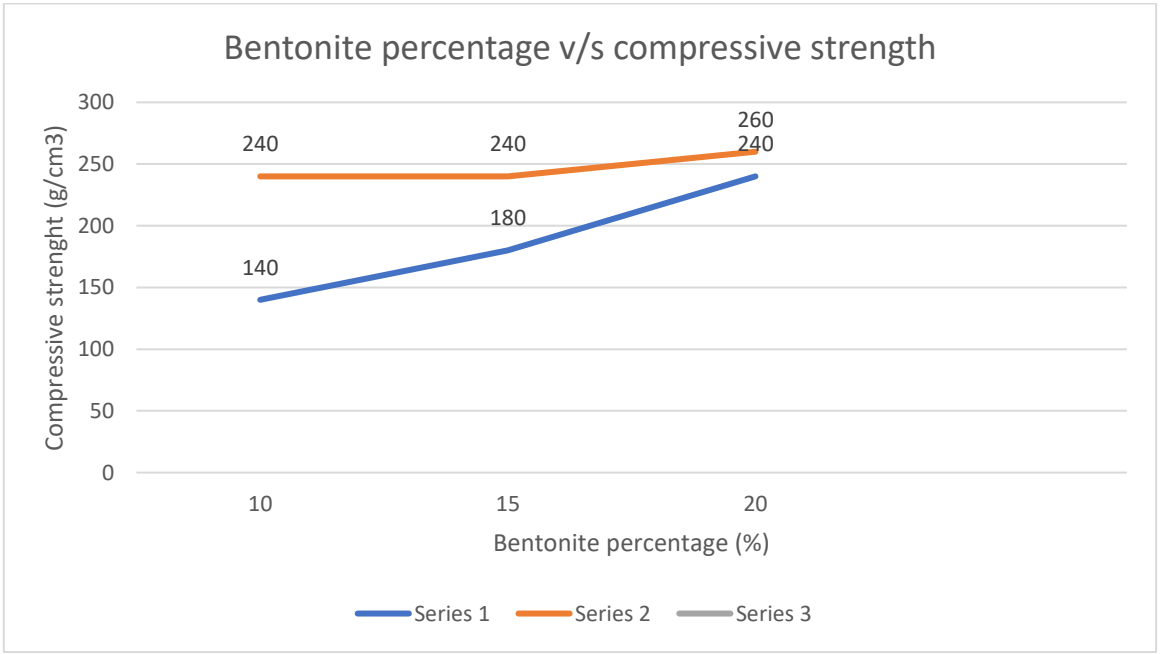

Figure 4.4. Graph between Bentonite percentage and compressive strength

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E .Sand + moisture + clay - The required amount of sand is mixed with a required percentage of clay and moisture. The mixture is rammed and then tested. The following are the results obtained. The maximum compressive strength obtained is 560 g/cm^3. The variation of the percentage of binder and moisture gives us different results.

Sand (grams)	Moisture(%)	Moisture(ml)	Clay (%)	Clay(grams)	Compressive strength (g/cm^3)
168	6	12	10	20	2 x 100= 200
158	6	12	15	30	5.4 x 100=540
148	6	12	20	40	5.6 x100 = 560
164	8	16	10	20	1.8 x100 = 180
154	8	16	15	30	4.4 x100 = 440
144	8	16	20	40	5 x 100 = 500

Table 4.5: Sand + moisture + clay

1)Graph The graph shows the variation of compressive strength of sand with clay as the binder with 6% and 8% moisture-

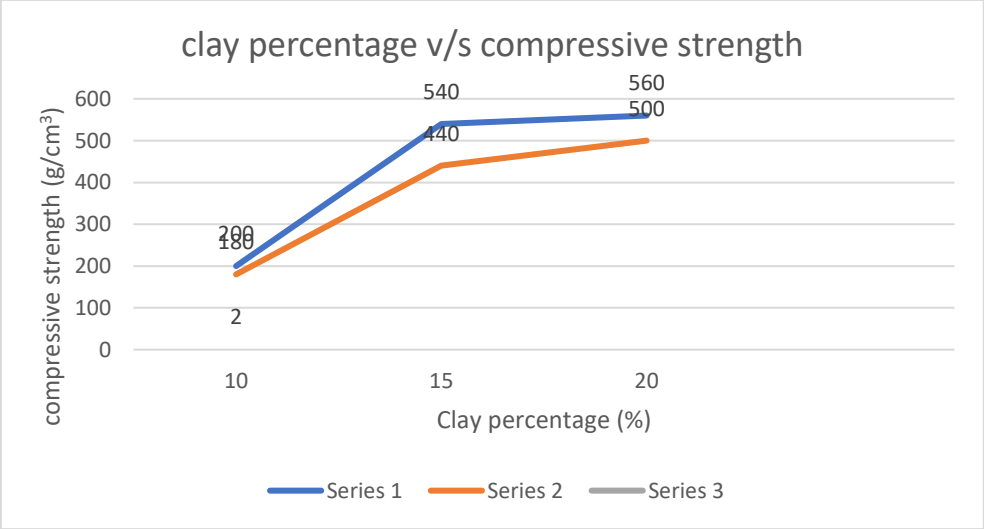

Figure 4.5. Graph between clay percentage and compressive strength

V. APPLICATIONS

Foundry practice is a major part of manufacturing from the very beginning of the industry. Sand moulds are a major part of the casting process. With the concepts and conclusions of this paper we can select the best suited binder for the preparation of sand moulds.

VI.CONCLUSION AND SCOPE FOR FUTURE STUDIES

analysis of different parameters like permeability, shear strength and refractoriness which also are also very important properties of moulding sand.

The tests of sand with different types of binders was conducted and the highest compressive strength value was for the combination of sand weighing 148 grams with 12 ml of moisture and 40 grams of Furnace Ash.

Therefore, we can conclude that Furnace Ash has good compressive strength.

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