The effect of parameters on physical and strength properties of composites with low cement castable

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Abstract
Ceramic matrix composites are going to be used extensively compared to metal matrix composites. The reinforcement might be a metal. In this study low cement castable was used as the matrix and steel balls with steel needles were used as reinforcement. Optical metallography, X ray diffraction, scanning electron microscopy and spectrography were used to investigate elements and phases. Bulk density, apparent porosity and water absorption were measured. Results show that a castable composed of Bauxite, refractory cement, with suitable q=0.22 in Andreasen Equation for grain size distribution with 20% steel balls and 2% steel needles yields the best performance. The effect of 20 wt% of 5 and 1 mm steel balls on physical and mechanical properties showed that smaller size provides better distribution and higher strength.

1 Introduction
It is nearly a hundred years that refractories are categorized in different group and uses in many industries. The refratories shapes are divided in two group, shaped refractories and shapeless refractories usually are produced in refractories brick and have different shape for the different part of the furnaces [1]. Using refractories brick arises some problem such as long time for installation and removes of refractories and weak bond between the bricks which case using monolithic refractories as a lining and refractories. Monolithic refractories are categorized on the application of them and one of the most important of monolithic refractories is castable refractory [2-3].
Low cement and very low cement castable refractories development was an important step in monolithic refractories production. New castable refractories have longer life times, easy and faster installation with lower price for user [4-5].

2 Materials and testing methods
2.1 preparation of sample
Primary materials were included of chinese bauxite with the size of 0-1mm, 1-3mm and 3-5mm as a main body of the refractories.

Fonodo cement is a hydrolic bond with high alumina. This cement has a high refractories properties and high strength with high purity. This cement is excellent for using as refractories. Micro silica with 97% purity and tri poli phosphate nitriun as a flux were used.
To prepare the castable, firstly water added to bauxite and stired, then refractory cement and microsilica and tri poli phosphate natriun added and stired for 5 mins. The product was pured to steel mold with the size of 50*50*50 mm.

2.2 Indication of compression
One of the methods which are using for compression is Andreasen distribution:

$$q = 100\left(\frac{d}{D}\right)^n \quad (1)$$

In this equation q is percent of particles smaller than d and D is the size of the largest particles in mixture. The n parameter is an experimental amount which is depend on the mixture and usually is between 0.2 and 1.5 to produce the best compression [6]. The important of n is to identify the partial amount of small particle in the mixture. For example if q=0.3 and diameter of the largest particle in mixture is D=3 mm and the percent of the particle smaller than 75 mm is 32.

$T_1 \rightarrow n=0.2$ $T_2 \rightarrow n=0.22$
$T_3 \rightarrow n=0.24$ $T_4 \rightarrow n=0.26$
$T_5 \rightarrow n=0.28$ $T_6 \rightarrow n=0.3$

2.3 Physical and strength properties of the castable
Bulk density of the samples (BD) and apparent porosity (%AP) calculated using ASTM C0020-00R0S Standard [7].

$$B.D = \frac{w_1}{w_3}$$

$$\%AP : \frac{w_2 - w_1}{w_3} \quad (2)$$

W1: weight of dried samples
W2: weight of moisture samples
W3: weight of samples in water

Cold presser strength of the samples using Tony technic press with 350 ton force was measured after 20 days under ASTM CO133 Standard.

3. Results and discussion
3.1 Compaction determination
Considering Andreasen equation and different percent of cement as shown in table 1, the strength of samples was investigated. It was defined that the five percent of cement, distribution factor (n) of 0.22 give the best compaction and move strength, (Fig1).

T6 n=0.3	T5 n=0.28	T4 n=0.26	T3 n=0.24	T2 n=0.22	T1 n=0.2	Sample	
14/20	13/32	12/43	11/53	10/62	9.71	bauxite(3-5)	Percent
24/09	22/95	21/76	20/51	19/19	17.81	bauxite(1-3)	
57/66	59/68	61/76	63/91	66.14	68.44	bauxite(0-1)	
2	2	2	2	2	2	Micro silica	
0.02	0.02	0.02	0.02	0.02	0.02	tri poli phosphate natriun	
5	5	5	5	5	5	cement	

Table1. Composition of castable

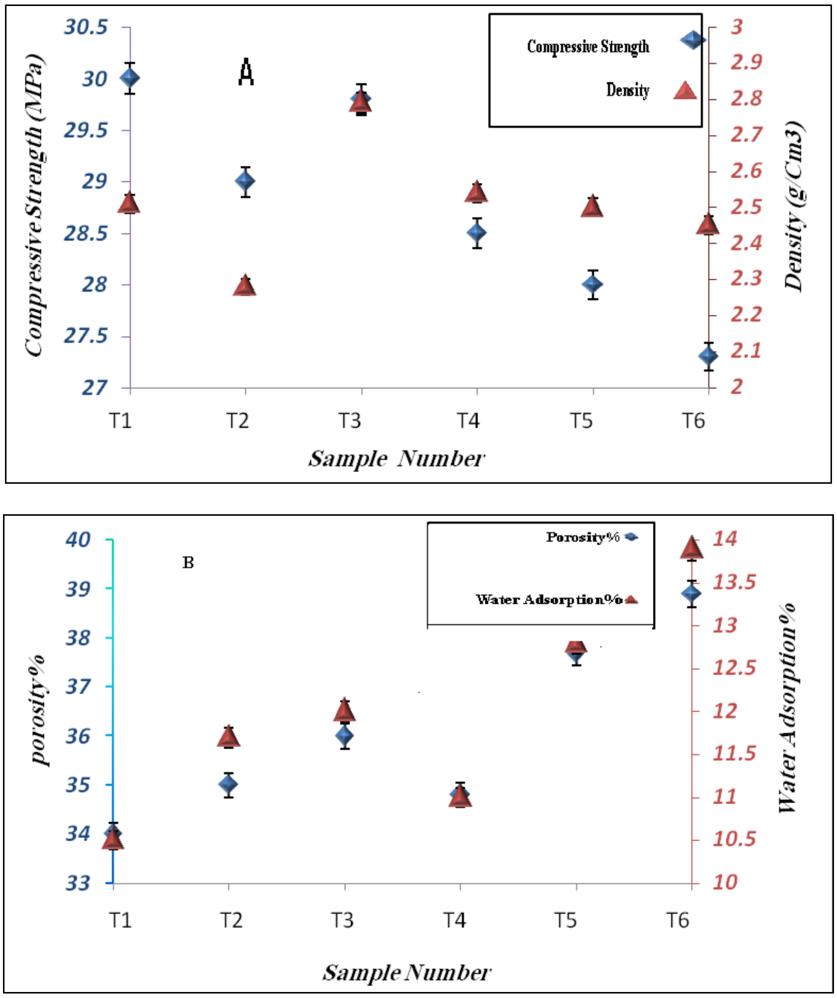

Figure1. **A**) Compressive Strength, Density. **B**) Water Adsorption, Porosity

3.2 Physical and strength of the castable refractories

Change in physical and strength of the castable refractories with five percent cement is shown in Fig 2. As can be seen increase in density, the strength is increased.

Can be seen increase in porosity case increase in strength. It may be explain by needle shapes create in the porosities. Increase in porosity can case reduce in strength but by form the needle shape phase in the porosity, they can increase the strength of the samples. These needle shape phase is shown in figure 2.

Figure2. Needle shape phase in the pure

The EDX analysis of the needle shape phase is shown in figure 3. It can be concluded that with increase in porosity the chance of creation of needle shape phase increase, and case increase in strength [8].

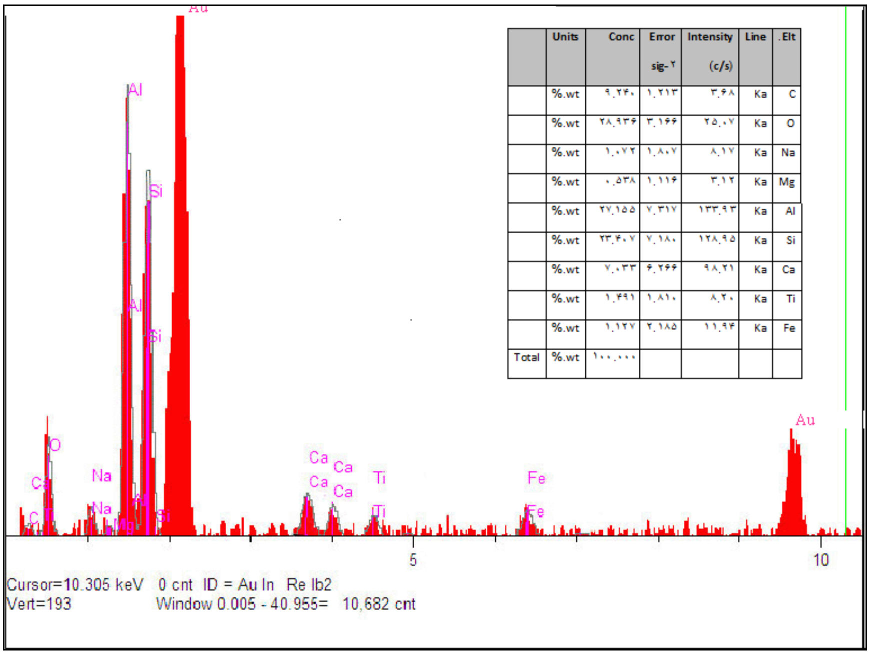

Figure3. The EDX analysis of the needle shape phase

The phases in the samples were identified using X-Ray diffraction method. The X-ray spectra are shown in figure 3. As shown in fig 4 the present phases are Al_2O_3, $2SiO_2.3Al_2O_3$, $3CaO.Al_2O_3$ and $2CaO.SiO_2$.

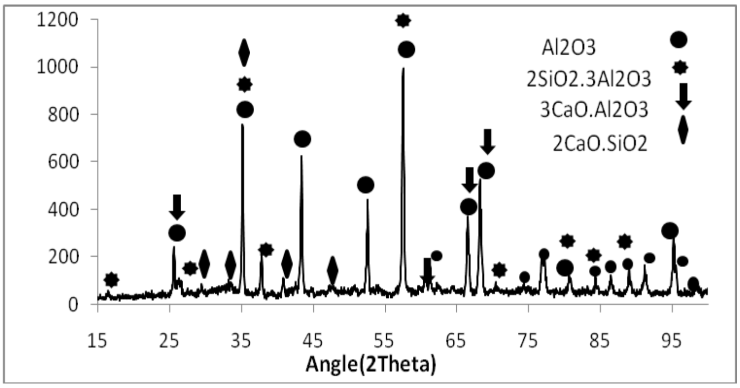

Figure 4. XRD Analysis of castable

3.3 Density adjustment

To increase the density 20% steel shot added to castable refractories with the size of 1 mm, that is show in figure 5. If the amount of steel shot increases from 20% reduces the formability of the castable [9-10]. The figure 6 shows the strength of the samples with the percent of steel shot.

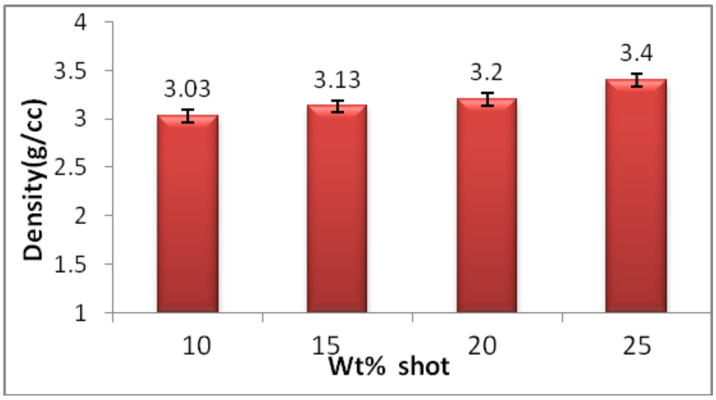

Figure5. Effective of amount of steel shot from castable

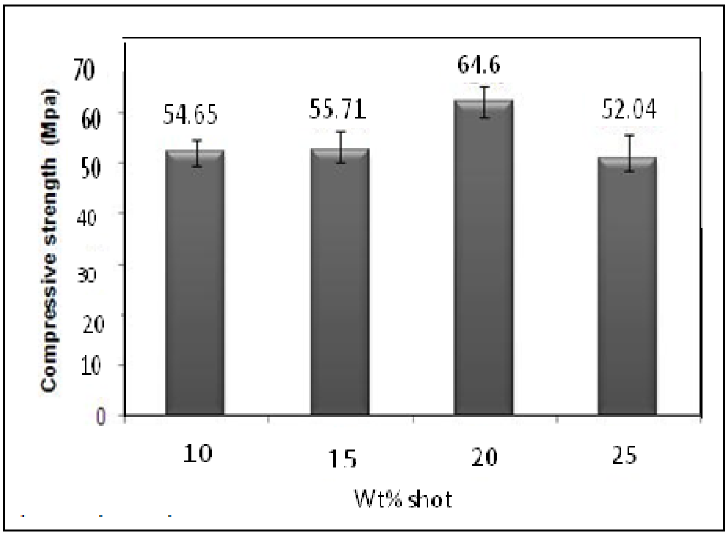

Figure6. Strength of the samples with the percent of steel shot

The strength of the samples with 20% steel shot has the highest amount which is 64.6 MPa. Microstructure of the samples after preparation is shown in figure 7. The steel shot and the ceramic matrix clearly can be recognized in this figure.

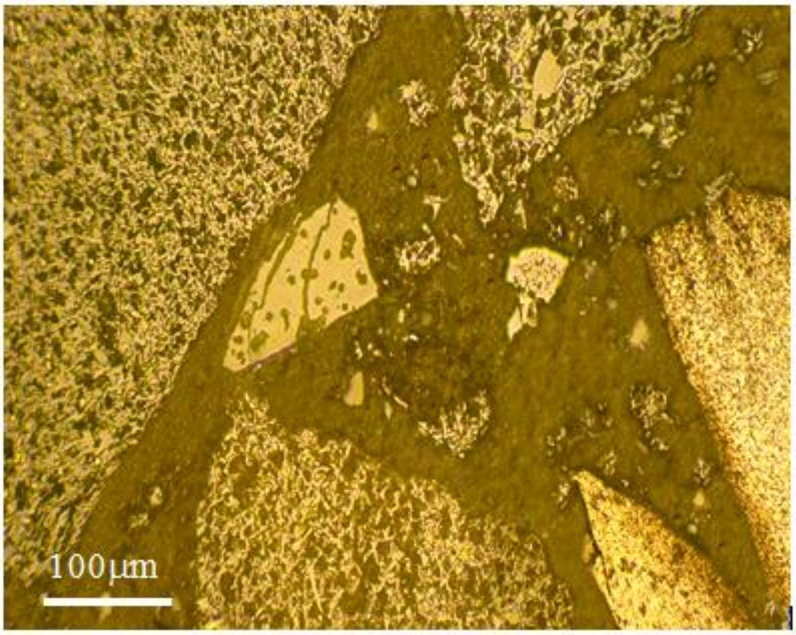

Figure 7. Microstructure of the The steel shot and the ceramic matrix

4. conclusion

1-Chinese bauxite with 3 particle sizes of 0-1mm, 1-3mm, 3-5mm and alumina refractory cement can be used for a low ement astable.
2-One of the effective factor in strength in cement of castable is particle distribution. The best strength could be obtained with n=0.22 in Andreazen equation and 5% cement.
3-By the increase of strength, strength of castable is increased. This can be related to development of needle shape srystals inside the pures.
4-Amount of 20% steel balls of 1mm size can give the best strength and distribution.

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