iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VI **Month of publication:** June 2021

DOI: https://doi.org/10.22214/ijraset.2021.35098

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

Effect of Polypropylene Fiber, GGBS and Fly Ash over the Strength Aspects of Concrete: A Critical Review

Khalid Bashir Mir[1], Sandeep Salhotra[2]
[1]*Student of ME, Chandigarh University, Punjab, India*
[2]*Department of civil engineering, Chandigarh University, Punjab, India*

Abstract: ***In this review study the usage of three different kinds of constructional materials was discussed in detail. The three materials comprised of Ground Granulated Blast Furnace Slag, fly and polypropylene fiber. Ground Granulated Blast Furnace Slag is basically the slag derived after the quenching process of iron slag produced during the processing of iron in iron industry. Fly ash is the waste generated from the coal processing industries and is mainly used in the road constructions works. Polypropylene fiber is a synthetic fiber that has very high tensile strength and flexural strength. This fiber is also known as synthetic fiber as it is mainly used in the synthetic industry.***

Depending upon the results of previous studies over the usage of these materials various conclusions has been drawn which are as follows.

The results of studies related to the usage of Ground Granulated Blast Furnace Slag as partial replacement of cement concluded that the most optimum usage percentage of Ground Granulated Blast Furnace Slag as partial replacement of cement was found to be between 20 percent and 30 percent and beyond this limit the strength of concrete was decreasing.

The past studies related to the usage of fly ash as partial replacement of cement shoed that the most optimum usage percentage of fly ash was found to be between 15 percent to 20 percent and beyond this percentage the strength parameters of concrete such as compressive strength, flexural strength and split tensile strength starts declining up to a greater extent. The studies related to the usage of polypropylene fiber showed that the usage of this fiber increases the compressive strength of soil and the most optimum results were found between 1.0 percent to 1.5 percent usages of polypropylene fiber. Above this percentage there will be negative effect on the strength aspects and the compressive strength starts declining.

Keywords: Fly Ash, Ground Granulated Blast Furnace Slag, Polypropylene Fiber, Green Concrete, Fiber Reinforced Concrete

I. INTRODUCTION

A. General

Concrete is found to be most used constructional material in the world. It is mainly composed of cement, natural fine aggregate and natural coarse aggregate. All these constituents of concrete are mainly derived from different sources but day by day it has been seen that some other alternative materials can also be used for the production of concrete.

The strength aspects of the concrete completely depends upon the percentage, type and properties of its constituent materials , so therefore the strength of the concrete can be improved by using some other supplementary cementitious materials. In this research work different waste materials were studied so as to determine some other waste materials for enhancing the strength parameters of the concrete.

Mainly three materials were discussed in detail that includes ground granulated blast furnace slag that is derived from the iron processing industry, then fly ash which is derived from the coal processing industries and polypropylene fiber.

B. Ground Granulated Blast Furnace Slag

Ground Granulated Blast Furnace Slag of GGBS is mainly the waste slag produced during the processing of iron in the iron processing industry. Ground Granulated Blast Furnace Slag in general aspects is a white powdered form slag that has very high tensile strength and compressive strength. It can be utilized to enhance the properties of both soil as well as concrete and its composites. It is mainly obtained after the quenching of hot iron slag done with the help of either water or steam.

Figure. Ground Granulated Blast Furnace Slag
https://www.alibaba.com/product-detail/Ground-Granulated-Blast-Furnace-Slag-GGBS_62475976867.html

C. Fly Ash

Fly ash is basically the waste generated from the coal processing industries. This waste is then either used for some constructional purpose or dumped in the open space. The dumping of this waste fly ash is very much hazardous from the environmental point of view so an alternative of dumping should be determined so as to reduce impact over the environment. Fly ash is generally of 2 major types that is class f fly ash and class c fly ash depending upon the percentage of the chemical composition of the fly ash.

Figure. Fly Ash
https://www.carboncure.com/concrete-corner/the-future-of-fly-ash-in-concrete/

D. Polypropylene Fiber

Polyprylene is synthetic fiber whose monimer mer is propylene. It is a lined assembly grounded on the monomer CnH_2n. It is mass-produced from propylene gas in existence of a substance such as titanium chloride. Alongside Polyprylene is a by-product of oil decontaminating measures. Most polypropylene employed is highly crystalline and geometrically even (i.e. isotactic) opposite to amorphous thermoplastics, such as polystyrene, PVC, polyamide, etc., which radicals are placed randomly (i.e. ataxic).

Figure. Polypropylene Fiber
https://www.indiamart.com/proddetail/polypropylene-fibers-2475811388.html

II. LITERATURE REVIEW

A. (Xie, Wang, Rao, Wang, & Fang, 2019)

In this research work three materials were used in combined form so as to improve and enhance the strength aspects of the concrete. Recycled concrete aggregate was used as replacement of natural coarse aggregate, ground granulated blast furnace slag was used as partial replacement of ordinary Portland cement and fly ash was used as partial replacement of ordinary Portland cement. Recycled concrete aggregate was used at 100 percent replacement percentage. ground granulated blast furnace slag was used at 25 percent, 50 percent, 75 percent , in combination with fly ash that is replacement at 25 percent, 50 percent, 75 percent. Depending upon the mixes and the combinations, several concrete specimen were prepared and then cured for seven days, fourteen days, twenty eight days and fifty six days. Then all the samples were dried properly in order to remove all kind of moisture content from it. Then several tests were performed and the test results showed that the maximum strength was observed at 50 percent usage of ground granulated blast furnace slag and 50 percent usage of fly ash when used in combined form.

B. (V. R. P. Kumar, Gunasekaran, & Shyamala, 2019)

In this research work coconut shell coarse aggregate and ground granulated blast furnace slag was used in combined form for improving and enhancing the strength parameters of the conventional concrete. Coconut shell coarse aggregate was used as replacement of coarse aggregate and ground granulated blast furnace slag was used as partial replacement of ordinary Portland cement. Coconut shell coarse aggregate was used at 100 percent and ground granulated blast furnace slag was used art different percentages such as 0 percent, 5 percent, 10 percent, 15 percent and 20 percent. Both ground granulated blast furnace slag and coconut shell coarse aggregate was used in combination with each other not separately. After this several cubes, beams and cylinders were casted and the cured for 7 days and 28 days. After proper curing all the samples were then tested for compressive strength test, flexural strength test and split tensile strength test. The test results showed that the maximum strength was obtained at 15 percent usage of ground granulated blast furnace slag and 100 percent usage of coconut shell coarse aggregate when used in combination with each other.

C. (Tavasoli, Nili, & Serpoush, 2018)

In this experimental work ground granulated blast furnace slag and silica fume were used in combined form as well as in separate for predicting the strength aspects of the conventional concrete or normal concrete. Both ground granulated blast furnace slag and the silica fume were used as partial replacement of cement at different percent. First ground granulated blast furnace slag was used at 0 percent, 30 percent, 50 percent, 65 percent and 80 percent, to predict the most optimum percentage of ground granulated blast furnace slag to be used as partial replacement of cement. From the test results it was found that at 50 percent replacement usage strength aspects were maximum. After this 50 percent of ground granulated blast furnace slag was used in combination with silica fume at 5 percent, 1o percent and 15 percent. Then several samples were prepared and the results conclude that in combined form the maximum strength was obtained at 50 percent usage of ground granulated blast furnace slag and 5 percent usage of silica fume.

D. (P. Kumar, Pankar, Manish, & Santhi, 2018)

In this experimental research work related to concrete, ground granulated blast furnace slag and metakaoline were used in combination with each other to enhance the strength aspects of the concrete. Both ground granulated blast furnace slag and metakaoline are supplementary cementitious materials so were mainly used as partial replacement of ordinary Portland cement. Ground granulated blast furnace slag was used at 20 percent, 50 percent and at 80 percent and similarly metakaoline was used at 20 percent, 50 percent and 80 percent. Alkaline hydroxide and silicate solution were also used to improve the overall strength aspects of the concrete samples. After this several cube, beams and cylinder were casted depending upon the compressive strength test, flexural strength test and split tensile strength test respectively. The test results showed that the maximum strength was obtained at 50 percent usage of ground granulated blast furnace slag and 50 percent usage of metakaoline.

E. (Vijaya Bhaskar Reddy & Srinivasa Rao, 2016)

In this investigational study, micro silica and ground granulated blast furnace slag were used in combination with each other so as to improve the strength and engineering properties of the conventional concrete. For achieving this goal, both micro silica and ground granulated blast furnace slag were used as partial replacement of ordinary Portland cement in combinations with one another. Micro silica was used at 0 percent, 5 percent, 10 percent and 15 percent whereas ground granulated blast furnace slag was used at 20 percent, 30 percent, 40 percent and 50 percent. After this several samples were prepared and all the samples were tested for compressive strength test of concrete. The test results concluded that the maximum strength was obtained at 40 percent usage of

ground granulated blast furnace slag and 10 percent usage of micro silica when both these were used in combinations with one another.

F. (Saboo, Shivhare, Kori, & Chandrappa, 2019)

In this research study, metakaoline and fly ash were mainly used to enhance the strength and durable properties of the normal concrete. For achieving this goal, first both the materials were collected from the nearest available source and the tested for its physical and chemical properties. After this both the materials were used as partial replacement of ordinary Portland cement. Metakaoline was used at lower percentages of 0 percent, 1 percent and 2 percent, while fly ash was used at higher percentages from 0 percent to 20 percent at an increment of 5 percent in each case respectively. After this several cubes were casted and compressive strength test was performed over it. The test results of the compressive strength test showed that the maximum strength was achieved at 2 percent usage of metakaoline and 20 percent usage of fly as when used in combination with each another as replacement of cement.

G. (Matos, Foiato, & Prudêncio, 2019)

This research work deals with the production of self-compacting concrete with the usage of fly ash and some chemical in the normal conventional concrete. For achieving this goal 2 different kind of fly ash were used that was class f fly ash and class c fly ash. Both the types of fly ash were used as partial replacement of ordinary Portland cement. Chemicals used for the research were sodium acierate. Both types of fly ash were used from 40 percent to 60 percent, at an increment of 5 percent in each case respectively that means usage was done at 40 percent, 455 percent, 50 percent, 55 percent and 60 percent. The test results for the formation of self-compacting concrete using fly bash showed that the compaction using fly ash was enhanced using both types of the fly ash and the most optimum percentage was conclude to be 45 percent for both types of fly ash.

H. (Tošić, Marinković, Pecić, Ignjatović, & Dragaš, 2018)

In this research work recycled concrete aggregate and fly ash was mainly used to improve the strength aspects of the concrete and to utilize this waste materials in concrete as a constructional material. Recycled concrete aggregate was used as partial replacement of the natural coarse aggregate and the fly ash was used as replacement of the ordinary Portland cement. Recycled concrete aggregate was used at 50 percent and 10 percent, while fly ash was used from 0 percent to 20 percent at an increment of 5 percent in each case that is it was mainly used at 0 percent, 5 percent, 10 percent, 15 percent and 20 percent. Then depending upon the percentages of Recycled concrete aggregate and fly ash several specimen were casted and after curing were tested for compressive strength test and flexural strength test. The test results showed that the maximum strength was obtained at 15 percent usage of fly ash and 100 percent usage of recycled concrete aggregate when used in combined form.

I. (Nath, Sarker, & Biswas, 2018)

In this research work fly ash was mainly used as partial replacement of ordinary Portland cement. This research work was mainly carried out in marine environment so as to predict the behavior of concrete under marine conditions. Basically fly ash was used as partial replacement of ordinary Portland cement at 10 percent, 20 percent, 30 percent and 40 percent and then tested in marine environment. For achieving this, first several cubes, beams and cylinders were casted and the cured for 3 days, 7 days, 14 days and 28 days. Then all the samples were dried properly so as to remove extreme moisture concrete from it. After this the concrete was kept in marine conditions like container so as to predict its strength parameters under marine conditions after this the samples were taken out and then tested compressive strength test, flexural strength test and split tensile strength test. The test results showed that the maximum strength was achieved at 20 percent usage of fly ash under marine conditions.

J. (W. Wang, Lu, Li, & Li, 2017)

In this research work fly ash was mainly used to enhance the strength aspects of the conventional concrete. Fly ash was mainly as a waste from the coal processing industry and then used in concrete as replacement of ordinary Portland cement. Fly as mainly used as partial substitution of ordinary Portland cement at 0 percent, 5 percent, 10 percent, 15 percent, 20 percent, 25 percent and 30 percent. For achieving the main goal first several specimens were casted and then cured for three days, seven days, fourteen days and twenty eight days. After proper curing all the samples were dried in oven so as to remove moisture content from it. After drying it was tested for flexural strength test and split tensile strength test. The test results of both flexural strength test and split tensile strength test showed that the maximum strength was achieved at 20 percent usage of fly ash and beyond this limit the flexural strength and split tensile strength was decreasing rapidly.

III. CONCLUSIONS

A. General

In this review study the usage of three different kinds of constructional materials was discussed in detail. The three materials comprised of Ground Granulated Blast Furnace Slag, fly and polypropylene fiber. Ground Granulated Blast Furnace Slag is basically the slag derived after the quenching process of iron slag produced during the processing of iron in iron industry. Fly ash is the waste generated from the coal processing industries and is mainly used in the road constructions works. Polypropylene fiber is a synthetic fiber that has very high tensile strength and flexural strength. This fiber is also known as synthetic fiber as it is mainly used in the synthetic industry. Depending upon the results of previous studies over the usage of these materials various conclusions has been drawn which are as follows.

B. Ground Granulated Blast Furnace Slag

The results of studies related to the usage of Ground Granulated Blast Furnace Slag as partial replacement of cement concluded that the most optimum usage percentage of Ground Granulated Blast Furnace Slag as partial replacement of cement was found to be between 20 percent and 30 percent and beyond this limit the strength of concrete was decreasing.

C. Fly Ash

The past studies related to the usage of fly ash as partial replacement of cement shoed that the most optimum usage percentage of fly ash was found to be between 15 percent to 20 percent and beyond this percentage the strength parameters of concrete such as compressive strength, flexural strength and split tensile strength starts declining up to a greater extent.

D. Polypropylene Fiber

The studies related to the usage of polypropylene fiber showed that the usage of this fiber increases the compressive strength of soil and the most optimum results were found between 1.0 percent to 1.5 percent usages of polypropylene fiber. Above this percentage there will be negative effect on the strength aspects and the compressive strength starts declining.

IV. FURTHER CREDITS

(Agrawal, Wanjari, & Naresh, 2019; Bouaissi, Li, Al Bakri Abdullah, & Bui, 2019; Caetano, Rodrigues, & Pimienta, 2019; Castoldi, Souza, & de Andrade Silva, 2019; Chen, Wang, Najm, Venkiteela, & Hencken, 2019; Das, Dey, Dandapat, Mukharjee, & Kumar, 2018; Eidan, Rasoolan, Rezaeian, & Poorveis, 2019; Gao, He, Li, Tang, & Qu, 2017; Guo et al., 2019; Hossain, Shahjalal, Islam, Tiznobaik, & Alam, 2019; Huang, Xu, Chi, Deng, & Zhang, 2019; Khan & Ali, 2019; M. P. Kumar, Mini, & Rangarajan, 2018; P. Kumar et al., 2018; V. R. P. Kumar et al., 2019; Lee, Wang, Ding, & Cheng, 2019; Limbachiya, Ganjian, & Claisse, 2016; Matos et al., 2019; Mohebi, Bahnamiri, & Dehestani, 2019; Müller, Novák, & Holan, 2019; Nagrockienė & Rutkauskas, 2019; Nath et al., 2018; Nguyen, Chatchawan, Saengsoy, Tangtermsirikul, & Sugiyama, 2019; Qin, Zhang, Chai, Xu, & Li, 2019; Rajini & Sashidhar, 2019; Rao, Sravana, & Rao, 2016; Saboo et al., 2019; Tavasoli et al., 2018; Teixeira, Camões, Branco, Aguiar, & Fangueiro, 2019; Tošić et al., 2018; Vijaya Bhaskar Reddy & Srinivasa Rao, 2016; D. Wang, Ju, Shen, & Xu, 2019; W. Wang et al., 2017; Xie, Wang, Rao, et al., 2019; Xie, Wang, Zhang, Fang, & Li, 2019)

REFERENCES

[1] Agrawal, U. S., Wanjari, S. P., & Naresh, D. N. (2019). Impact of replacement of natural river sand with geopolymer fly ash sand on hardened properties of concrete. *Construction and Building Materials, 209*, 499-507. doi:https://doi.org/10.1016/j.conbuildmat.2019.03.134

[2] Bouaissi, A., Li, L.-y., Al Bakri Abdullah, M. M., & Bui, Q.-B. (2019). Mechanical properties and microstructure analysis of FA-GGBS-HMNS based geopolymer concrete. *Construction and Building Materials, 210*, 198-209. doi:https://doi.org/10.1016/j.conbuildmat.2019.03.202

[3] Caetano, H., Rodrigues, J. P. C., & Pimienta, P. (2019). Flexural strength at high temperatures of a high strength steel and polypropylene fibre concrete. *Construction and Building Materials, 227*, 116721. doi:https://doi.org/10.1016/j.conbuildmat.2019.116721

[4] Castoldi, R. d. S., Souza, L. M. S. d., & de Andrade Silva, F. (2019). Comparative study on the mechanical behavior and durability of polypropylene and sisal fiber reinforced concretes. *Construction and Building Materials, 211*, 617-628. doi:https://doi.org/10.1016/j.conbuildmat.2019.03.282

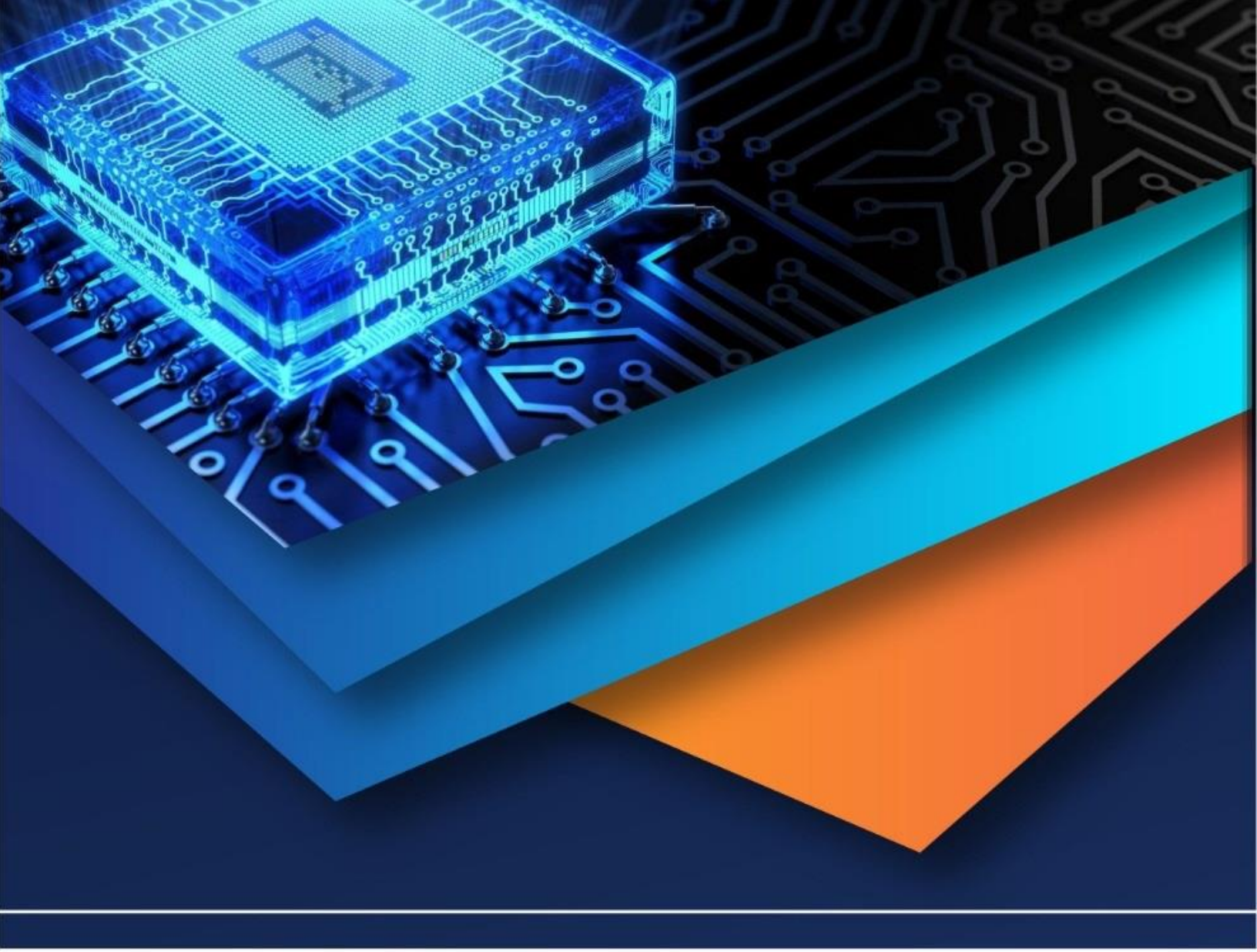
[5] Chen, X., Wang, H., Najm, H., Venkiteela, G., & Hencken, J. (2019). Evaluating engineering properties and environmental impact of pervious concrete with fly ash and slag. *Journal of Cleaner Production, 237*, 117714. doi:https://doi.org/10.1016/j.jclepro.2019.117714

[6] Das, C. S., Dey, T., Dandapat, R., Mukharjee, B. B., & Kumar, J. (2018). Performance evaluation of polypropylene fibre reinforced recycled aggregate concrete. *Construction and Building Materials, 189*, 649-659. doi:https://doi.org/10.1016/j.conbuildmat.2018.09.036

[7] Eidan, J., Rasoolan, I., Rezaeian, A., & Poorveis, D. (2019). Residual mechanical properties of polypropylene fiber-reinforced concrete after heating. *Construction and Building Materials, 198*, 195-206. doi:https://doi.org/10.1016/j.conbuildmat.2018.11.209

[8] Gao, Y., He, B., Li, Y., Tang, J., & Qu, L. (2017). Effects of nano-particles on improvement in wear resistance and drying shrinkage of road fly ash concrete. *Construction and Building Materials, 151*, 228-235. doi:https://doi.org/10.1016/j.conbuildmat.2017.06.080

[9] Guo, H., Tao, J., Chen, Y., Li, D., Jia, B., & Zhai, Y. (2019). Effect of steel and polypropylene fibers on the quasi-static and dynamic splitting tensile properties of high-strength concrete. *Construction and Building Materials, 224*, 504-514. doi:https://doi.org/10.1016/j.conbuildmat.2019.07.096
[10] Hossain, F. M. Z., Shahjalal, M., Islam, K., Tiznobaik, M., & Alam, M. S. (2019). Mechanical properties of recycled aggregate concrete containing crumb rubber and polypropylene fiber. *Construction and Building Materials, 225*, 983-996. doi:https://doi.org/10.1016/j.conbuildmat.2019.07.245
[11] Huang, L., Xu, L., Chi, Y., Deng, F., & Zhang, A. (2019). Bond strength of deformed bar embedded in steel-polypropylene hybrid fiber reinforced concrete. *Construction and Building Materials, 218*, 176-192. doi:https://doi.org/10.1016/j.conbuildmat.2019.05.096
[12] Khan, M., & Ali, M. (2019). Improvement in concrete behavior with fly ash, silica-fume and coconut fibres. *Construction and Building Materials, 203*, 174-187. doi:https://doi.org/10.1016/j.conbuildmat.2019.01.103
[13] Kumar, M. P., Mini, K. M., & Rangarajan, M. (2018). Ultrafine GGBS and calcium nitrate as concrete admixtures for improved mechanical properties and corrosion resistance. *Construction and Building Materials, 182*, 249-257. doi:https://doi.org/10.1016/j.conbuildmat.2018.06.096
[14] Kumar, P., Pankar, C., Manish, D., & Santhi, A. S. (2018). Study of mechanical and microstructural properties of geopolymer concrete with GGBS and Metakaolin. *Materials Today: Proceedings, 5*(14, Part 2), 28127-28135. doi:https://doi.org/10.1016/j.matpr.2018.10.054
[15] Kumar, V. R. P., Gunasekaran, K., & Shyamala, T. (2019). Characterization study on coconut shell concrete with partial replacement of cement by GGBS. *Journal of Building Engineering, 26*, 100830. doi:https://doi.org/10.1016/j.jobe.2019.100830
[16] Lee, W.-H., Wang, J.-H., Ding, Y.-C., & Cheng, T.-W. (2019). A study on the characteristics and microstructures of GGBS/FA based geopolymer paste and concrete. *Construction and Building Materials, 211*, 807-813. doi:https://doi.org/10.1016/j.conbuildmat.2019.03.291
[17] Limbachiya, V., Ganjian, E., & Claisse, P. (2016). Strength, durability and leaching properties of concrete paving blocks incorporating GGBS and SF. *Construction and Building Materials, 113*, 273-279. doi:https://doi.org/10.1016/j.conbuildmat.2016.02.152
[18] Matos, P. R. d., Foiato, M., & Prudêncio, L. R. (2019). Ecological, fresh state and long-term mechanical properties of high-volume fly ash high-performance self-compacting concrete. *Construction and Building Materials, 203*, 282-293. doi:https://doi.org/10.1016/j.conbuildmat.2019.01.074
[19] Mohebi, Z. H., Bahnamiri, A. B., & Dehestani, M. (2019). Effect of polypropylene fibers on bond performance of reinforcing bars in high strength concrete. *Construction and Building Materials, 215*, 401-409. doi:https://doi.org/10.1016/j.conbuildmat.2019.04.230
[20] Müller, P., Novák, J., & Holan, J. (2019). Destructive and non-destructive experimental investigation of polypropylene fibre reinforced concrete subjected to high temperature. *Journal of Building Engineering, 26*, 100906. doi:https://doi.org/10.1016/j.jobe.2019.100906
[21] Nagrockienė, D., & Rutkauskas, A. (2019). The effect of fly ash additive on the resistance of concrete to alkali silica reaction. *Construction and Building Materials, 201*, 599-609. doi:https://doi.org/10.1016/j.conbuildmat.2018.12.225
[22] Nath, P., Sarker, P. K., & Biswas, W. K. (2018). Effect of fly ash on the service life, carbon footprint and embodied energy of high strength concrete in the marine environment. *Energy and Buildings, 158*, 1694-1702. doi:https://doi.org/10.1016/j.enbuild.2017.12.011
[23] Nguyen, T. B. T., Chatchawan, R., Saengsoy, W., Tangtermsirikul, S., & Sugiyama, T. (2019). Influences of different types of fly ash and confinement on performances of expansive mortars and concretes. *Construction and Building Materials, 209*, 176-186. doi:https://doi.org/10.1016/j.conbuildmat.2019.03.032
[24] Qin, Y., Zhang, X., Chai, J., Xu, Z., & Li, S. (2019). Experimental study of compressive behavior of polypropylene-fiber-reinforced and polypropylene-fiber-fabric-reinforced concrete. *Construction and Building Materials, 194*, 216-225. doi:https://doi.org/10.1016/j.conbuildmat.2018.11.042
[25] Rajini, B., & Sashidhar, C. (2019). Prediction mechanical properties of GGBS based on geopolymer concrete by using analytical method. *Materials Today: Proceedings, 19*, 536-540. doi:https://doi.org/10.1016/j.matpr.2019.07.729
[26] Rao, S. K., Sravana, P., & Rao, T. C. (2016). Abrasion resistance and mechanical properties of Roller Compacted Concrete with GGBS. *Construction and Building Materials, 114*, 925-933. doi:https://doi.org/10.1016/j.conbuildmat.2016.04.004
[27] Saboo, N., Shivhare, S., Kori, K. K., & Chandrappa, A. K. (2019). Effect of fly ash and metakaolin on pervious concrete properties. *Construction and Building Materials, 223*, 322-328. doi:https://doi.org/10.1016/j.conbuildmat.2019.06.185
[28] Tavasoli, S., Nili, M., & Serpoush, B. (2018). Effect of GGBS on the frost resistance of self-consolidating concrete. *Construction and Building Materials, 165*, 717-722. doi:https://doi.org/10.1016/j.conbuildmat.2018.01.027
[29] Teixeira, E. R., Camões, A., Branco, F. G., Aguiar, J. B., & Fangueiro, R. (2019). Recycling of biomass and coal fly ash as cement replacement material and its effect on hydration and carbonation of concrete. *Waste Management, 94*, 39-48. doi:https://doi.org/10.1016/j.wasman.2019.05.044
[30] Tošić, N., Marinković, S., Pecić, N., Ignjatović, I., & Dragaš, J. (2018). Long-term behaviour of reinforced beams made with natural or recycled aggregate concrete and high-volume fly ash concrete. *Construction and Building Materials, 176*, 344-358. doi:https://doi.org/10.1016/j.conbuildmat.2018.05.002
[31] Vijaya Bhaskar Reddy, S., & Srinivasa Rao, D. P. (2016). Experimental studies on compressive strength of ternary blended concretes at different levels of micro silica and ggbs. *Materials Today: Proceedings, 3*(10, Part B), 3752-3760. doi:https://doi.org/10.1016/j.matpr.2016.11.024
[32] Wang, D., Ju, Y., Shen, H., & Xu, L. (2019). Mechanical properties of high performance concrete reinforced with basalt fiber and polypropylene fiber. *Construction and Building Materials, 197*, 464-473. doi:https://doi.org/10.1016/j.conbuildmat.2018.11.181
[33] Wang, W., Lu, C., Li, Y., & Li, Q. (2017). An investigation on thermal conductivity of fly ash concrete after elevated temperature exposure. *Construction and Building Materials, 148*, 148-154. doi:https://doi.org/10.1016/j.conbuildmat.2017.05.068
[34] Xie, J., Wang, J., Rao, R., Wang, C., & Fang, C. (2019). Effects of combined usage of GGBS and fly ash on workability and mechanical properties of alkali activated geopolymer concrete with recycled aggregate. *Composites Part B: Engineering, 164*, 179-190. doi:https://doi.org/10.1016/j.compositesb.2018.11.067
[35] Xie, J., Wang, J., Zhang, B., Fang, C., & Li, L. (2019). Physicochemical properties of alkali activated GGBS and fly ash geopolymeric recycled concrete. *Construction and Building Materials, 204*, 384-398. doi:https://doi.org/10.1016/j.conbuildmat.2019.01.191



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY