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Abstract- This paper reveals comparative experimental investigation of brick made up of desert sand and metakaoline with brick made up of fly ash and Portland cement. Desert sand and metakaoline is added in various proportions to prepare the brick, the weight of desert sand and metakaoline is in percentage of weight of brick. Both desert sand brick and fly ash brick are made by applying compressive force on raw material by hydraulic compression machine. To examine physical properties of desert sand, sieve analysis and Pycnometer test are performed, for properties of cement and metakaoline, Fineness, Standard consistency, Initial and final setting time, Soundness, Compressive strength, for Crushed Stone. Moreover, physical properties of desert sand brick are examined for dimension tolerance and density of desert sand brick. The result showed sustainable improvement in the hardness of desert sand brick over fly ash brick. The present study shows improvement in the characteristics of brick made up of desert sand and metakaoline in comparison with fly ash brick.

Key words- Desert Sand Brick, Metakaoline, Compressive Strength, Fly Ash Brick

1. INTRODUCTION

The Great Indian Desert known as Thar Desert in the west of Rajasthan covers 2,00,000 sq km area (Roy, 1978). This is 61.3% of Rajasthan state area and 6.3% of country area (Ameta, 2013). This soil is non-cohesive in nature and hence soil is susceptible to easy erosion by rain and wind (Al-Khanbashi et al., 2000). also, desert sand is loose and susceptible to collapse upon wetting due to rain water (Elsharief et al., 1999). Desert sand is not appropriate to use in constructions without addition of binders. Hence, desert sand is mixed with binders such as cement, natural clays, bentonite, cement-by-pass dust, and incinerator ash, to construct roads, water barrier structures (Mohamedzein et al., 2003). and metakaoline (raw material for Alkali activated cements (Palomo, et al., 1999; Zhang et al., 2010a, 2010b).

Alkali activated cements (AAC) are inorganic polymers (IP) which are produced from activation of solid alumino-silicate material. This result in a new class ofthree-dimensionallynetworkofalkalialumino-silicates(Ingles,1970;PatfoortandWastiels, 1989; Abdullah, 2012; Jaarsveld et al., 2002; Rowels and O'Connor, 2003; Duxson, et al., 2007; Slaty et al., 2013; Lemougna et al., 2014). These are alternative materials to Portland cement as they have a comparable hardness, chemical stability, and compressive strength, but they required less energy for manufacturing. and meanwhile alternative binders emits less greenhouse gases during production (Patfoort and Wastiels, 1989; Steveson and Sagoe-Crentsil, 2005, Xu and Deventer, 2000). Earlier journals observed the durability characteristics was more for geopolymer and other AAC obtained from different raw materials like metakaoline (Palomo, et al., 1999; Zhang et al., 2010a, 2010b). Metakaoline is alternate binding material to cement used for various mixtures in different proportions

(Peigang, et al. 2016). This means Metakaoline can bring positive effect not only on early strength of 28-days, but also on durability especially frost resistance of structure (Bilek et al. 2013). The results indicated that these materials have a good resistance against erosion and durability.

The properties of conventional brick observed from Indian standard code shows that the standard size of brick is 190 x 90 x 90 mm and the maximum tolerances are ±5 mm for length, ±0.5 mm for width, and ±2 mm for height. The weight of the burnt convectional bricks should be nearly 3200 gm.

Till date, it is observed that there is a grey area to work on desert sand for making bricks with the help of desert sand and metakaoline as binder. The purpose of this research is to investigate the strength of desert sand brick in comparison with fly ash brick.

2. EXPERIMENTAL PROGRAM

The prime objective of this work is to develop new brick based on desert sand and metakaoline useful to condense environmental pollution.

The different steps of this experimental investigation are as follows:

- Study the physical and chemical properties of desert sand and other materials.
- Preparation of brick made up of desert sand and metakaoline and the brick made up of fly ash and Portland cement.
- Study the various geometrical properties such as dimension and density of desert sand brick which is made up of desert sand and metakaoline in comparison brick which is made up of fly ash and cement.

For this, many experimental tests were carried out on prototypes of the new designed brick.

3. MATERIAL

3.1 DESERT SAND

Desert sand is easily available at Thar Desert in west Rajasthan which cover nearly 61.3% of area of Rajasthan state (Ameta, 2013 Roy, 1978). Desert Sand is light yellowish brown colour cohesion less soil with loose soil structure and the clay content in sub soil region varies from 4 to 8% and pH ranges from 8.0 to 8.5 (Roy, 1978). The chemical composition of Desert sand is shown in Table 1 and has large proportion of silicon dioxide (SiO2 ≈ 78%) and negligible proportion of gypsum which proves that the desert sand is cohesion less soil (O. Benjeddou et.al.2020).

Table 1: Composition of desert sand

Component	Al_2O_3	CaO	Fe_2O_3	K_2O	MgO	SO_3	TiO_2	PAF	SiO_2
Percentage	1.15	5.69	0.47	0.81	0.10	9.29	0.18	4.58	78.15

The test carried out on the desert sand is the particle size distribution according to IS :2720 (Part III & C-1) -1930. On the basis of Gradation curve, which shows that desert sand, is very fine soil. From the curve, the value of coefficient of curvature (Cc), and coefficient of uniformity (Cu) is determining which shows $Cc < 1$ and $Cu < 1.5$ which are well within the limits mentioned in Indian Standardcode.

Fig. 1: Sieve analyses test on desert sand

From particle size analysis fineness modulus is also being calculated as per IS:2720 (Part III/& C-1)-1930 which is 0.24 and indicate that the soil is too fine and all particles are ofequal size. To determine the specific gravity of desert sand by Pycnometer testmentioned in IS:2720 (Part III & C-1)-1930 is as follows and the average specific gravity of desert sand varies from 2.53 and water absorption0.71%.

Fig. 2: Pycnometer test on desert sand.

3.2 CRUSHED STONE

This is fine crushed stone which is obtained from crusher after crushing large size stones into small. These are typically of various sizes but this context used is 6 mm size. This fine stone is mixed with desert sand which function is same way as that of aggregate in concrete mixture. Specific gravity and water absorption of aggregate test is conducted to find out the feasibility of aggregate used in manufacturing of the desert sand brick.The procedure of testing aggregate for water absorption is followed as per IS: 2386 PART 3-1963 and that of specific gravity is per IS: 2386 PART 4-1963. The value of above test is well within the mentioned range, water absorption is 2.64% and specific gravity is 2.67.

3.3 CEMENT

The cement utilizes in manufacturing of desert sand brick is of 53 grades, each bag of 50kg by weight. All the properties which standardize Cement as per the IS code are carried out on them. The test result of cement as per IS code are asfollows.

Table 2: Properties of Cement

Sr. no.	Test performed	IS code	Result
1	Fineness of cement	IS: 4031 PART 1-1996	3.5 %
2	Standard consistency	IS: 4031 PART 4-1988	28 %
3	Initial and final setting time	IS: 4031 PART 5-1988	27 min and 585 min
4	Soundness of cement	IS: 4031 PART 3-1988	9.5 mm
5	Compressive strength of cement	IS: 4031 PART 6-1988	52.3N/mm^2

The cement used in this experimental study is a locally available. The results of the tests showed that the fineness and consistency of cement is 3.5% and 28% respectively. When cement id tested for initial and final setting time, it observes to be 27 minute and 585 minutes

respectively. The most important parameter which tested is compressive strength and average of all result is found out to be 52.3 N/mm^2.

3.4 FLYASH

Coal of Indian origin belongs to sub-bituminous, bituminous or lignite quality. It has following values: moisture content upto (Gupta M, et. al. 2000; Chandra A, et. al. 2004) 1.9-8.3 and the proportion of various elements are C, 39.3-60.2; H, 2.8-4.2; S, 0.3-0.5; N, 0.9-1.9; and O, 4.9-9.3%. Usually, the particle of Fly Ash particles light weight (density 1.97-2.89 g/cc), spherical (specific surface area, 4000-10,000 cm2/g; diameter, 1-150 m), very fine, refractory and have binding ability (Ganesh Babu, et. al., 2001). The colour of the Fly ash is grey to blackish grey which depends on combustion process and type of coal.

The Chemical component (Singh D V, et.al., 1996; Prasad A, et.al., 1999; Kumar P, et. al., 2005) of FA is as follows: SO3, 0.76; MgO, 0.97; alkalies, 1.41; CaO, 1.94; Fe2O3, 6.11; Al2O3, 23.59; SiO2, 59.38; and unburnt S & moisture, 3.74%. The binding property of fly ash is depending on Oxides of silicon, calcium, aluminum and iron, which is decreased by loss of ignition (Jain A K, et.al., 2001).

3.5 METAKAOLINE

Metakaoline is white colour product made from kaolinite clay stone which is calcined in a rotary kiln at 750^{0}C together followed with grinding in fine powder (Pavlina Hajkova, 2018).

Table 3: Properties of Metakaoline

Sr. no.	Test performed	IS code	Result
1	Fineness	IS: 4031 PART 1-1996	1.5 %
2	Standard consistency	IS: 4031 PART 4-1988	37 %
3	Initial and final setting time	IS: 4031 PART 5-1988	36 min and 790 min
4	Soundness	IS: 4031 PART 3-1988	7.0 mm
5	Compressive strength	IS: 4031 PART 6-1988	49.10N/mm^2

The Metakaoline used in this context will be available in building material shops. Various tests are performed on metakaoline and the test result show that the fineness and consistency of metakaoline is 15% and 37% respectively. When it tested under initial setting time the result observed is 36 minute and when tested under final setting time the result observed is 790 minutes. The most important parameter which tested is compressive strength and average of all result is found out to be 49.10N/mm^2.

4.0 PLAN OF PROJECT

4.1 COLLECTION OF MATERIAL

The ingredients of brick such as desert sand, cement, metakaoline, and crushed stone. Desert sand was transported from Great Indian Desert, Jaisalmer, Rajasthan, cement of 53 grade and metakaoline is obtained from local dealer, and crushed stone is obtained from crusher plant near city. After collection of all ingredients, they were transported to Government College of Engineering, Jalgaon at which the testing is being conducted and bricks are casted.

4.2 MATERIALTESTING

This part of experiment will show various test to be performed on collected material. The test conducted on Desert sand were Pycnometer, sieve analysis, water absorption and procedure are followed as per the Indian Standard Code. These tests are useful to examine the properties of

Deseret sand. Specific gravity and water absorption of aggregate are conducted on crushed sand. Some physical and chemical properties of Fly ash are also examined. Fineness, Standard consistency, Initial and final setting time, Soundness, Compressive strength these tests are performed on cement and metakaoline which are binder.

4.3 BATCHING

Batching was the most important step because it was to decide the various percentages of ingredients to be mixed for making bricks.The percentages of ingredients in bricks varied from 5 to 20% for cement and metakaoline and 5 to 20% of crushed stone. The entire ingredients were packed in set of desert sand-crushed stone-metakaoline for manufacturing of desert sand brick and fly ash – crushed stone – cement for manufacturing the fly ash brick as shown in table below. At the time of manufacturing this were used to make brick of each category.

Fly ash, Crushed Stone and Cement [A]

Table 4: Batching of Type-A Brick

Samplenumber	Fly Ash (%)	Crushed Stone (%)	Cement (%)
A1	90	5	5
A2	80	10	10
A3	70	15	15
A4	60	20	20

Desert Sand, Crushed Stone and Metakaoline (B)

Table 5: Batching Of Type-B Brick

Samplenumber	Desert Sand (%)	Crushed Stone (%)	Metakaoline (%)
B1	90	5	5
B2	80	10	10
B3	70	15	15
B4	60	20	20

4.4 PREPARATION OF SPECIMENS

This part of the present experimental investigation consists of preparing various specimens of desert sand – Metakaoline and fly ash – Cement along with Crushed Stone. The composition of different mixtures is presented in Table 4 and 5. It is noted that cuboid specimen shapes were prepared and tested in this work. Cuboid specimens were used to determine the compressive strength and water absorption for final product at age of 7 days as shown in Table 10 and 11. The dimensions of the cuboid specimen are 190 mm × 90 x 90mm. The steps of the used mixing procedure are the following,

1. Dry mixing of Desert Sand, metakaoline and Crushed stone (Fig. 3a).
2. Pouring of water in the mixture.
3. Wet mixing, first, for 30 seconds with slow speed and then for 1 minute with high speed (Fig. 3b);
4. Pouring of the mixture in the cubicmoulds.
5. Applying hydraulic compressive force (fig. no,4)
6. Finally, removal of cuboid specimens.

Fig. 3 a) Dry Mixing of all ingredients b) Wet mixing of all ingredients

4.5 MANUFACTURING OF BRICK

In this process, the wet material was then moved in mould where it was compressed with sufficient amount of pressure to get brick. After the compression, bricks were taken out for drying to acquire strength.

Fig. 4 Applying pressure on material by Hydraulic Compression Machine

4.6 DRYING AND CURING OF BRICK

The process of drying is followed by process of casting of bricks under hydraulic compression machine. The drying must be in shade because it causes loss of water due to evaporation which may causes the brick to crack. The specimens were kept, until the testing time, for shade drying under normal temperature such as 23°C and a relative humidity between 55 and 65%. After getting initial strength to brick curing is done by sprinkling water on surface which prevent the evaporation loss from brick. The process of curing is continued for 7 days. In drying process brick gets sufficient strength, so this step is necessary in the manufacturing of bricks.

4.7 TESTING

Dried and cured desert sand or fly ash bricks were brought to laboratory for testing of compressive strength and water absorption after 7 days. Each set of batch had six numbers of bricks such that three were going to be used for compression testing and remaining three for water absorption test.

4.7.1 GEOMETRICAL PROPERTIES

Here are some of the geometrical properties such as length, width and height of bricks are considered and compared with Fly Ash brick. The size of brick used in construction varies from

country to country and from place to place. In India, the recommended standard size of an ideal brick is 190 x 90 x 90 mm with which mortar joint gives net dimensions of 200 x 100 x 100 mm.

4.7.2 DENSITY OF BRICK

In this process, every specimen whose density has to be measure is weighted. The dimension of each manufactured specimen is found to be 190 x 90 x 90mm. The density of each specimen is measured after 7 days curing process when its mass is stabilized. The results obtained under this test are presented in Table number 9 which gives densities of the specimen of each mixture.

5.0 RESULTS AND DISCUSSION

In the technical terminology, brick is the standard size, shape and weight of building unit. The standard size of brick includes its length, width and height. These geometrical properties are considered for brick which has some different dimensions. This is important due to efficient and easy handling and lying of brick. According to Indian Standards, the brick must have twice width for proper bond and stability of structure. Selection of any material for construction depends on its colour, surface texture, and weight.

5.1 DIMENSION TOLERANCE

As per IS 1725-1982, the standard dimension of brick is 190 x 90 x 90mm and the maximum tolerances are ±5 mm for length, ±0.5 mm for width, and ±2 mm for height. According to the results presented in table number 6 the all values of bricks are well withing the range and allowable.

Table 6: Length of fly ash brick and desert sand brick

Types of Brick	Length in mm	Width in mm	Height in mm
Fly ash brick	193	91	92
Desert sand brick	192	90	91

From above result, it is observed that dimension of Desert sand brick is same as that of burnt bricks which is approximately 190 x 90 x 90 mm. This is beneficial in actual practice since it is easy to handle and transport. Sometimes hollow brick can also be manufactured.

5.2 WEIGHTS OF BRICK

As per IS code 1725-1982 weight of the burnt convectional bricks should be nearly 3200 gm. The following table shows the average weight of desert sand bricks.

Table 7: Weight and density of fly ash brick and desert sand brick

Types ofBrick	Type of brick	Weight in gm	Density gm/cc
Fly Ash + crushed Stone + cement	A1	2089	1.36
	A2	2141	1.39
	A3	2185	1.42
	A4	2322	1.50
Desert sand + crushed Stone + metakaoline	B1	2963	1.93
	B2	3126	2.03
	B3	3291	2.13
	B4	3359	2.18

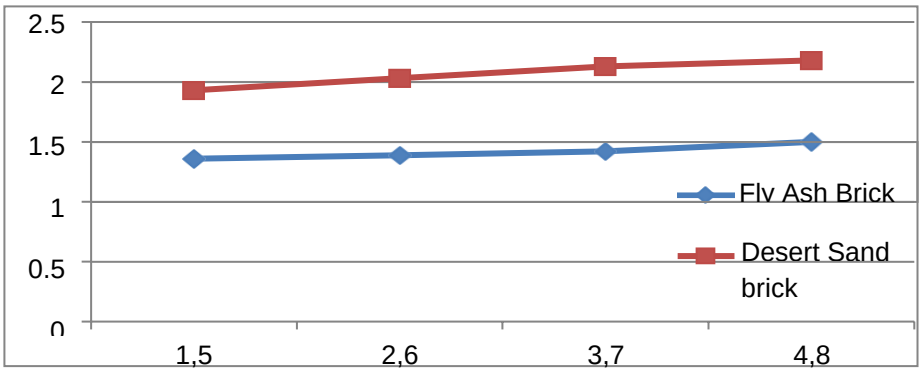

Fig. 5 Density of fly ash brick and desert sand brick

From the above data it is observed that the weight of desert sand (B) bricks is more than that of Fly-Ash bricks (B) due to presence of desert sand in place of fly ash. As the percentage of crushed stone increase the weight of brick which also increases from brick A1 to A4 and B1 to B4. From above the brick which gives optimum strength will be considered as best brick among the tested bricks. As seen from above test, there is no change in the size of both the bricks makes it suitable for the construction works.

6.0 CONCLUSION

The present context was conducted to verify the potential of desert sand. The following conclusion is drawn based on the current investigation:

- From the experimental work, it is observed that, there is no change in shape, size and structure of the bricks after curing period which shows these bricks are versatile for the construction works.
- Brickmade with help of metakaoline as binder shows sufficient increase in density of brick in comparison with brick made up of cement as binder, which improve compressive strength and durability of material.
- The rise in the density of desert sand brick is phenomenally incremented by 45% in comparison with fly ash brick. Rise in density indicates the increase in the hardness of the brick.
- From the above research work it is concluded that the most appropriate percentage of metakaoline in combination of desert sand is 15%.
- Finally, the use of desert sand in building material satisfies the primary criteria of Indian Standard and will gives better results as compared with fly ash brick.

REFERENCES

1) Abdullah, M.M.A.B.; Jamaludin, L.; Hussin, K.; Bnhussain, M.; Ghazali, C.M.R.;Ahmad,M.I. FlyAsh Porous Material using Geopolymerization Process for High Temperature Exposure. Int. J. Mol. Sci. 2012, 13, 4388-4395. DOI: 10.3390/ijms13044388
2) Al-Khanbashi, A., Mohamed, A.M.O., Moet, A. and Hadi, B. (2000) a PhD thesis, “Stabilization of desert sand using water-borne polymers” in Proceedings of the First International Conference on Geotechnical, Geo-environmental Engineering and Management in arid Lands, Al-Ain, United Arab Emirates, pp.143–148.
3) Al-Aghbari M.Y., Mohamedzein Y.E.-A. and Taha R.A. (2009),” Stabilisation of desert sands using cement and cement dust” Ground Improvement 162 Issue GI3, pp. 895–904. DOI: 10.1680/grim.2009.162.3.145.
4) Ameta N. K., Dr. Wayal A. S., Hiranandani P., (2013) “Stabilization of Dune Sand with

Ceramic Tile Waste as Admixture" AJER, Volume-02, Issue-09, pp-133-139.www.ajer.org.

5) Bilek V.,(6/2013) "Development and properties of concretes with ternary binders", Cement WapnoBeton, pp.343-352, ISSN-1425-8129. DOI: 10.4028/www.scientific.net/KEM.629- 630.49

6) Duxson, P., Fernandez-Jimenez, A., Provis, J.L., Lukey, G.C., Palomo, A., Van Deventer, J.S.J., (2007). Geopolymer technology: The role of inorganic polymer technology in the development of 'green concrete' Sci. 42, 2917–2933. DOI: https://doi.org/10.1016/j.cemconres.2007.08.018.

7) Elsharief, A.M., Mohamedzein, Y.E-A. and Hussien, Y. (1999) Geotechnical properties of Qoz soil, In: Proceedings of the Twelfth Regional Conference for Africa on Soil Mechanics and Geotechnical Engineering, Durban, South Africa, pp. 317–320.

8) Ingles, O.G., (1970). Mechanism of clay stabilization with inorganic acids and alkalis. J. Soil Res. 8, 81–95, DOI: https://doi.org/10.1071/SR9700081.

9) Lemougna, P.N., Chinje Melo U.F., Delplancke, M.-P., Rahier, H., (2014). Influence of the chemical and mineralogical composition on the reactivity of volcanic ashes during alkali activation. Ceram. Int. 40 (1 PART A), 811–882. DOI: https://doi.org/10.1016/j.ceramint.2013.06.072.

10) Palomo, A., Blanco-Valera, M.T., Granizo, M.L., Puertas, F., Va'zquez, T., Grutzeck, M.W., (1999). Chemical stability of cementitious materials based on metakaoline. Cem. Concr. Res. 29, 997–1004. DOI: http://dx.doi.org/10.1016/S0008-8846(99)00074-5.

11) Patfoort, G.A., Wastiels, J., (1989). Use of Local Resources in Construction Materials, Vriji Universiteit Brussel, Brussels, Belgium, pp. 12–14.

12) Peigang He, Meirong Wang, ShuaiFu, DechangJia, ShuYan, JingkunYuan, Jiahuan Xu , Pengfei Wang , Yu Zhou, (2016)" Effects of Si/Al ratio on the structure and properties of metakaoline based geopolymer", Ceramics International4214416–14422. DOI: https://doi.org/10.1016/j.ceramint.2016.06.033.

13) Rowels, M., O'Connor, B., (2003). Chemical optimization of the compressive strength of alumino-silicate geopolymer synthesized by sodium silicate activation of metakaolinite. J. Mater. Chem. 13, 1161–1165. DOI: DOI: 10.1039/b212629j.

14) Slaty, F., Khoury, H.,Wastiels, J., Rahier, H., (2013). Characterization of alkali activated kaolinitic clay. Appl. Clay Sci. 75–76, 120–125. DOI: 10.1016/j.clay.2013.02.005.

15) Van Jaarsveld, J.G.S., Van Deventer J.S.J.G., Lukey, C., (2002). The effect of composition and temperature on the properties of fly ash-and kaolinite-based geopolymers. Chem. Eng. J. 89, 63–73. DOI: https://doi.org/10.1016/S1385-8947(02)00025-6.

16) Xu, H., Van Deventer J.S.J., (2000). The geopolymerisation of alumino-silicate minerals. Int. J. Miner. Process. 59, 247–266. DOI: https://doi.org/10.1016/S0301-7516(99)00074-5.

17) Zhang, Z., Yao, X., Zhu, H., (2010a). Potential application of geopolymers as protection coatings for marine concrete: I. Basic properties. Appl. Clay Sci. 49, 1–6. DOI:http://dx.doi.org/10.15446/dyna.v82n194.46352.

18) Zhang, Z., Yao, X., Zhu, H., (2010b). Potential application of geopolymer as protection coatings for marine concrete: II. Microstructure and anticorrosion mechanism. Appl. Clay Sci. 49, 7–12.DOI:10.1016/j.clay.2010.01.014.