Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 2, Number 3; January-March, 2015 pp. 272-274

http://www.krishisanskriti.org/jceet.html

Effective Utilization of Water Treatment Plant Sludge for Brick Manufacturing

Vivek Chaudhary[1] and K.S. Gumaste[2]

[1]M.Tech Student (Civil-Environment Engg.) Walchand College of engineering, Sangli
[2]Dept. of Civil Engg Walchand College of Engineering, Sangli
E-mail: [1]chaudharyvivek101@gmail.com, [2]krishnakedargumaste@gmail.com

Abstract—*Rapid urbanization all over the world has resulted in an increase of water and wastewater treatment plant sludge. In cities, sludge disposal by landfilling may not be suitable solution now due to land scarcity. In order to sort out the disposal problem of the sludge, sludge management towards the minimization and reutilization of sludge as a useful resource is one of the solutions. Properties of sludge resemble the properties of the construction materials. So, sludge can be utilized as raw material for manufacturing bricks. Moreover in western Maharashtra region, the engineering properties of bricks are not meeting the requirements, as laid by IS code. This paper reviews the study of various research works that had been done, in order to find the suitable type of sludge for brick manufacturing in western Maharashtra region. This study emphasis on producing bricks manufactured from clay blended with sludge, having properties as per IS code.*

1. INTRODUCTION

Potable water resources are limited on the earth. Only 3% of the total water present on the planet is potable wherein, large part is in the polar region in the form of glaciers. With the increasing population, burden on water and wastewater treatment plants have increased. Process of treating water and wastewater produce large amount of sludge. This sludge is generally disposed in streams, oceans, open land and landfills. All this disposal method cause significant impact on environment. When the sludge is disposed into the landfills, it creates leachate and contaminates the ground water, when the sludge is directly disposed into water bodies, it degrades the water quality in downstream side and when sludge is incinerated, it creates air pollution. There is necessity to find out different ways for the management of the sludge.

Brick is oldest building material and still is in use, because of its intensive properties. Brick is economical, durable and easy to handle. Bricks are used as exterior and interior walls, these are also used in load bearing structure when possesses good engineering properties. Bricks are generally manufactured in kilns and clamps. Bricks manufactured in kilns show good engineering properties due to controlled temperature compared to bricks manufactured in clamps. Quality of brick mainly depends on the clay utilized for its manufacturing. Brick of Maharashtra shows low engineering properties as compared to brick of other part of India [1]

Wastewater treatment plant sludge has higher percentage of organic matter. This sludge when handled effectively, it can be used in agricultural industries. On the other hand, water treatment plant sludge is generally comprises of colloidal particle, which come together and form macrofloc when subjected to coagulation followed by flocculation. When alum is used as coagulant in coagulation, WTP sludge has high aluminium content. It is difficult to dispose alum sludge as the accumulation of aluminium in the water bodies and human cause various health issue. Alzheimer disease occurs due to accumulation of aluminium.

2. REVIEW OF PREVIOUS WORK DONE

Properties of Burnt Brick in India

Gumaste K.S. *et al* (2004) studied the properties of bricks in India. This study address the various properties of bricks produce in different regions in India. Burnt clay of two varieties viz. table moulded and wire-cut was collected from different regions of India. The various test carried out to obtain the properties of bricks i.e. compressive strength, dry density, water absorption and initial rate of absorption. Brick samples from various states/regions were collected and tested. Dry density of the collected bricks samples were in the range of 16.00 - 19.50 kN/m^3. But brick sample from Maharashtra had low dry density 13.3 kN/m^3. The water absorption for a majority of the table moulded bricks in the range of 10-16%. The bricks of Maharashtra region on the other hand showed very high water absorption values (26% and 22%).The table moulded bricks from Karnataka, Kerala, Gujarat and Bihar have initial rate of absorption values in the range 1.17-2.58 kg/m^2/minute. Table moulded bricks from Andhra Pradesh, Rajasthan and Jammu had slightly higher IRA values and was in the range of 3 - 5.7 kg/m^2/minute. The table moulded bricks from Maharashtra showed very high IRA value of 9.33 and 6.97 kg/m^2/minute. However the wire cut bricks had relative lower initial rate of absorption values in the range 1.25 - 1.52

kg/m^2/minute. The table moulded bricks of Karnataka, Andhra Pradesh and Maharashtra had mean compressive strength in the range of 2.5-8.3 N/mm^2. On the other hand, bricks of Rajasthan and Jammu both from Northern regions of India show relative higher mean compressive strength of 9.4 N/mm^2 and 14.4 N/mm^2. Table moulded and wired-cut bricks of northern regions also showed strengths in the range of 8.2 - 23 N/mm^2.

Brick Manufacturing from Water Treatment Sludge and Rice Husk Ash

Hegazy in his study investigated the complete substitution of brick clay by WTP sludge blended with rice husk ash with various ratios. Chemical analysis of WTP sludge, rice husk ash and clay were determined according to ASTM C114-00 by using X-ray fluorescence spectrometer. The results of chemical composition showed that WTP sludge and rice husk ash has similar chemical composition as clay. In WTP sludge silica content was slightly less than that of clay. On the other hand silica content in rice husk ash was more than clay. Lab scale brick with nominal dimension of 5 × 5 × 2 cm^3 with batch process were manufactured. Four batch proportion of clay, WTP sludge and rice husk ash was used. In first proportion (control brick) only clay was used and in other three proportion (series A, B and C) only WTP sludge and rise husk ash were taken in proportion. In series proportion, WTP sludge and rice husk ash were taken in proportion 25%, 50% and 75% and 75%, 50% and 25% by weight respectively. Each brick series were fired at four different firing temperatures of 900, 1000, 1100, 1200°C. Engineering properties like water absorption, efflorescence and compressive strength were analyzed according to Egyptian standards. Compared to control bricks in which 100% clay was used, all of the sludge-RHA brick types had higher water absorption at lower firing temperature. At firing temperature of 1100 and 1200°C, bricks had water absorption equal to clay brick. The specific gravity of control clay brick ranged between 1.84 to 1.95 and specific gravity of sludge-RHA ranged between 0.78 and 1.46. Compressive strength of control clay brick ranged between 58.09 and 69.44 kg/cm^2 and sludge-RHA ranged between 28.78 and 79.96 kg/cm^2. There were nine sludge-RHA bricks type that met the requirement of the E.S.S 1524/1993 for the load bearing walls and three sludge-RHA bricks type that achieved compressive strength between 27 and 35 kg/cm^2 according to E.S.S. 1524/1993 for load bearing walls. With the increase in the firing temperature, compressive strength increases which ensuring the complete crystallization process. At same firing temperature sludge-RHA achieved higher compressive strength than that of controlled clay bricks

Exploring the Utilization Potentials of Water Works Sludge as Laterite Brick Material

Victoria studied the utilization potentials of water works sludge as laterite brick material. In this study dewatered WTP sludge by gravity thickening method. Chemical analysis of laterite and WTP sludge were done. WTP sludge was used as supplement in the locally available laterite in varying proportion of 0%, 5%, 15% and 20% by weight of laterite. Hand moulding method was used in brick moulding, which had size 70mm × 70mm × 70mm. The mixture of sludge and laterite was first kept for seven days in polyethylene bags and later subjected to air drying for another seven days. Each brick series was fired at 850, 900, 950, 1000 and 1050°C for 6 hours. The bricks were then evaluated for engineering properties according to NIS 74:1976 and CNS 1999. In the chemical analysis it was found that the chemical composition of WTP sludge was similar to that laterite except alumina content, alumina content was higher in the WTP sludge. Particle size distribution of sludge and laterite classified as fine clayed and clayed soil respectively according to ASSHTO classifications. The value of compressive strength of some bricks ranged between 1.2 and 3.94 N/mm^2. Six sludge-laterite brick types exhibit compressive strength higher than 2.5 N/mm^2. The results from the study showed that compressive strength increases with increasing temperature. Water absorption test was also conducted on the bricks, from the test it is found that five bricks type exhibits less than 25%, which met the requirements of NIS 74:1976. The density of brick was found out to be 1.2 to 1.5 g/cm^3 and increasing firing temperature results in an increase in density of brick. Test on shrinkage also performed and 2.8 to 5.6% shrinkage was found. The efflorescence test was performed in accordance with NIS 74:1976. The result showed that efflorescence was nil in all laterite brick types.

Mixing Water Treatment Residual with Excavation Waste Soil in Brick

Huang C. *et al* (2005) carried out the study of water treatment residual and excavated waste soil for making bricks. In the study bricks were manufactured by taking raw materials which were water treatment residual and excavated waste soil separately. Along with this, bricks were also prepared from various proportion of water treatment residual in excavated waste soil. Proportions of the water treated residual in excavated waste soil were 0%, 15% and 30% on weight basis. The brick size produce were of the size 6×3×2 cm. The bricks qualities were evaluated on their loss on ignition (LOI), firing shrinkage, compression strength, bulk density and water absorption along with the chemical analysis of raw material. Loss on ignition for WTR and EWS were 18% and 10% respectively. Firing shrinkage was also determined and it was observed that WTR volumetric shrinkage reduction upto 45% at 1100°C. On the other hand in EWS volumetric shrinkage was upto 18%. At 1100ºC sintering temperature Compressive strength of EWS and WTR bricks were reported to be 1400 kgf/cm^2 and 400 kgf/cm^2 respectively. Water absorption of the EWS and WTR bricks were 5% and 7% respectively. An 18% volume reduction was observed at 1100ºC .The change in the sintering of the WTR is much more dramatic. Significant

shrinkage began to occur at 950ºC and a 45% volume reduction was determined at 1100ºC. When bricks were made from blending the 15% to 30% WTR with EWS at 1050ºC can be used as second and third degree construction bricks according to ASTM C39-81.

Incorporation of Sludge from Water Treatment Plant into Red Ceramic

Monteriro S.N. *et al* (2005) has carried out study on use of water treatment sludge in manufacturing of red ceramic. In the study, tests were conducted to determine chemical composition and particle size distribution of the clay and sludge. The chemical composition of the sludge was found to be similar as that of clay Particle size distribution conducted in accordance with Brazilian standards where equivalent spherical diameter of material was calculated using stokes's law. In particle size distribution of clay 47% was found as clay (less than 2µm), silt (2-20µm) 24% and fine sand (20-200µm) was 26%. Sludge has finer particle with a value of 86.5%. Mixtures were prepared with amount of 0, 3, 5 and 10% of sludge incorporated into clay by weight. Rectangular specimen were obtained by 20MPa pressure molding and fired at 700, 900 and 1100˚C. Ceramic properties related to the bulk density, linear shrinkage, water absorption and flexural rupture strength were determined. Water absorption of sludge-clay bricks was between 22 and 25%. At 1100°C flexural rupture strength was between 18 and 24 MPa. The obtained results shows that incorporation of water treatment sludge increase the water absorption and reduce the mechanical strength of clay fired ceramic as the changes caused in the porosity by relative elevated weight loss during firing stage.

Resource recovery of sludge as a building material

Tay *et al* (2005) reviews the studies by various researchers in reutilizing sludge as non-conventional construction material. For brick making mixture of dried sludge from wastewater plant and clay was taken and crushed into fine pieces by crushing machine. The crushed mixture was extruded into brick sample which were dried and then fired in a kiln at 1080°C for about 24 hours. Proportion of sludge used in mixture of sludge and clay were 0%, 4%, 8%, 10%, 14%, 20%, 27%, 30% and 40% by weight. Specific gravity, water absorption and firing shrinkage were evaluated. Specific gravity was reported between 1.98 and 2.38; with the increase in the sludge proportion specific gravity was decreased. Water absorption was reported between 0.03 and 3.63%, with the increase in sludge proportion water absorption also increases. Firing shrinkage was between 9.91% and 12.87%. The surface texture of the brick was uneven, mainly due to the organic component being burnt off during the firing.

Sludge as cementitious material, in this research study the authors examine the potential for utilizing digested and dewatered sludge to produce cementitious material. In preparing the cementitious specimens, the sludge was oven dried and mixed with limestone powder at various proportions by weight. The mixtures were grounded and incinerated in a furnace for different temperatures and duration under controlled burning. The ash collected was ground to less than 80 micron before being tested for various properties. From the investigation, an optimum condition of the mix composition, burning temperature, burning duration and curing condition upon highest possible strength development of the cement was determined. It was found that under air curing the cement specimen with 50% sludge fired at 1000°C for four hours exhibited the highest compressive strength. Chemical analysis of sludge cement shows that the chemical composition was similar to Portland cement with slight variation.

3. DISCUSSION

Generally water treatment plant sludge is disposed into the rivers. It creates environmental impact on water bodies and health issues to the user of that water in downstream side. If rivers are non-perennial, due to less amount of water, self-purification does not occur as it should be. It is demand of now to look out the disposal problem of the generated sludge. Using the same sludge in another industry as raw material can be one of the efficient solution.

Also brick in Maharashtra do not fulfill the required engineering properties as mentioned in the IS code. Brick being basic element has to be strong enough so as to improvise the structural strength. In Maharashtra black cotton soil is present in ample amount, which has shrinkage – swelling property due to presence of montmorillonite mineral and not appropriate for brick manufacturing. Utilizing the sludge in brick manufacturing is not only economical method but also environment friendly. Also if sludge is used in large scale for manufacturing the bricks all over the country, clay can be avoided from depletion.

Sludge can be taken from water and wastewater treatment plants. Wastewater sludge is rich in organic matter on the other hand water treatment plant sludge is inorganic in nature. While burning process the organic matter in the wastewater sludge converted into volatile material and ash which will increase the porosity in the brick. Also wastewater sludge can be used as manure in agricultural industry. Water treatment sludge is better option over, as wastewater sludge is inorganic, suitable for brick manufacturing and it has disposal problem. Hence, use of water treatment plant sludge for brick manufacturing is better option.

4. CONCLUSION

Literature review shows that the bricks in Maharashtra do not possess engineering properties as per IS code. Variation in the soil is required so as to produce bricks having engineering properties as per IS code. In addition literature shows that the

chemical composition of the water treatment plant sludge is similar to the clay. WTP sludge is a suitable material for mixing in the clay for brick manufacturing.

REFERENCES

[1] Gumaste K.S., Reddy B.V.V., Rao K.S.N, and Jagdish K.S., properties of burnt brick and mortars in India, Masonary *International: Journal Of The British Masonry Society , volume 17, No. 2, 2004, pp. 45-52*

[2] Hegazy B.E, Fouad H.A. and Hassanaian A.M , Brick Manufacturing From Water Treatment Sludge And Rice Husk Ash, *Australian Journal Of Basic And Applied Sciences, volume 6, 2012, pp. 453-461*

[3] Huang C., Pan J. R. and Liu Y., Mixing Water Treatment Residual With Excavation Waste Soil In Brick And Artificial Aggregate Making, *Journal of Environmental Engineering, Feburary 2005, pp. 272-277*

[4] Monteiro S.N., Alexandre J.. Margem J.I., Sanchez R. and Vieira C.M.F., Incorporation Of Sludge Waste From Water Treatment Plant Into Red Ceramic, *Construction And Building Material, volume 22, (2008) pp.1281-1287*

[5] Tay J. H. and Show K.Y., Resource Recovery of Sludge as a Building And Construction, *Water Science And Technology, Volume 32, No. 11 (1997), pp. 259-266*

[6] Victoria A.N., Characterization and Performance of Water Works Sludge as Brick Material, *International Journal of Engineering and Applied Sciences, volume 3, no. 3, May 2013, 69-79*

[7] Victoria A.N., Exploring the Utilization Potentials of Water Works Sludge as Laterite Brick Material, *International Journal of Engineering Research and Technology, volume 2 issue 4, April 2013, pp. 2605-2612*