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Research paper

Properties of CO_2 sand brick

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Abstract

Brick is the most commonly used building material for construction. The CO_2 absorption in the brick manufacturing process can provide a green environment. Therefore, focus should be now on seeking eco – friendly solutions for greener environment. Thus the paper focused on the Carbon di-oxide sand brick which can be manufactured by using carbon di-oxide gas injected into the air tight mould which contains silica sand with sodium silicate and dipping with epoxy resin as a binding agent which provides 2.5 times higher strength than the normal concrete structure in tensile strength and also it requires less reinforcement in place of concrete walls.

Keywords:*Silica Sand; Environmental Friendly; Recyclable;Carbon Dioxide; Sodium Silicate.*

1. Introduction

Brick is the simplest and most ancient of all building materials. Bricks are one of the widely used construction and building material around the world. In India, the process of brick manufacturing has not changed since many centuries except some minor refinements. There have been very less efforts are made in our country to improve the brick- making process for enhancing the quality of the bricks.

The clay bricks continuous usage in the construction industry has lead to an extensive loss of the fertility of the top soil which has adversely affected the environment and agriculture. The outdated methods of clay brick manufacturing and less skilled labor has resulted in inferior quality of bricks with low compressive strength which are unsuitable for multi storey buildings. The clay bricks add a lot of dead load to the building leads to some of the disadvantages of using this for the construction purpose.

The fly ash bricks are best suited for places like subtropical areas, where the climate is warm as the bricks does not absorb heat and are not helpful for cold seasons too. The surfaces of the bricks are quite smooth and hence results in a low mechanical strength and less bonding. The fly ash bricks losses its weight adversely when burnt at 1000^{o}C. In many areas around the world, there is already a shortage of natural materials for the production of the conventional bricks. Hence there is a need of the hour to find an alternative to the conventional bricks, which not only serves as a replacement but also eliminates the disadvantages of the conventional bricks.

2. Materials used

2.1. Silica sand

Silica sand is a naturally occurring granular material composed of finely divided rock and minerals particles. It is defined by size being finer than gravel and coarser than silt. It is composed of silicon and oxygen atoms in a continuous framework of SiO_4-Silicon-Oxygen (Tetrahedra) with each oxygen being shared between two tetrahedral giving an overall chemical formula of SiO_2. The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropicalcoastal settings is silica(silicon dioxide, or SiO_2), usually in the form of quartz. Silica(SiO_2) sand is the sand found on a beach and is also the most commonly used sand. It is made by either crushing sandstone or taken from natural occurring locations, such as beaches and river beds and the picture as well as physical properties of silica sand shown as in below as figure 1and table 1



Fig. 1: Silica Sand.

Table 1: Physical Properties of Silica Sand

Chemical Composition	Silica Sand (%)
SiO_2	99.48
Al_2O_3	0.22
Fe_2O_3	0.03
MgO	0.02
CaO	0.13
Na_2O	0.04
K_2O	0.02
SO_3	-
L.O.I	-

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2.2. Sodium silicate

Sodium silicate is the common name for the compounds with the formula $(Na_2SiO_2)_{nO}$. A well-known member of this series is sodium metasilicate, Na_2SiO_3 and also called as WATER GLASS or LIQUID GLASS. These materials are available in aqueous solution. The pure compositions samples are often greenish or blue owing to the presence of iron containing impurities. Sodium carbonate and silicon dioxide react when molten to form sodium silicate and carbon dioxide

$Na_2CO_3 + SiO_2 \rightarrow Na_2SiO_3 + CO_2$

All are glassy, colourless, and soluble in water. Sodium silicate is stable in neutral and alkalinesolutions. Sodium Silicate is an aqueous solution which is combined with silica sand and used as a binder for the manufacture of brick. Sodium Silicate acts as a binder and combined with Silica sand in the ratio of 98:1.5:0.5 (Silica sand: Sodium silicate: Carbon dioxide).

2.3. Carbon dioxide

Carbon dioxide is a colourless gas with a density about 60% higher than that of dry air. Carbon dioxide consists of a carbon atom covalently double bonded to two oxygen atoms. It occurs naturally in earth's atmosphere as a trace gas. The current concentration is about 0.04% (405ppm) by volume, having risen from pre-industrial levels of 280ppm. In the manufacture of CO_2 Sand Brick, the combined mixture of silica sand and Sodium silicate is mixed and made into a fine mixture and then it is air tight mould and then Carbon dioxide is allowed to pass through the mould at that point the sodium silicate combines with the carbon from the carbon dioxide and forms a rigid material in the form of brick. Carbon dioxide is the most important raw materials for the formation of brick. Carbon-dioxide is allowed to pass through the mould for upto 2-3 kg/m^3 for continuously for 45-60 seconds.

2.4. Epoxy resin

Epoxy is either any of the basic components or the cured end products of epoxy resins, as well as a colloquial name for the epoxide functional group. Epoxy resins, also known as polyepoxides, are a class of reactive prepolymers and polymers which contain epoxide groups. Epoxy resins may be reacted either with themselves through catalytic homopolymerisation, or with a wide range of co-reactants including polyfunctional amines, acids (and acid anhydrides), phenols, alcohols and thiols and the physical properties of epoxy resin are given in table 2. These co-reactants are often referred to as hardeners or curatives, and the cross-linking reaction is commonly referred to as curing. Reaction of polyiodides with themselves or with polyfunctional hardeners forms a thermosetting polymer, often with favorable mechanical properties and high thermal and chemical resistance.

Table 2: Physical Properties of Epoxy Resin

S.No	Properties	Results
1	Specific Gravity	2.57
2	Sieve Analysis	0.15 to 0.125mm
3	Liquid Limit	120-170
4	Plastic Limit	27-30
5	Water Absorption	18-23

3. Chemical reaction of the method

The major chemical reaction involved in the manufacture of CO_2 brick is that the Silica sand which has a enriched content of silica(SiO_2) has combined with the sodium silicate(Na_2SiO_2) as a binder. The combined mixture of silica sand and sodium silicate is made to compact in an air tight mould and then the carbon dioxide gas is allowed to pass through the mixture of ingredients in the mould with an air pressure of upto 2-3 Kg/cm^2 for upto 45-60 seconds. Thus, the passed carbon dioxide gas combined with the mixture of silica sand and sodium silicate and the Carbon ion from the carbon dioxide is being replaced by the oxygen ion from the silica sand and oxygen from the CO_2 is being removed as the by products from the manufacture of the CO_2 Sand brick.

$(SiO_2 + Na_2SiO_2) + CO_2 = (SiCO + Na_2SiO_2) + 2O_2$

(SILICA SAND+SODIUM SILICATE) + CARBONDIOXIDE = (SIC+ Na_2SiO_2) +2 OXYGEN

4. Experimental Procedure

After collecting all the materials, a mould was prepared by the dimensions of 220 x 100 x 75mm as shown in figure 2. The inner sides of the moulds were to be kept smooth without any friction.

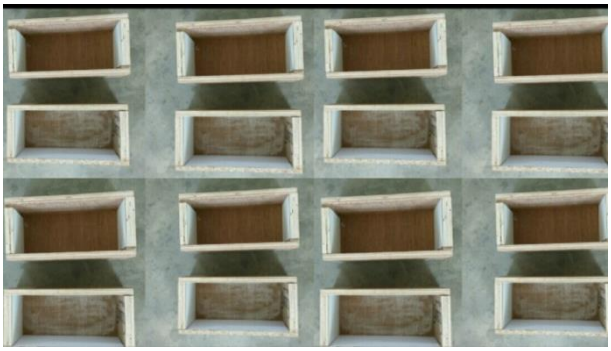


Fig. 2: Mould.

To provide friction free inner sides to the moulds, the inner sides are made with mica so that the moulds can be removed easily after casting with bricks. The required quantities of silica sand and sodium silicate are mixed thoroughly by kneading until the mass attained a uniform consistency and it was given in figure 3.



Fig. 3: Mixing of Raw Materials.

Dry sheet of papers are placed on the floor and the moulds are kept on it. A very thin coat of lubricant (Grease or oil) is applied to the inner sides of the mould before the beginning of the casting process. The sand is pressed or forced in the mould in such a way that it fills all the corners of mould. The extra or surplus sand is removed either by wooden strike or metal strike or frame with wire and it was displayed in figure 4.



Fig. 4: Hand Moulding Process.

A strike is a piece of wood or metal with a sharp edge. Now $CO_2$is pumped into the mould and bonds with the silica sand to make a solid brick- like material in less than a minute and it is given in the figure 5. The bricks were taken out from the moulds. The next step is to infuse the bricks with a binder such as epoxy or urethane and it is shown in figure 6. Bathing the blocks in the binder creates a hardened block that has all the proper requirements for a strong building component.



Fig. 5: Passing of CO_2 in Brick Mould.



Fig. 6: Coated with Binding Material.

5. Results and discussions

After casting the bricks, they were analysed for various tests to check the properties of the bricks with the existing and standard results. The following tests were carried out to check the strength and durability of the brick

5.1. Water Absorption Test

A brick is taken and it is weighed dry. It is then immersed in water for a period of 16 hours and it is shown in figure 7. It is weighed again and the difference in weight indicates the amount of water absorbed by the brick. It should not, in any case exceeds 20 per-cent of weight of dry brick.



Fig. 7: Water Absorption Test.

$W= ((m_2-m_1)/m_1) \times 100$

$= ((3.264-2.801)/2.801) \times 100=16.52\%$

5.2. Compressive Strength Test

The compressive strength of a brick is found out by placing it in a compression testing machine as shown in figure 8. Load is applied axially at a uniform rate and maximum load at which the specimen fails is noted for determination of compressive strength of brick is given by the formula as

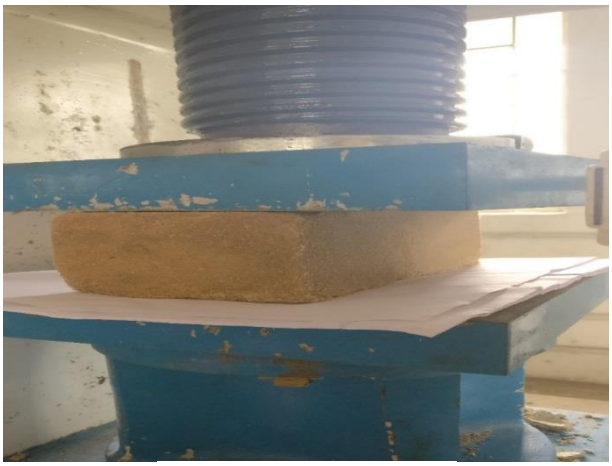


Fig. 8: Compressive Strength Test.

Compressive strength= (Maximum load at failure/ loaded area of brick) and the results are shown as in table 3

Table 3: Results of Compressive strength

S.No	Brick Number	Load	Stress(N/mm^2)
1	B1	148	8.03
2	B2	148	9.19
3	B3	150	9.00
4	B4	147	9.23
5	B5	149	9.05
6	B6	150	9.10

As per BIS: 1077-1957, the minimum crushing or compressive strength of bricks is 3.50N/mm^2 but according to CO_2 sand brick the average compressive strength is 8.93 N/mm^2.The brick with crushing strength of 7 to 14 N/mm^2 are graded as A and those having above 14 N/mm^2 are graded as AA. Hence the brick can be graded as grade A.

5.3. Impact Test

In this test bricks are allowed to fall from a height of 1 meter. If bricks break, then it has low impact value and is not suitable for construction as shown in figure 9. Good quality bricks do not break after fall.



Fig. 9: Impact Test.

5.4. Efflorescence Test

The soluble salts, if present in bricks, will cause efflorescence on the surface of bricks. For finding out the presence of soluble salts in a brick, it is immersed in water for 24 hours. It is then taken out and allowed to dry in shade. The absence of grey or white deposits on its surface indicates absence of soluble salts.
If the white deposits cover about 10 percent surface, the efflorescence is said to be slight and it is considered as moderate, when the white deposits cover about 50 percent of surface. If grey or white deposits are found on more than 50 percent of surface, the efflorescence becomes heavy and it is treated as serious, when such deposits are converted to powdery mass.

5.5. Shape and Size Test

In this test, a brick is closely inspected as shown in figure 10. It should be of standard size and its shape should be truly rectangular with sharp edges.



Fig. 10: Shape and Size Test.

5.6. Soundness Test

In this test, the two bricks are taken and they are struck with each other as given in figure 11. The bricks should not break and a clear ringing sound should be produced.

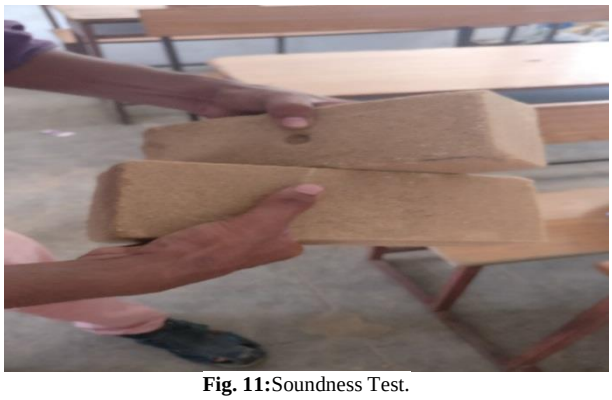


Fig. 11: Soundness Test.

5.7. Structure Test

A brick is broken and its structure is examined as shown in figure 12. It should be homogeneous, compact and free from any defects such as holes, lumps etc.



Fig. 12: Structure Test.

The finished bricks can also be more easily transported from where they are locally produce to the building site, and thanks to their tensile strength, they can create walls that require little or no added steel reinforcement. The product also has the promise of being a valuable way to sequester carbon.

6. Conclusion

- In this study, the compressive strength, water absorption, efflorescence, soundness test, shape and size, structure and impact test for bricks made with silica sand co_2were investigated. The bricks were carried out by hand moulding process. This brick satisfies the requirements of Indian standard codes. The maximum compressive strength of brick is 9.09N/mm^2 are graded as A. The average value of water absorption is 16.52%.
- The traditional brick masonry boasts an impressive crushing strength (vertical load) but is much lower in tensile strength unless reinforced, but whereas in CO_2 brick the tensile strength can be higher with less reinforcement when compared to the traditional brick masonry.
- Since the Carbon dioxide is used for the manufacture of brick the normal carbon dioxide content in the atmosphere can be reduced which can reduce the global warming of the atmosphere.Since it reduced the global warming, it can be considered as an eco-friendly construction.
- The brick's strength is predicted to be 2 times that of concrete in less than 24 hours, which is used for emergency building at critical condition and predicted to have a 50-year lifespan.

- These types of brick constructions are made in the place for the rapid recovery of disaster places and thus the life span of the structure is assumed to be of more life span.

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IS Codal Provisions

- Is 2386: Part 5: 1992-Specification Of Soundness Test
- Is 2690: Part 2 :1992- Specification Of Hand Molding
- Is 383:1970 Specification Of Fineness Modulus Test
- Is 2386: Part 3 : 1963: Specification For Specific Gravity
- Is 2386: Part 3 : 1963: Specification For Water Absorption
- Is 9013 Specification Of Compression Test
- Is 3495(Part 1, 2, 3):1992, Methods of Tests of Burnt Clay Building Bricks for the Determination of Compressive Strength (Part 1), Determination of Water Absorption Test (Part 2), Determination of Efflorescence (Part 3).

References

[1] V. Nivetha, E. Hema, V. Jayakumar ,"Fabrication of bricks using white clay and silica sand ",SSRG International journal of civil Engineering, March(2017).

[2] Mohammed a. Alnawafleh," Mechanical and physical properties of silica bricks produced from local materials ", Australian Journal of Basic and Applied Sciences, 3(2): 418-423, 2009.

[3] Leoleinrostanddeffodeffo, raphaelndisyamutuku and timothy nyomboi,"Strength performance of silicate limestone compressed bricks", Journal of Civil Engineering and Construction Technology, Vol. 8(6), pp. 53-58, July 2017.https://doi.org/10.5897/JCECT2016.0423.

[4] Hussein hameedkarim, oday al-taie," Manufacturing refractory silica bricks from silica sand",University of Technology, January(2012).

[5] Estimation of co_2 of different aggregate mixtures by m. R. Islam, t. S. Tufa (2015).

[6] Chee- Ming Chan, "Effect of Natural Fibres Inclusion in Clay Bricks: Physico-Mechanical Properties," International Jounal of Civil and Environmental Engineering, March 2011. J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68-73.

[7] GazzeAlmarahle, "Production of Silica refractory Bricks from White Sand," American Journal of Applied Science, 2 (1):465-468, 2005, ISSN 1546-9239.

[8] Mohammad Shahid Arshad, Dr. P.Y. Pawade, "Reuse of Natural Material for Making Light Weight Bricks," International Journal of Scientific & Technology and Research Volume 3, Issue 6, June 2014.

[9] M. Scinduja, S. Nathiya, C.V. Shudesamithroon, M. HarshavarthanaBalaji, T.Sarathivelan, S. Jaya Pradeep, "Innovative Brick Material," International Journal for Research in Applied Science & Engineering Technology(IJRASET), Special Issue-1, Oct 2014, ISSN: 2321-9653.

[10] Bhaumik, P.K., 1986. Production and properties of supper duty silica bricks, Refractories Journal, 6-11.

[11] Mohantly, P., N. Singh and D. Smith, 1986. Silica - a critical study. Part, and refractories journal, 12(7):9-5.

[12] Mohanned A., Alnawafleh, "Mechanical and physical properties of silica sand Bricks produced from Local Materials", Tafila Technical University", Australian Journal of Basic and Applied Sciences, 3(2):418-423,2009.

[13] Leolin Rostand DeffoDeffo, Raphael NdisyaMutuku and Timothy Nyomboi, "Strength performance of silicate limestone compressed Bricks", Journal of Civil Engineering and Construction Technology, Volume.8 (6), pp. 53-58, July 2017. https://doi.org/10.5897/JCECT2016.0423.