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Behaviour Of Fly Ash Bricks With Replacement Of Materials – A Review

S. Rubini[1], N. Raja venkatesan[2], G. Vignesh[3]
[1](Assistant Professor, Department of Civil Engineering),
[2,3](Under Graduate Students, Department of Civil Engineering),
M.Kumarasamy College of Engineering, Karur, Tamilnadu, India.

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Abstract:
In our present day to day modern life, one of the serious threatening environmental issue is Plastic waste generation. Which it causes a major harm to the environment and cause a serious disease such as cancer for human beings. And also affects the marine ecosystem by which it gets generate on land and migrates to water bodies and destroys the health of marine living beings such as poisoning and get ingested into them also become a critical issue for human health when they consume those. Which in order to control and manage these threats and also to develop the environmental sustainability, the plastic wastes are recycled by using them into the constructional materials, which is the good beneficial and act as a good reliable source [2]. In this study, we are going to get the knowledge about the incorporation of recycle of plastic waste materials and other alternative replacement materials into the fly ash bricks and other normal or nominal or conventional bricks along with the experimental behavior of the bricks which consists of compression strength test, water absorption test, thermal conductivity test, efflorescence test, shape and size test , hardness test, soundness test, SEM and EDS analysis.

Keywords: *plastic waste, replacement, fly ash bricks, ecofriendly, physical , chemical, thermal, SEM, EDS analysis.*

I. INTRODUCTION

Plastic wastes are the one of the critical threats for the sustainability of our earth which the generation of solid waste plastic are in large quantities now-a-days [2]. The annual generation of the plastic wastes around world for a year is above 300 million metric tons. In India, based on per capita consumption, the generation of plastic waste is estimated that nearly 15722 tons per day. A study shows that the 0.75% of more than 5500 metric tons MSW per day is a plastic waste [17]. The usage of plastic wastes in constructional applications will leads to a greater solution for management of municipal solid plastic waste and depletion of deposits of raw materials utilized for constructional purpose. Here, in this study we use to get ideas for replacing the waste plastics in manufacturing of fly ash bricks. And which it also includes tests of compression, water absorption, efflorescence that followed the specification that given under IS Indian standards and also other standards. Which the plastics are added and also focused for better disposal solution and to develop the usage of plastics in building material production.

II. MATERIALS

A. Fly ash

It is a raw material which obtained from the thermal power plants by the process of burning coal. It is a volcanic material which is a man made one. There are above 160 million tons of fly ash is formed in India annually. Which is divided into two types as Class F and the Class C based on ASTM C618 and based on IS 3812 it is classified into Grade I and

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Grade II. Formerly, it is classified based on content of lime but latter it is classified according to reactivity of lime. In fly ash blocks and bricks manufacturing, the fly ash and lime are the major ingredients. Which fly ash is major source of pozzolana [14]. It is a residue that divided finely that obtained from the coal combustion which is transported by flue gases and collection is done through electrostatic precipitator [16]. Mass usage of fly debris is one of the adequate answers for moderate such issues. The channels for mass use are land filling, mine filling and farming. Utilization of class F fly debris in mass amounts is exceptionally viable for balancing out sub grade soils. Such cinders in blend with the lime/concrete have found for yielding great compressive quality for prepared or readied material. Fly debris is being utilized widely in soil change. Fly debris can progress the water holding limit of soil. Being a wellspring of fundamental plant supplements, fly debris discoveries claims in farming. The significant end employments of fly debris are, use in manufacture blocks and concrete mortars, and so forth [19]. The particles of fly ash are spherical mostly, which also includes solid spheres, the density of those are 2300-2600 kg/m^3 and the weight of cenospheres are (0.2-1.1%) of the total weight of ash and its density of <1400 kg/m^3. The specific gravity for fly ash differs from 1.90 for subbituminous ash and to 2.96 for iron-rich bituminous ash. The physical, chemical properties of fly ash are affected by many factors, which are by type of coal, type of boiler, condition of operation and condition of post-combustion. Aluminosilicate compounds is the major chemical composition of fly ash and which includes some calcium and metallic oxides. Ba, Pb, Sr, Cr, V, Ni and Zn are trace elements of fly ash. On combustion method the particle size varies from lesser than 1µm to greater than 200µm [21]. Presently fly debris is utilized for the production of cement bricks, in other development resolutions. Fly debris is commonly put away clammy to maintain a strategic distance from air contamination. In this way, the gathered fly debris is basically dried by sun. Dried fly-debris is handled in route by sifting with 425 µm filter and dried in oven at raised temperatures formerly the sample preparation [6].

B. LIME

In building construction, an important material used for binding purpose is Lime. It reacts at normal temperature with fly ash and makes a cementitious property possessing compound. Which it is calcium oxide (CaO) that associate naturally with magnesium oxide (MgO). The high strength of compound is based on the production of calcium silicate, which after the reaction of lime and fly ash [16]. Reactivity of lime on fly debris is a basic constraint that significantly oversees the utilization of fly debris in hydrated lime-based fly debris blocks [5]. As per Chinese standard, the evaluation of Lime's technical quality is done which it resulted that the effective content of CaO% and MgO % is 62.5 and content of residue is 14.7% and Grade of lime is 2 [22].

C. QUARRY DUST

Quarry dust is a byproduct, which is obtained from the coarse aggregate production. After the removal it is defined as a non-valuable material, residue or tail. And the stone is processed into fine particles lesser than 4.75mm. It can be utilized as a partial replacement material in the construction industry. The chemical composition of Quarry dust is SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, SO_3. It was utilized as a mineral filling material and it mainly consists of CaO. The specific gravity of Quarry dust is 2.6 and specific surface is 0.23m^2/g. Quarry dust with parts of sharp angles and rough it gives good clamping and increases the strength and has lesser unit weight and higher shear strength. In brick production, it provides higher compression strength and lesser water absorption with which it provides good results [9]. It is a residue which obtained from granite quarry and it is also economical than the river sand, which it provides a better alternative source for depletion of natural resources used for materials of construction industry [16].

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III. TEST ON MATERIALS

A. Fly ash : Particle density test

The element thickness of fly ash is well-defined as the mass per unit capacity of the things received later drying according to given below [20].

Arrangement of the example

The underlying example is divided and separated upto around 200 g of the ingredient is gotten. This is spread in a low compartment and dried out in a well-ventilated broiler at 105 $\pm$ 5 ~ to consistent mass. It is then chilled in a desiccator [20].

Technique for Determination Using a Pycnometer Bottle

Spot 10 g (uniformly a bigger amount if a bigger jug is utilized) of the example, arranged as depicted above and liberated from irregularities, in a 25 ml of pycnometer bottle. Fill the jug half, by the chose fluid, place in a desiccator and clear with a void siphon until the sum total of what air has been expelled. Fill the jug by the fluid and keep up at a steady temperature of somewhere in the range of 15~ and 25~ The picked temperature should not shift by more than 0.5 K throughout the test [20].

B. Fly ash : Fineness by dry sieve analysis.

This strategy portrays the assurance of fly debris fineness by dry sifting on a test sift as indicated by ISO 565. Fly debris fineness as dictated by dry sifting is communicated as the rate (m/m) held on the test sieve utilized [20].

Apparatus and method

Sifting is to be done as per ISO 2591, utilizing assessment strainers with wire of woven material conforming to ISO 565. The distance across of the sifter outline will be the 200 mm and a weighed fly debris test of around 20 g ought to be utilized. In the event that the ostensible dimensions of the assessment strainer is more prominent or equivalent to 63/xm, the assessment might be per-shaped by hand sifting as indicated by EN 196, Part 6. With ostensible examination sifter measures underneath 63/zm, a sifting apparatus ought to be utilized for example air jet sifting apparatus. In understanding with ISO 2591, the sifting procedure ought to be ended when the amount going over the strainer in one min is under 0.1 percentage of the charge [20].

IV. MANUFACTURING OF BRICKS

Based on (IS:12894-2002), the brick is casted in the standard size of (190mmX90mmX90mm) in laboratory, with usage of ingredients such as soil, lime, FA in proportions of 5:15:80 and 10:10:80; 5:25:70 and 10:20:70; 5:35:60 and 10:30:60. For the purpose of moulding, which the samples are mixed in a enough quantity of water content to get a workable consistency for purpose of moulding. Then the mould was cleaned and filled with soil and lime fly ash mixture without the allowance of air bubbles. Then the leveling of upper surface is done and the removal of surplus content of mix to be done. The Application of pressure for the bricks that moulded by hand is not done. The bricks that are moulded by pressure are prepared by load the application of 10, 30 and 50 kN. Which those bricks are allowed for two days to get dry and to protected from sunlight. Then the specimens are get immersed into the water for up to one day or 24 hours, and after that they removed out from water. Then they should be subjected for curing from 7 and 28 days by wet jute bags. After curing, the samples are verified for compression strength and absorption of water as per the provision of IS:3495 (Part 2000)-1992. Prior, to testing, the voids and frogs of specimen are filled with sand cement mortar (1:1) [15].

V. TEST ON BRICKS

A. Compression strength test

One of the most important strength properties of the earth bricks is compressive strength. The Compressive strength of the bricks are based on fiber percentage and function of type of soil present in the Bricks [1]. For testing the compression

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strength of the brick of 28 and 90 days, which the testing is done on Universal testing machine (UTM) [13]. The fly ash brick provides about three times higher compression strength than the ordinary clay brick. 3.5 N/mm^2 is the minimum compression strength of normal clay brick. And the compression strength of fly ash brick is 10-12 N/mm^2. The fly ash brick do not possess the compression strength of mentioned above which they used for various works. To examine the compressive strength of bricks, the apparatus used for examining is universal testing machine. When the curing is done, the bricks are taken for testing. The bricks are to place on compression testing apparatus. After placing, the load application is done up to 3000kN at rate of 2.9kN/min. To note reading, when the specimen get failure at maximum load is indicated by testing machine. To obtain the appropriate compressive strength of a certain mix proportion, three bricks of the certain brick design are to be tested and to calculate the average [16]. Here it is detected that based on fly ash and cement content, the strength of all mixtures [12]. To analyze the compression strength of bricks which the maximum load is divided by the applied load area for the certain sample [11].

B. Water absorption test

The factor that which affect the brick durability is water absorption [11]. Which this test indicates the deterioration of the structure of brick when the water infiltrated into it. Previous of compression test, all total specimen of bricks is subject to water absorption test. After the dry specimen of bricks are weighed and they were put immersed into a water tank at 25℃ to 29℃ (or) room temperature for 24 hours. After that the bricks were removed from the water tank. Then the removal of surface water on bricks is done by patting dry with a cloth of lint free. Then the brick specimens are weighed [13]. The amount of water absorbed percentage for each specimen of brick is calculated by formula of,

$$Water\ absorption = [(W2 - W1)/W1] * 100$$

Which, W2 represents the weight of wet soaked specimen of brick and W1 represents the weight of dry specimen of brick [7]. The water absorption of a certain brick mix proportion is calculated by taking average of three specimen of that certain brick mix proportion [16].

C. Thermal conductivity test

Warm execution parameters, for example, explicit warmth limit characterized as — "amount of warmth required to give a unit temperature change to a unit mass of material", were acquired utilizing Differential Scanning Calorimetry warm investigation. A warm conductivity test was achieved utilizing a fast-warm conductivity meter QTM500 instrument utilized for estimating warm conductivity benefits of construction materials. The Instrument of QTM-500 utilized for estimating the warm conductivity has a restricting estimating scope of (0.023 W/(mK) to 12 W/(mK)) by an exactness and reproducibility of ± 5% and ± 3% on perusing esteems separately. The base example dimensions essential for testing is (100 x 50 x 20 mm) thinness. Warm conductivity of ingredients was tried at chamber temperature and at totally immersed conditions utilizing QTM500. Warm mass can be characterized as the — "result of the particular warmth limit and thickness of material"; its SI unit is kJ/K m^2. In genuine conditions, the hygroscopic property of a structure workmanship component likewise impacts its warm exhibition. This is anyway not inside the extent of the present investigation. The collaboration between the microstructure and its hygroscopic spread and capacity is intricate and hard to direct. Further, given the way that the microstructure of the building materials is hard to recreate, such examinations are hard to remain complete repeatable by reliability for logical investigation and examination [3].

D. Efflorescence test

This test is conducted on the clay and fly ash bricks which its results are compared as grey and white deposition. Which in normal bricks it is slight

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to moderate and in fly ash bricks it is in surface area of lesser than 10%. In efflorescence test, the brick is placed longitudinally or vertically as one end immersing into water which the immersion depth of brick at one end in water should 2.5cm. Until the water evaporates, the whole setup must be left in a dry-good-ventilated zone at temperature of 20°C-30°C. After the complete absorption evaporation of water is done, to observe the percentage of appearance of white spots on the exterior of brick. When any change was detected on surface of brick by the deposition of salt content then it is noted or reported as 'efflorescence' and any difference is not appeared then it is noted or reported as 'not efflorescence' [8].

E. Hardness test

This assessment is done on clay and the fly ash by scratching with our finger nail on the surface area of the bricks which does not make any impression on bricks then the bricks are said to be in good condition [8].

F. Soundness test

This test is taken for fly ash and clay bricks by colliding the two bricks of each one by each other. When it provides a good clear ringing sound then it is said to be in good condition [8].

G. Shape and size test

This test is undertaken on clay and the fly ash bricks by broking the brick and when it seems to be free of any defects like lumps, holes etc., then it is said to be that it has good shape and size. Which should be homogeneous and compact [8].

H. Scanning electron microscopy (SEM/EDS)

To study about fracture surface, raw material component and microstructure and mechanism of strength formation of SRM-URB, it is analyzed by help of KYKY-2800B SEM and also by energy dispersive X-ray spectroscopy (EDS). And also, which the Au coated Pre-processed samples are analyzed by the state of ultra-high vacuum operation, Acceleration voltage of kV and secondary electron detector, which the study is done on EDS detector of Kevex-sigma level with resolution of 129eV. Which it can make analyze the elemental range from Be to U [22]. The EDS patterns of SRM and Fly ash are shown in Fig. 1(a) and Fig. 1(b).

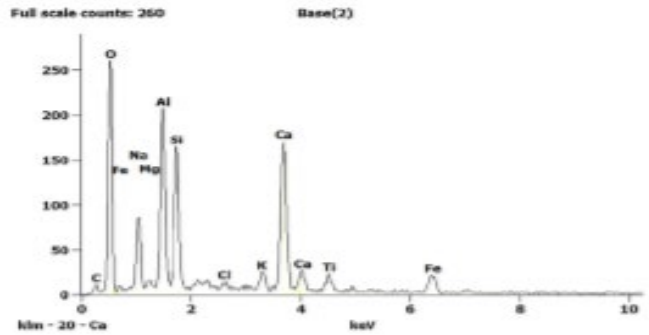

Fig. 1(a)

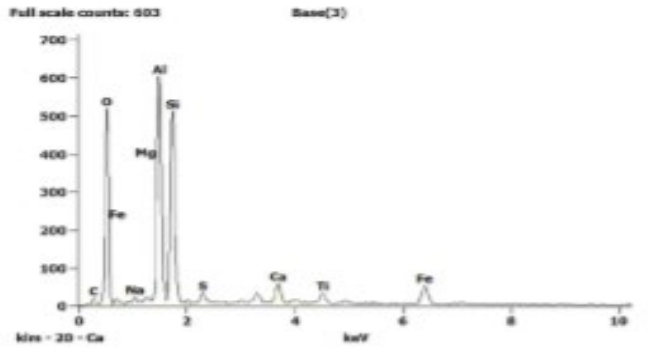

Fig. 1(b)

The characterization of the reactive products of wall blocks that which autoclaved by solid wastes and its microstructure and morphology are analyzed by usage of S-4800 SEM with different admixtures are shown in Fig. 2 [4].

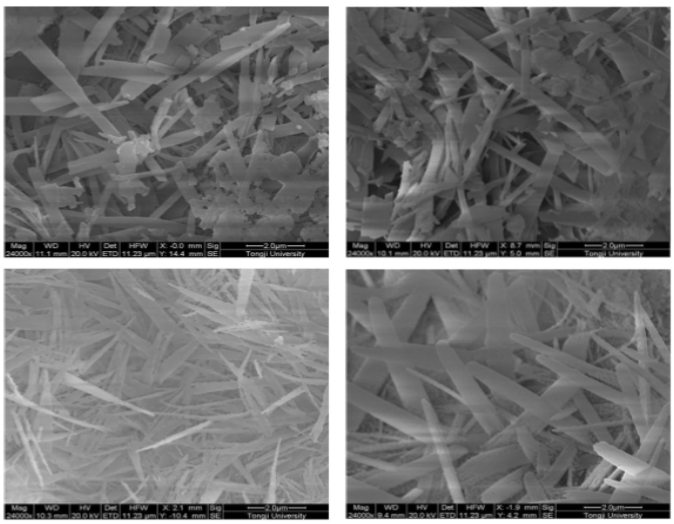

Fig. 2

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The compression strength of specimen sample is done at various levels of curing and oven dried of 110℃ and make them to pass through as a power into 75-micron sieve. From Bruker D8 fully automated advance diffractometer, operating at 40kV with usage of CuKα radiation of 40mA. The collection of data is between the 5° and 100° 2Θ. By Quanta LV/ESEM the SEM imaged are obtained under high pressures and water vapor which it is also added to solid state scatter detector and Standard secondary (Eve hat-Thorley) [14].

VI. DISCUSSION ON TEST RESULTS

A. Compression strength test

Through various experimental results the proportion I gives the maximum value of compressive strength. Which the proportion I mix percentage is an optimal one of fly ash brick that consists of (Fly ash – 5%, Gypsum – 2%, Lime – 30%, Quarry dust - 3%) which it results that decreases of compressive strength when there is increase in fly ash content is shown in Fig. 3 [16].

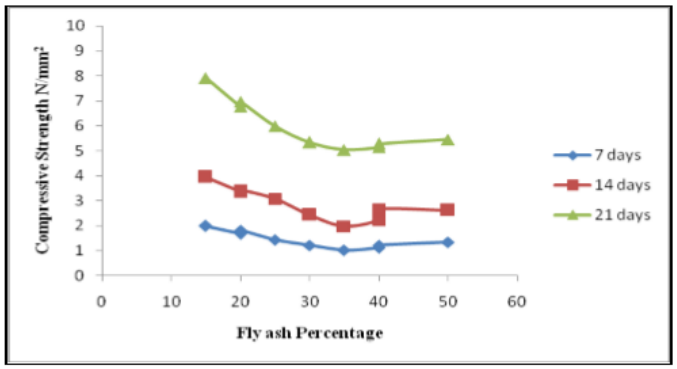

Fig. 3

The bricks provide compressive strength between the range of 7.13MPa and 17.36 MPa. The clay bricks and cement bricks provide the compressive strength of 15 MPa and 12 MPa and 70kgf/cm^2 is the clay brick's minimum compressive strength. Here the increase in cement and fly ash content, increases strength for all mix proportions is observed that shown in Fig. 2a and Fig. 2b. Which they concluded due the rise of fly ash in mixture it enhances strength with the BA:FA proportion of 1:1.25, it provides strength at peak value and 0.45 with ratio of BA/C [11].

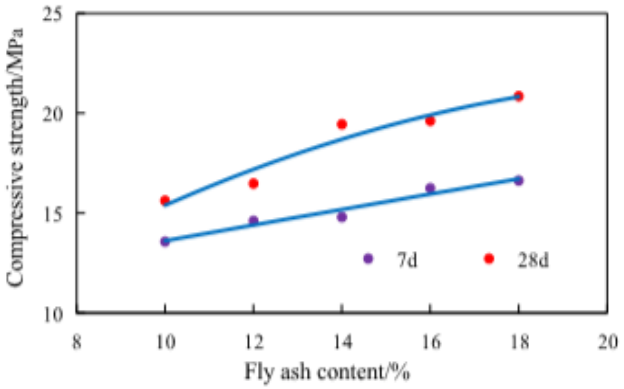

Fig. 4(a)

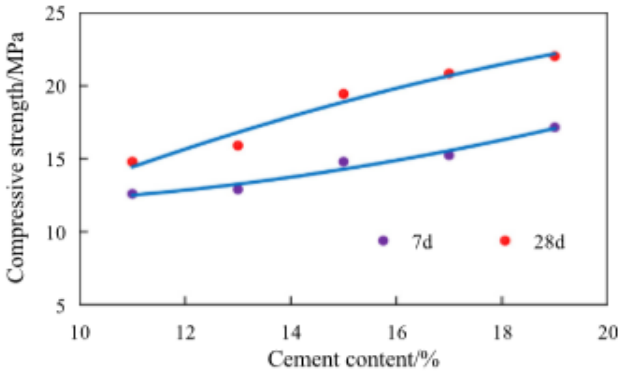

Fig. 4(b)

This experimental investigation shows that the together 28-day of UCS and 7-day of UCS rise with rise of content of fly ash and cement content are mentioned in Fig. 4(a) and Fig. 4(b). Underneath this condition, 12% of fly ash and 37% of RM, where specimens reach 16.48 MPa of UCS that meets requirement of Chinese standard MU15 (GB/T14684-2011) Underneath the high contented of fly ash of 16% and 33% of RM content. 28 day and 7-day of UCS of the sample that reaches 19.62 MPa and 16.25 MPa that which is close to requirement of Chinese standard MU20. When fly ash is utilized as a bearing and structural material it should be used in 16%, otherwise 12% is enough[22].Among the compressive strength of the various mix proportions it is observed that the fine aggregates are replaced at 5% with the plastic waste provides good and high compressive strength

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compared with the conventional brick[7]. Here it is detected that the based-on content of fly ash and cement, the strength of all mixtures increases.

B. Water absorption

In this study, each mixture design ranges between 12.6% and 29.2% of water absorption. The water absorption attains maximum at weather exposure is 17% and at when the weather exposure is moderate for the same bricks is 22%. The mixture of BA:FA ratio 1:05 is the lowest among all value of mixtures. Fly ash is a material which is a water permeable that which increases the absorption of water in the toughened matrix capacity that which it is utilized in mix [11]. Here the absorption of water is decrease in increase of the FA+BS and which increases with W/(BS+QD) increase [18].

C. Thermal conductivity test

Warm properties of stone work units estimated for TM Bricks and FaL-G blocks are mentioned below. The estimation of thickness of TM Bricks is highly contrasted with FaL-G blocks. In that capacity the exterior absorbency estimation of the FaL-G is 20.46% and has a ordinary eccentricity estimation of 3.31; comparatively, TMB has a scope of 20% – 32.17%; this variety is because of the quality kept up during assembling of blocks. The particular warmth limit of FaL-G is lesser than that of TM Brick blocks, that control warmth stockpiling and move over brick work units. The TM Bricks has a developed warm frame contrasted with a FaL-G block [3]. The warm mass relies upon the thickness and explicit warmth limit of brick work units, where goods can be measured and planned by differing the thickness of the ingredients. The warm conductivity of the ingredients assumes a significant job in controlling the warmth move over the workmanship units. It very well may be estimated at dual outrageous circumstances, viz. for totally dry and totally immersed ingredients. It is notable that warm conductivity at soaked circumstances will be more prominent than at dry circumstances [10].

VI. CONCLUSION

Through this various study the conclusion is drawn as,

1. Compressive strength of bricks increases based on the content of fly ash and cement of the bricks.
2. So, the replacement of ingredients which done for fly ash should reduce the compressive strength of brick.
3. Partial replacement materials can be used as filler materials.
4. The increased content of the replacement materials increases the water absorption and permeability and also compressive strength of bricks.
5. Plastic wastes provide good results when they partially replaced in bricks.

REFERENCES

1. Akinwumi, Isaac I., Ayebaemi H. Domo-Spiff, and Adeniyi Salami. "Marine plastic pollution and affordable housing challenge: Shredded waste plastic stabilized soil for producing compressed earth bricks." Case Studies in Construction Materials 11 (2019): e00241.
2. Awoyera, P. O., and A. Adesina. "Plastic wastes to construction products: status, limitations and future perspective." Case Studies in Construction Materials (2020): e00330.
3. Gourav, K., et al. "Studies into structural and thermal properties of building envelope materials." Energy Procedia 122 (2017): 104-108.
4. Guo, Xiaolu, and Tangjun Zhang. "Utilization of municipal solid waste incineration fly ash to produce autoclaved and modified wall blocks." Journal of Cleaner Production 252 (2020): 119759.
5. Gupta, Vivek, et al. "Study on the mineral phase characteristics of various Indian biomass and coal fly ash for its use in masonry construction products." Construction and Building Materials 235 (2020): 117413.
6. Krishna, M. Prudhvi, et al. "Mechanical properties of fly ash/sawdust reinforced epoxy hybrid composites." Materials Today: Proceedings 5.5 (2018): 13025-13030.

May-June 2020
ISSN: 0193-4120 Page No. 6718 - 6725

7. Kumar, K. Prem, and M. Gomathi. "Production of Construction Bricks by Partial Replacement of Waste Plastics." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN (2017): 2278-1684.
8. Kumar, Rinku, and N. Hooda. "An experimental study on properties of fly ash bricks." International journal of research in aeronautical and mechanical engineering 2.9 (2014): 56-67.
9. Kürklü, Gökhan, and Gökhan Görhan. "Investigation of usability of quarry dust waste in fly ash-based geopolymer adhesive mortar production." Construction and Building Materials 217 (2019): 498-506.
10. Lingbawan, Sandra Guzman. "Thermal Properties of Fly Ash Bricks." The UNSW Canberra at ADFA Journal of Undergraduate Engineering Research 2.2 (2009).
11. Naganathan, Sivakumar, Almamon Yousef Omer Mohamed, and Kamal Nasharuddin Mustapha. "Performance of bricks made using fly ash and bottom ash." Construction and Building Materials 96 (2015): 576-580.
12. Pahroraji, Mohamad Ezad Hafez Mohd, et al. "Properties of coal ash foamed brick stabilised with hydrated lime-activated ground granulated blastfurnace slag." Construction and Building Materials 235 (2020): 117568.
13. Rahman, Muhammad Ekhlasur, et al. "Utilization of blended waste materials in bricks." Technologies 6.1 (2018): 20.
14. Reddy, BV Venkatarama, and K. Gourav. "Strength of lime–fly ash compacts using different curing techniques and gypsum additive." Materials and structures 44.10 (2011): 1793-1808.
15. Rushad, S. Tabin, et al. "Experimental studies on lime-soil-fly ash bricks." International Journal of Civil & Structural Engineering 1.4 (2011): 994-1002.
16. Sumathi, A., and K. Saravana Raja Mohan. "Compressive strength of fly ash brick with addition of lime, gypsum and quarry dust." International Journal of ChemTech Research 7.1 (2014): 28-36.
17. Singh, P., and V. P. Sharma. "Integrated plastic waste management: environmental and improved health approaches." Procedia Environmental Sciences 35 (2016): 692-700.
18. Shakir, Alaa A., Sivakumar Naganathan, and Kamal Nasharuddin Mustapha. "Properties of bricks made using fly ash, quarry dust and billet scale." Construction and Building Materials 41 (2013): 131-138.
19. Sarkar, A., et al. "Particle size distribution profile of some Indian fly ash—a comparative study to assess their possible uses." Fuel Processing Technology 86.11 (2005): 1221-1238.
20. Wesche, K., et al. "Test methods for determining the properties of fly ash and of fly ash for use in building materials." Materials and Structures 22.4 (1989): 299-308.
21. Xu, Gang, and Xianming Shi. "Characteristics and applications of fly ash as a sustainable construction material: A state-of-the-art review." Resources, Conservation and Recycling 136 (2018): 95-109.
22. Zhao, Yi, et al. "Preparation and properties of sintering red mud unburned road brick using orthogonal experiments." Construction and Building Materials 238 (2020): 117739.