Constructing SandBrick from Microbial Induced Cementing Bacteria (MICP)

Abdullah Emam & Mohamed Essam

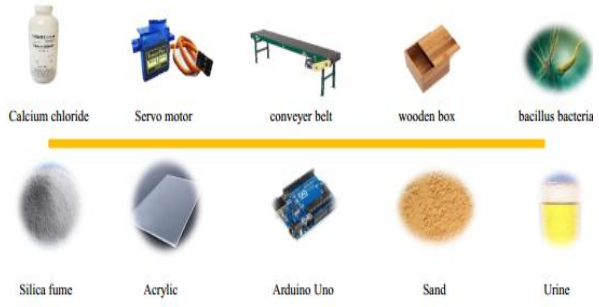
Index Terms— Needless to say, Egypt is one of the developing countries that faces multiple challenges: Pollution and weak health care system which affect mainly two aspect of life: public health and communication. The grand challenge which our project focused on is pollution; waste and industrial smoke pollute the air with high amounts of toxic gases such as CO_2 and SO_4. So, a solution has been adopted to produce a highly-strengthened brick with a lower price. The solution is about extracting and precipitating silica fume (which is a high toxic material in gaseous state) from the industrial smoke, and mixing it with BacillusPasteurii bacteria, urine and calcium chloride to make a brand-new strengthened brick almost as hard as a marble. Based on the obtained results, our project could slightly solve Egypt's major problems, mainly the pollution Problem.

Index Terms— ***CSH – Silica Fume – Robot Arm – Microbial Induced Calcuim carbonate Percipitation — Conveyer Belt mashine***

1 Introduction

The public health in Egypt is experiencing a drawback every year. The major aspect that contribute to the low public health is pollution. Being the second largest city in pollution, Cairo's air has about 160 microorganism per cubic meter. This tremendous amount of pollution is a result of factory's smoke and cars' exhausts. This increase in pollution has led to enormous increase in infant mortality. Also, the amount outdoor pollution has been increased. So, some prior solutions to rise up with the public health were tried.
One attempt was the catalytic converter, which is an exhaust emission system that converts harmful pollutants into less harmful emissions before they everleave the car's exhaust using a redox reaction. The catalytic converter is efficient solution, but it is not widely used at the present time because the metal catalyst (platinum) is very expensive to be used in a car exhaust system and it works only at a fairly high temperature. This system managed to solve one problem which is the pollution but the cost is still a problem. So, the solution we are proposing was based on a lot of comprehensive research and the design requirements which are to be stability and cost. Stability was met by successfully precipitating silica fume from the silica industries smoke, making no harm in the smoke, bacteria turns calcium chloride to calcium carbonate that increases the strength from 120 Kg. Wt/ cm2 (ordinary brick) to 156 Kg.Wt/ cm_2. In the system of manufacturing high-quality brick. The cost was achieved by not only selecting our material list carefully and replacing with cheaper items if possible but also with choosing the best method to construct the prototype.

2 Materials



3- Procedures

The prototype was made through many consecutive procedures:
The silica fume has been extracted from the silicon factories' smoke by condensing the smoke which gives a precipitate of silica fume. A wooden box was made using the shopbot machine, nails were used to fix the wood together, sand was put in the wooden box, and finally, Urine and Bacillus pasteurii bacteria have been mixed togetherand put on the sand Calcium chloride has been diluted to 0.5 molars by placing it in the later. Then the diluted calcium chloride has been added to the sand till the sand was saturated to form the brick.

- Conveyer Belt:

A machine has been designed to control the whole system. This machine has a DC motor and conveyor Belt to make it easy for constructing the brick. And this machine depends on specific codes to be able to do its functions.

- Robot Arm:

After designing the brick and making it, a robotic arm was

made so that the process can be managed easily.
The design was simulated on Adobe Illustrator, then, it was transferred to a laser cutter to be cut precisely on an acrylic sheet. After that, the pieces were joined together using screws and Nuts. Servo motors have been used to obtain force to move the hands of the robotic arm.

4- EQUATIONS

Equation related to the Chemical reactions:
Bacteria metabolize urea in water, which result in the production of ammonia and carbonic acid:

Eq.1: $CO(NH2)_2 + 2H_2 \rightarrow 2NH_3 + H_2CO_3$

The carbonic acid spontaneously equilibrates in solution to produce carbonate:

Eq.2: $H_2CO_3 \rightarrow HCO_3^- + H^+ \rightarrow CO3^{-2} + 2H^+$

Supersaturating of carbonate minerals (in the presence of Ca^{+2}) occurs because of the increased pH, resulting from hydroxide ions being released during the production of ammonium from ammonia as shown in Eq.3

Eq.3: $NH3 + H_2O \rightarrow NH_4^+ + OH$

The result of this metabolic reaction is the precipitation of calcium carbonate on the cell surface of bacteria

Eq.4: $Ca^{+2} + HCO_3^- \rightarrow CaCO_3 + H^+$

Finally, this calcium carbonate will bind sand particles together to make it withstands loads up to 1583 N.
In the presence of micro-silica, the silicon dioxide from the micro-silica will react with the calcium hydroxide to produce more aggregate binding CSH (Calcium silicate hydrate) as follows:

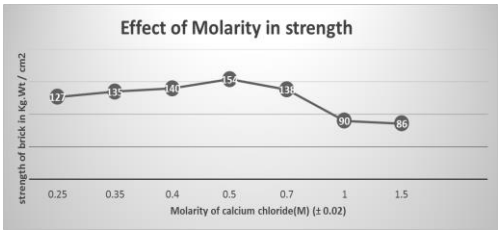
Eq.5: $3Ca(OH)_2 + 2SiO_2 + H_2O \rightarrow 3CaO \cdot 2SiO_2 \cdot 4H_2O$

This CSH will fill the pores between sand particles, increasing the compressive strength of the brick from 120 Kg.Wt/Cm^2 to 156 Kg.Wt/Cm^2, and make the brick water-proof.

5 HELPFUL HINTS

5.1 Figures and Tables (Fig (1))

Figure (1)



This figure (1) illustrate the relation between population and poolution in different cities. Egypt comes in the second place as one of the most polluted cities in the world.
Nowadays the difference between the rates of increasing in population is not very high relative to pollution. However, by 2050, it's expected that the pollution will increase more than today. A Guide to pollution Challenge, from http://news.bbc.co.uk/2/hi/science/nature/5072642.stm

(Fig (2))

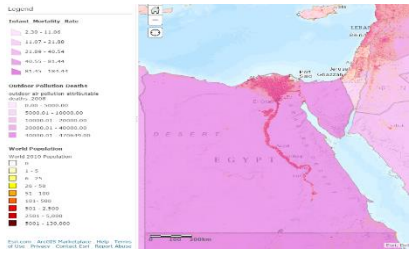
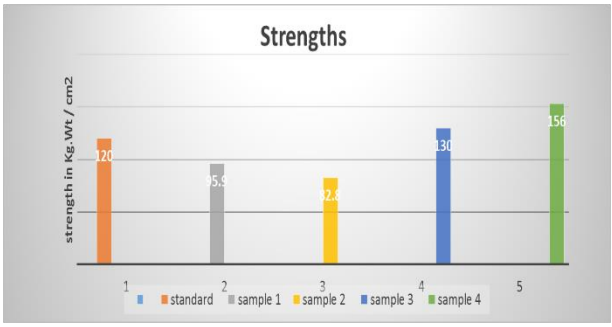
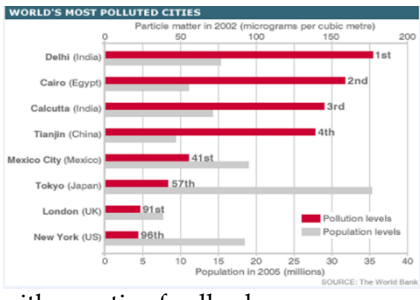


Figure (2) illustrates that the death rata has been increasing due to pollution.It is significantly clear that outdoor pollution contributes tremendously in the death rate. While searching, it was found that brick factories cause most of the outdoor pollution due to the rise of greenhouses gases from these factories.

Graph (1)



Graph (1) shows the result of our sand brick. There was a standered sample with which the other samples were compared to. The independent factors were the number of days the brick was left in the sun and the prescence of silica fume. There is a direct relation between the compressive strength and the number of days left in the sun as well as the prescence of silica fume. Sample 5 could bear a compressive strength of 156 Kg.Wt/Cm^2 when left in the sun for 7 days.



Graph (2) shows how the concentration of calcium chloride affects the strength of the brick. It was concluded that the best molarity to get the most stable brick was .5M. Otherwise, It will be with negative feedback.

5.2 Theorems and Proofs

The project is supposed to solve the pollution problem. As a complete flawless system, it achieved excellent demanded results according to testing the prototype for commercial use. By making a decision which is to provide a solution that introduce a new face of brick industry from

Basillus Pasetruii bacteria, urine, sand, calcium chloride and silica fume. That will produce a brick that can withstand 156 $Kg.Wt/Cm^2$ instead of 120 $Kg.Wt/Cm^2$. Besides; a robot arm and conveyer belt mashine that will control the process brick production in our factory. Our project has many advances like using bacteria to produce a unique type of brick that is as hard as marble. Moreover, condensing the silica powder from silicon factories to use it has increased the brick compressive strength. The bacteria we have used is found in swamps and can be replicated in labs to produce huge amount of this strain.

8 Conclusion

To summarize and define the scientific and healthy be fits of the product brick, the problem has been first determined. As the rate of death due to pollution and home accidents has been increasing rapidly, thus reducing the communication, the need to manufacture bricks and reduce its pollutant is indispensable. But with nowadays bricks, the gases produced during the fabrication are fetal to humans and the quality of bricks are almost impossible to achieve. To solve that problem once and for all, two goals has been set to be reached, which are making the brick highly-strengthened and producing almost no gases in manufacturing. So a brick from urine, sand, silica fume and bacillus pasteurii bacteria has been done to increase the efficiency of bricks industry. Not only that, but also the process itself has been manned by a building machine that runs automatically and a robot arm to put the brick in its specific location with no need for workers (labor force). To guarantee the commercial use of the machine and the product brick, the prototype has been tested several times. To test the strength of the product brick different values of forces have been applied on the brick to see how much it could bear. The results were that the brick could handle at maximum 156 kg.wt/ cm_2. All that served one purpose which is the success of the project as a whole.

8 End Sections

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9 References

[1]. Eco Friendly Brick Produced by the Reaction of bacteria. SSRG International Journal of Chemical Engineering Research (SSRG-IJCER) – volume 1 Issue1 Nov 2014, D.Karunagaran Assistant Professor, Dept. of Chemical Engineering, Sri Sivasubramania Nadar College of Engineering, Kancheepuram. http://www.laboratoryequipment.com/news/2012/02/microwaveovens-make-

[2]. Production nanotubes-fast-easy. Microwave Ovens Make Production of Nanotubes Fast, Easy, May 12,2015. http://biomason.com/.bioMASON bioMASON Gro Bricks, bioMASON, March 15, 2017

[3]. http://throughthesand-glass.typepad.com/through_the_sandglass/2010/07/sand bacteria urine bricks continuing-performances-ofbacillus-pasteurii.htmlSand+bacteria+urine= bricks: continuing performances of bacillus pasteurii . Michael welland , July 19,2010

[4]. Zumdahl, S. S. (1976). Zumdal chemistry 9th edition . New Calefornia, Calefornia: Mary Finch.

[5]. Reece, J. B. (2014). Campbell Biology (10th ed.). Berkeley, California: Reece, Jane B.

[6]. Fathi, Y. (2012, November 12). Egypt's public hospitals: From bad to worse. Retrieved December 27, 2017, from http://english.ahram.org.eg/NewsContent/1/64/58686/Egypt/Politics-/Egypts-publichospitals-From-bad-to-worse.aspx

[7]. P., & I. (2017, October 14). Pocket Sized Robot Arm MeArm V0.4. Retrieved December 27, 2017, from http://www.instructables.com/id/Pocket-Sized-Robot-Arm-meArm-V04/

[8]. The Silica Fume Association. (n.d.). What is Silica Fume? Retrieved December 27, 2017, from http://www.silicafume.org/general-silicafume.html

9. Norchem Inc. (n.d.). How Does Silica Fume Work in Concrete? Retrieved December 27, 2017, from http://www.norchem.com/silica-fume-concrete.html

10 Contacts:

For any further information, Contact:
15055@stemegypt.edu.eg
15086@stemegypt.edu.eg