JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Experimental Investigations on Properties of Green Concrete Using Pozzocrete P60 and Recycled Plastic Polypropylene – A REVIEW

[1] T. Shanthanathan, [2] Dr.K. Ramadevi

[1] PG Student, [2]Professor
[1] Department of Civil Engineering,
[1] Kumaraguru College of Technology, Coimbatore – 641 049, Tamilnadu, India

Abstract : The escalating environmental concerns and the need for sustainable construction materials have fuelled the exploration of innovative alternatives in the field of concrete technology. This study examines the experimental investigation of green concrete using recycled plastic polypropylene as a partial replacement for fine aggregate and Pozzocrete P60 as a supplementary cementitious material. The experimental program involves the formulation of concrete mixtures with varying proportions of Pozzocrete P60 and recycled plastic polypropylene. Concrete was partially substituted by Pozzocrete P60 fly ash at levels of 0%, 10%, 20%, 30%, 40% 50% by weight and recycled plastic polypropylene is used as partial replacement of fine aggregate in the ratio of 3% at which added in the concrete as optimum percentage. The primary objective is to assess the influence of these sustainable additives on the mechanical and durability properties of the resulting concrete. Mechanical properties, including compressive strength, flexural strength, and split tensile strength, will be evaluated. Additionally, durability aspects, such as water absorption, permeability, and resistance to chemical attacks, will be investigated to determine the long-term performance of the concrete material. Furthermore, the environmental impact of the green concrete will be assessed through day today analysis, considering factors such as energy consumption, carbon footprint, and resource utilization. The findings of this study aim to contribute valuable insights into the feasibility and efficiency of utilizing Pozzocrete P60 and recycled plastic polypropylene in the production of sustainable and eco-friendly concrete. The Innovation could act as a guide for the building sector toward environmentally friendly options, encouraging sustainable practices without compromising structural integrity.

Index Terms **- Green concrete, Pozzocrete P60, Recycled plastic polypropylene, Sustainable construction, Mechanical properties, Durability, Environmental impact.**

INTRODUCTION

In the present day, the construction industry is rapidly increasing on a big scale, which demands a large consumption of concrete. Concrete is made out of cement, gravel, sand, and water. As sustainability becomes a focus in the building sector, the exploration and use of cement alternatives expands, offering a range of benefits for both the environment and structural performance. This innovation approach involves incorporating supplementary cementitious materials and recycled additives to minimize the environmental impact of concrete production. The costs of cement are also constantly rising. With ever-increasing global challenges caused by industrial waste products, there is a critical need to utilise these goods properly to decrease health and environmental problems. Investigating the revolutionary potential of Pozzocrete P60 as a partial replacement for cement, in addition to the dynamic incorporation of Recycled Placstic polypropylene as a fine aggregate substitute focusing on the experimental investigations conducted to explore the unique properties imparted by the combination of Pozzocrete P60 and recycled plastic polypropylene. Pozzocrete P60, an advanced pozzolan, is known for its ability to enhance concrete performance and sustainability, while recycled plastic polypropylene introduces a recycled element, reducing the demand for virgin materials and addressing plastic waste concerns. This study provides a detailed investigation into the characteristics of green concrete with a focus on the positive relationships between recycled plastic polypropylene and Pozzocrete P60.

LITERATURE STUDY

1)Ahmed S. Ouda, Mahmoud Gharieb - (18 January 2021) Investigate on PFA waste was modified upon partially replaced with the CW waste at replacement levels of 0%, 5%, 10%, 15% and 20%, by weight. The hardened specimens were cured in 100% RH at 40 ± 2 ℃ for 1, 7, 14 and 28 days. After 28 days, some specimens were exposed to elevated temperatures of 200 ℃, 400 ℃, 600 ℃ and 1000 ℃ with a heating rate of 5 ℃ /min. Another batch of specimens were subjected to seawater for 1, 3 and 6 months. The mechanical properties as well as microstructure analysis prior and after exposure were monitored. the results show that the inclusion of CW in alkali-activated pastes containing PFA has a positive influence on properties in terms

of compressive strength and morphology structure. At the substitution level of 20%, the compressive strength was reduced compared to the other mixtures, however it increased against the reference samples. The mix M10 exhibited the higher compressive strength values in wet and dry conditions at all curing times. The inclusion of CW up to 20% increased the compressive strength at 200 °C and 400°C of exposure, due to increased adhesion forces between the gel particles within the geopolymer matrix, as a result of the release of chemically crystallized water after exposure to thermal loads.

2)Rushabh Shah, Dr. Jayeshkumar Pitroda – (February 2013) Discusses on the use of masonry in load-bearing structures and high-rise buildings, particularly in developing and underdeveloped countries. It highlights the importance of mortar in the performance of masonry walls and the need to explore the use of waste materials in construction. This study also presents the experimental investigation on the compressive strength development of mortar in which cement is partially replaced with Pozzocrete (P40, P60 and P100) as 0%, 10%, 30%and 50% by weight of cement. Four set of mixture proportions were made. The findings in this research suggest that it is less economical to make high-strength masonry mortars by incorporating Pozzocrete (P40, P60, and P100) into mixed cement. Adequate strength developments were not found in mortars made of the mixed cement and Pozzocrete. The results indicate that the % change in cost reduce up to 15.72 for 50% replacement of Pozzocrete (P40) and 10.06 for 50% replacement of Pozzocrete (P60).

3)Ahmed S. Ouda, (2021) In this study, the effects of pozzocrete fly ash (PFA) on the physical, mechanical, and radiation shielding properties of alkali-activated geopolymer mixtures made from calcined concrete waste-based dolomite aggregate (DCW) were investigated. Two series of geopolymer samples were prepared with different levels of sodium hydroxide as an alkaline activator. The concrete waste was partially replaced with PFA at various weight percentages. The bulk density, compressive strength, attenuation coefficients (μ & μm), and gamma transmission factors (half-value layer, HVL; tenth-value layer, TVL; and mean free path, MFP) were measured at different hydration times. The gamma attenuation coefficients were determined using a NaI (Tl) scintillation detector with Cs-137 and Co-60 radiation sources. The results showed that the inclusion of 15% PFA in the DCW-geopolymer system activated with 10% sodium hydroxide improved both the physical and mechanical properties. Additionally, this geopolymer composite exhibited superior performance in attenuating gamma rays through a 5 cm thickness shield compared to other mixtures.

4) Shah Palas A, Mehta Jay G, PathariyaSaraswati C, RanaJaykrushna A, Patel Ankit N, (2014), In this experimental investigation, SBA was used as a partial replacement for fine aggregate at a ratio of 10%. Cement was then replaced with Pozzocrete (P60) at ratios of 10%, 20%, and 30%. Concrete specimens were casted and tested at 7, 14, and 28 days. The compressive strength of the concrete was compared with traditional concrete. The compressive strength of the concrete increased with an increase in the partial replacement of Pozzocrete. The optimum strength of concrete was achieved with a 10% replacement of Pozzocrete and a 10% replacement of fine aggregate with SBA. The cost analysis of the materials used in the concrete mix showed that the total cost varied depending on the type of concrete and the percentage of replacement. The cost of materials included cement, fine aggregate, coarse aggregate, grit, SBA, and Pozzocrete. Based on the experimental study, it can be concluded that the utilization of sugarcane bagasse ash and Pozzocrete in concrete offers several benefits. It leads to the development of eco-friendly building materials, reduces CO2 emissions, and minimizes stress on the environment. The optimum replacement percentages for SBA and Pozzocrete were found to be 10%. This research provides valuable insights into the use of waste materials in concrete production for improved strength and cost-effectiveness.

5) Dushyant R. Bhimani, Jayeshkumar Pitroda, Jaydev J. Bhavsar – (2013), They conducted experiments to determine the compressive strength and water absorption of concrete with different mix proportions of Pozzocrete and used foundry sand. The study aims to achieve technical, ecological, and economic benefits by utilizing these industrial wastes in construction applications. The document also mentions the importance of recycling foundry sand and Pozzocrete to save energy, reduce the need for virgin materials, and minimize health and environmental problems. The study aimed to investigate the engineering and construction properties of concrete made with a partial replacement of cement by Pozzocrete P60 and fine aggregate by used foundry sand. Five different mix proportions were tested, with varying percentages of Pozzocrete P60 and used foundry sand. Compressive strength tests were conducted at 7, 14, and 28 days, and water absorption tests were performed at 28 days.The results showed that the addition of Pozzocrete P60 and used foundry sand had a significant impact on the compressive strength and water absorption of the concrete. The compressive strength increased with the addition of Pozzocrete P60, and the highest strength was observed in the mix with 30% Pozzocrete P60 and 50% used foundry sand. The water absorption also decreased with the addition of Pozzocrete P60 and used foundry sand, indicating improved durability of the concrete.

6) Arash Karimipour – (2020), The document discusses the use of untreated coal waste (UCW) as a replacement for natural aggregates in concrete. The study aims to find a solution to reduce the negative impact of UCW on the environment. The properties of concrete, such as slump, compressive strength, splitting tensile strength, flexural resistance, dry unit weight, elastic modulus, water absorption, and electric resistivity, are measured with different contents of UCW as aggregates. The influence of UCW as a partial replacement for natural coarse aggregates (NCA) and natural fine aggregates (NFA) is examined. Steel fibers (SF) and polypropylene fibers (PPF) are also added to the concrete mixtures to mitigate the negative effects of high replacement contents of UCW. The slump value decreases with the replacement of NCA with up to 10% of UCCA, but then increases when more than 10% of UCCA is used. Adding fibers reduces the workability of concrete, with steel

fibers (SF) having a greater impact than polypropylene fibers (PPF). The compressive strength of concrete is also influenced by the replacement of NCA with UCCA and the addition of fibers, with UCCA reducing the strength and fibers improving it. The electrical resistivity of concrete, which is related to its durability properties, is affected by the water absorption and the type of fibers used. Overall, the document provides insights into the effects of different materials and factors on the workability and mechanical properties of concrete.

7) Faiz U.A. Shaikh, Steve W.M. Supit (9 March 2015), It discusses the use of ultrafine fly ash in concrete and various tests and analyses conducted on concrete specimens to evaluate their properties and durability. The tests include compressive strength, water sorptivity, chloride diffusion, mercury intrusion porosimetry, rapid chloride permeability, volume of permeable voids, and accelerated corrosion. The document also mentions the use of ultrafine fly ash in concrete mixtures and its effects on workability and strength. The addition of ultrafine fly ash (UFFA) in concrete has shown several positive effects. It has reduced the workability of concrete and the reduction in slump increases with an increase in UFFA content. UFFA has also improved the compressive strength of concrete at all ages, with the highest strength achieved when cement is replaced by 8% UFFA. Additionally, UFFA has been effective in reducing the pore space and its connectivity inside the concrete, leading to a reduction in chloride diffusion and improved corrosion resistance. The incorporation of UFFA has also resulted in a decrease in the mass loss of rebar due to corrosion. Overall, the use of UFFA in concrete has shown promising results in terms of workability, strength, durability, and corrosion resistance.

8) Steve W.M. Supit, Faiz U.A. Shaikh, Prabir K. Sarker (28 November 2013), The study investigates the impact of ultrafine fly ash (UFFA) on the compressive strength and workability of mortars. The experimental work involves replacing a certain percentage of cement with UFFA and evaluating the strength development of the mortars. The physical properties and mixture proportions of the materials used are also provided in the document. The experimental works are divided into two parts. Part one is conducted in binary blended cement mortar where Portland cement (PC) type I is replaced by UFFA at level of 5%, 8%, 10%, 12% and 15% (by wt). In this part, cement mortar and high-volume fly ash (HVFA) mortars containing 40%, 50%, 60% and 70% of class F fly ash are also prepared and used as control mortars. The UFFA level which exhibited highest compressive strength is the selected and used in part two where the effect of UFFA in high volume fly ash replacement is evaluated. The study reveals that the cement mortars with 8% UFFA of cement replacement exhibited higher compressive strength at 7 and 28 days than control mortars. There is also a great improvement on compressive strength of HVFA mortars, particularly at early age. The large surface area of the UFFA promotes the hydration process and enhances the microstructure of the cement mortars to yields better strength and mechanical properties.

9) Patricia Kara D Maeijer, Bart Craeye, Ruben Snellings, Hadi Kazemi-Kamyab ,Michel Loots, Koen Janssens , Gert Nuyts (13 October 2020), This document discusses an experimental program that investigates the behavior of ultra-fine fly ash in cement-rich environments, specifically at the paste, mortar, and concrete levels. The study aims to determine the effect of fly ash on the workability, mechanical properties, and durability of concrete. In the study, a total of 8 different concrete mixes were produced. Four mixes were made with CEMI cement, including a reference mix with 0% fly ash (CEMI-REF), a mix with 15% FA1 cement replacement (CEMI-FA1-15%), a mix with 25% FA2 cement replacement (CEMI-FA2-25%), and a mix with 25% cement replacement with FA1 and FA2 (CEMI-FA1 + FA2-25%). Similarly, four mixes were made with CEMIII cement, including a reference mix with 0% fly ash (CEMIII-REF), a mix with 15% FA1 cement replacement (CEMIII-FA1-15%), a mix with 25% FA2 cement replacement (CEMIII-FA2-25%), and a mix with 25% cement replacement with FA1 and FA2 (CEMIII-FA1 + FA2-25%). Each mix had a constant water/binder ratio of 0.45. A total of 152 specimens were produced for testing mechanical properties and durability, including 15 cubes and 4 cylinders per mix. the compressive strength of concrete with 25% cement replacement using ultra-fine fly ash (FA2) was equal to the reference mix at 28 days. In terms of durability, replacing cement with ultra-fine fly ash had a positive impact on resistivity, chloride migration coefficient, and alkali-silica reaction (ASR), but had a negative impact on carbonation resistance. The study concluded that 25% cement replacement with ultra-fine fly ash was the most effective in limiting the risk of harmful ASR.

10) Xiao Han, Jinbo Yang, Jingjing Feng , Cuiling Zhou, Xiaoqing Wang (30 August 2019) The authors conducted experiments to compare the hydration performance and mechanical properties of cement pastes and mortars containing different percentages of FA and UFA. The utilization of ultrafine fly ash cement (UFAC) can improve the hydration performance and mechanical properties of concrete. UFAC paste has a higher hydration rate and lower cumulative hydration heat compared to cement paste. The fine particles of ultrafine fly ash (UFA) in UFAC paste act as nucleating centers and contribute to the formation of compact microstructure. UFAC mortar has higher flexural strength and compressive strength compared to cement mortar after 90 days of curing. UFA exhibits a higher pozzolanic effect and filling effect than regular fly ash (FA), leading to improved mechanical strength in the long term.

11) Shi Yin , Rabin Tuladhar , Tony Collister, Mark Combe, Nagaratnam Sivakugan, Zongcai Deng (15 October 2015) In this study, the post-cracking performance of different types of recycled polypropylene (PP) fibres was assessed and compared to virgin PP fibres in concrete. The research focused on the relationship between residual flexural strength and cracking behavior, as well as the ability of the fibres to redistribute stresses and bridge cracks. The Round Determinate Panel Test (RDPT) and Crack Mouth Opening Displacement (CMOD) test were used to evaluate the post-cracking behavior of the fibre reinforced concrete. The results showed that the diamond-indent recycled fibres exhibited excellent post-cracking

performance, with a good balance of tensile strength, Young's modulus, and concrete bonding. This research demonstrated the feasibility of using recycled fibres as reinforcement in concrete footpaths.

12) G.M. Sadiqul Islam, Sristi Das Gupta (29 May 2016). This document discusses the experimental study conducted on fibre reinforced concrete to evaluate its permeability characteristics. The study includes information on the materials used, concrete mix proportions, and testing methods. The document also provides data on the physical properties of aggregates and fibres, as well as the permeability coefficients of different types of fibre reinforced concretes. The study used non-metallic fibres (polypropylene) for reinforcing and crack-resisting in concrete, with fibre content ranging from 0.1% to 0.3% by volume. Concrete mix proportions were prepared to achieve a target strength of 35 MPa at 28 days, with variations in superplasticizer dosage and fibre proportions. The study conducted various tests, including compression and split tensile strength tests, as well as gas and water permeability tests, on both plain concrete and fibre reinforced mixes. The document provides data on the physical properties of aggregates and fibres, as well as the permeability coefficients of different types of fibre reinforced concretes.

13) Ibrahim H. Alfahdawi, S. A. Osman, R. Hamid, Abdulkader Ismail Al-Hadithi (August 2016) In this study, discusses the utilization of waste plastic polypropylene and polyethylene terephthalate (PET) as alternative aggregates to produce lightweight concrete. The article highlights the benefits of using plastic materials in concrete, such as enhanced mixture quality and reduced environmental impact. It also provides information on the preparation of plastic materials, their effects on the physical and mechanical properties of concrete, and potential applications. The document emphasizes the need for further research in this field and suggests areas for future investigation. The use of plastic materials in concrete can improve mixture quality and reduce the accumulation of single-use plastic waste. The use of plastic materials in concrete mixes can enhance the compressive strength. Substituting plastic materials for 0.1% to 0.5% of the mix volume can improve the compressive strength by approximately 8% to 14.2%. Adding plastic at a ratio of 1% of the total mix volume can improve the compressive strength by as much as 35%. However, using a greater volume of plastic materials at ratios of 0.6% to 1.5% of the total mix volumes can result in reductions in compressive strength from 4% to as high as 43%.

14) Athika Wongkvanklom, Patcharapol Posi, Sahalaph Homwuttiwong, Vanchai Sata, Ampol Wongsa, Duangkanok Tanangteerapong, and Prinya Chindaprasirt (03 May 2019) In this study, discusses the use of recycled plastic materials in geopolymer-based concrete. Geopolymer is a sustainable alternative binder that emits less CO2 and requires less energy compared to Portland cement. The document highlights the positive impact of replacing sand with recycled plastic in terms of weight, density, water absorption, and thermal insulating property. The strength and density of the concrete meet the minimum requirements of structural lightweight concrete according to ASTM C330. It highlights the positive impact of replacing sand with 25% and 50% RPB on weight, density, water absorption, and thermal insulating property. The mechanical properties of the RPB geopolymer concrete were also investigated. The study concludes that replacing RPB aggregate by 25%-50% produces concrete with acceptable mechanical properties, making it suitable for structural lightweight concrete. The results showed that replacing 25% to 50% of sand with RPB had a positive impact on the weight, density, water absorption, and thermal insulating property of the concrete. The strength and density of the concretes met the minimum requirements of structural lightweight concrete according to ASTM C330. However, replacing sand with higher percentages of RPB resulted in a decrease in compressive strength and other mechanical properties. Overall, it is suggested to use RPB geopolymer concrete as structural lightweight concrete due to its acceptable mechanical properties and compliance with ASTM standards.

15) Rabar H. Faraj, Aryan Far H. Sherwani, Ako Daraei (21 May 2019), In this study, discusses the durability properties of concrete, including the sorptivity test and gas permeability test. The sorptivity test measures the rate of water absorption by the concrete, while the gas permeability test determines the ability of gases to pass through the concrete. The document also mentions the use of silica fume in concrete mixtures, which can improve compressive strength. Overall, the document provides information on testing methods and factors that can affect the durability of concrete. The compressive strength of SCHSC is significantly reduced with increasing RPPP content, but SCHSC with compressive strength higher than 70 MPa at 90 days can be produced by using a RPPP content up to 40% replacement level and 10% SF. The results of the tests conducted on the concrete mixtures showed that the addition of RPPP and SF had an impact on various properties of the concrete, including workability, chloride ion penetrability, fracture energy, gas permeability, water sorptivity, and compressive strength. The specific effects varied depending on the content of RPPP and SF in the mixtures.

16) Hind M. AbdelMoti, Mustafa A. Mustafa (Februry-2019), In this study, the use of polypropylene waste plastic pellets as a partial replacement for fine aggregate in concrete. The study includes the materials used, such as cement, fine aggregate, coarse aggregate, and plastic waste. It also provides information on the mixture proportions and testing methods used to evaluate the fresh and hardened properties of the concrete. The results and discussion section highlights the impact of the plastic waste on the mechanical properties of the concrete. Overall, the document explores the potential of using plastic waste as a sustainable alternative in concrete production. The study investigated the effects of replacing fine aggregate with polypropylene (PP) plastic pellets in concrete mixtures. The compressive strength decreased with increasing percentages of PP replacement, attributed to the weak adhesive bond between the PP surface and the cement paste. The splitting tensile strength also decreased, while the flexural strength showed a slight increase compared to the control mixture. The density of the concrete decreased with higher percentages of PP replacement. In conclusion, the incorporation of plastic waste, such as PET

bottles, LDPE, and PVC, in concrete can have both positive and negative effects on its properties. The type, shape, and size of the plastic waste, as well as the substitution level, play a crucial role in determining the impact on concrete. Further research is needed to optimize the use of plastic waste in concrete and develop sustainable construction practices.

SUMMARY

The above-mentioned journals refer focusing on altering PFA waste by integrating CW waste at varying substitution levels. Displays a favourable impact on both compressive strength and microstructure upon CW inclusion. Suggests an increase in strength under higher temperatures due to enhanced adhesion forces. Examining the influence of Pozzocrete on mortar strength, it suggests challenges in achieving economically feasible high-strength mortar and indicates fewer notable improvements in mortars combining mixed cement and Pozzocrete. Concentrating on the effects of PFA in geopolymer mixtures alongside DCW, it exhibits enhancements in specific physical and mechanical properties with designated PFA proportions, showcasing superior performance in gamma ray absorption compared to other mixtures. Exploring the utilization of SBA and Pozzocrete in concrete to improve strength and cost-effectiveness, it proposes optimal replacement percentages and environmental benefits. This use results in increased concrete strength and reduced water absorption. Investigating the effects of Pozzocrete and foundry sand on concrete properties, it demonstrates heightened compressive strength and decreased water absorption, thus enhancing concrete durability. Studying the impacts of UCW on concrete properties, it discusses diverse mechanical attributes influenced by UCW and fiber additions. Evaluating the effects of UFFA on concrete workability, strength, and durability, it highlights positive impacts on compressive strength and reduced pore space, enhancing durability. Focusing on UFFA's influence on cement mortars, it uncovers enhanced compressive strength with UFFA, contributing to improved mechanical properties. Analyzing the effects of UFA on cement pastes and mortars, it emphasizes the beneficial impact of UFAC paste on hydration performance and mechanical properties. Assessing the post-cracking behavior of different recycled PP fibers in concrete, it underscores the superior performance of diamond-indent recycled fibers in reinforcing concrete. the incorporation of plastic waste, such as PET bottles, LDPE, and PVC, in concrete can have both positive and negative effects on its properties. The type, shape, and size of the plastic waste, as well as the substitution level, play a crucial role in determining the impact on concrete. Further research is needed to optimize the use of plastic waste in concrete and develop sustainable construction practices.

REFERENCES

[1]. Ahmed S. Ouda, Mahmoud Gharieb - (18 January 2021), Behavior of alkali-activated pozzocrete-fly ash paste modified with ceramic tile waste against elevated temperatures and seawater attacks, Construction and Building Materials, VOL. 285 (2021) 122866, P 1-14, DOI: https://doi.org/10.1016/j.conbuildmat.2021.122866

[2]. Rushabh Shah, Dr. Jayeshkumar Pitroda – (February 2013), Pozzocrete: Modern Material Partially Replaced with Cement in Mortar. ISSN: 2278-3075, Volume-2, Issue-3, February 2013 P 105 – 108, DOI: https://www.researchgate.net/publication/281178268

[3]. Ahmed S. Ouda, (2021), A preliminary investigation on gamma-rayattenuation of alkali-activated concrete waste based-geopolymer modified with pozzocrete-fly ash, Progress in Nuclear Energy 134 (2021) 103681, P 1 – 10, DOI: https://doi.org/10.1016/j.pnucene.2021.103681

[4]. Shah Palas A, Mehta Jay G, PathariyaSaraswati C, RanaJaykrushna A, Patel Ankit N, (2014), Sugarcane Baggase Ash and Pozzocrete as a Techno-Economical Solution in Design Mix Concrete, Volume: 4 Issue: 5 May 2014 | ISSN - 2249-555X, P 243 – 245.

[5]. Dushyant R. Bhimani, Jayeshkumar Pitroda, Jaydev J. Bhavsar – (2013), Innovative Ideas for Manufacturing of the Green Concrete by Utilizing the Used Foundry Sand and Pozzocrete, ISSN: 2319–6378, Volume-1, Issue-6, April 2013, P 28 – 32, DOI: International Journal of Emerging Science and Engineering (IJESE).

[6]. Arash Karimipour – (2020), Effect of untreated coal waste as fine and coarse aggregates replacement on the properties of steel and polypropylene fibres reinforced concrete, Mechanics of materials, VOL, (2020) 103592, P 2 – 20, DOI: https://doi.org/10.1016/j.mechmat.2020.103592.

[7]. Faiz U.A. Shaikh, Steve W.M. Supit (9 March 2015), Compressive strength and durability properties of high-volume fly ash (HVFA) concretes containing ultrafine fly ash (UFFA), Construction and Building Materials, VOL 82 (2015) 192–205, P 193 – 205, DOI: http://dx.doi.org/10.1016/j.conbuildmat.2015.02.068

[8]. Steve W.M. Supit, Faiz U.A. Shaikh, Prabir K. Sarker (28 November 2013), Effect of ultrafine fly ash on mechanical properties of high-volume fly ash mortar, Construction and Building Materials,VOL 51 (2014) 278–286, P 279 – 286, DOI: http://dx.doi.org/10.1016/j.conbuildmat.2013.11.002.

[9]. Patricia Kara D Maeijer, Bart Craeye, Ruben Snellings, Hadi Kazemi-Kamyab, Michel Loots, Koen Janssens, Gert Nuyts (13 October 2020), Effect of ultra-fine fly ash on concrete performance and durability Construction and Building Materials, VOL 263 (2020) 120493, P 1-13, DOI: https://doi.org/10.1016/j.conbuildmat.2020.120493.

[10]. Xiao Han, Jinbo Yang, Jingjing Feng, Cuiling Zhou, Xiaoqing Wang (30 August 2019) Research on hydration mechanism of ultrafine fly ash and cement composite, Construction and Building Materials, VOL 227 (2019) 116697, P 1-13, DOI: https://doi.org/10.1016/j.conbuildmat.2019.116697

[11]. Shi Yin, Rabin Tuladhar, Tony Collister, Mark Combe, Nagaratnam Sivakugan, Zongcai Deng (15 October 2015), post-cracking performance of recycled polypropylene fibre in concrete, Construction and Building Materials,VOl 101 (2015) 1069–1077, P 1070 – 1077, DOI: http://dx.doi.org/10.1016/j.conbuildmat.2015.10.056

[12]. G.M. Sadiqul Islam, Sristi Das Gupta (29 May 2016), Evaluating plastic shrinkage and permeability of polypropylene fiber reinforced concrete, Waste Management 28 (2008) 1835–1852, P 1836 – 1859.

[13]. Ibrahim H. Alfahdawi, S. A. Osman, R. Hamid, Abdulkader Ismail Al-Hadithi (August 2016), Utilizing waste plastic polypropylene and polyethylene terephthalate as alternative aggregates to produce lightweight concrete. Journal of Engineering Science and Technology Vol. 11, No. 8 (2016) 1165 – 1173, P 1165 – 1173.

[14]. Athika Wongkvanklom, Patcharapol Posi, Sahalaph Homwuttiwong, Vanchai Sata, Ampol Wongsa, Duangkanok Tanangteerapong, and Prinya Chindaprasirt (03 May 2019), Lightweight Geopolymer Concrete Containing Recycled Plastic Beads, Key Engineering Materials, ISSN: 1662-9795, Vol. 801, P 377-384.

[15]. Rabar H. Faraj, Aryan Far H. Sherwani, Ako Daraei (21 May 2019), Mechanical, Fracture, and Durability Properties of Self-Compacting High Strength Concrete Containing Recycled Polypropylene Plastic Particles, Journal of Building Engineering (2019), P 1 -13, DOI: https://doi.org/10.1016/j.jobe.2019.100808

[16]. Hind M. AbdelMoti, Mustafa A. Mustafa (Februry-2019), Use of Polypropylene Waste Plastic Pellets as Partial Replacement for Fine Aggregate in Concrete, UofKEJ Vol. 9 Issue 1 pp. 37- 43 (Februry-2019), DOI: www.ejournals.uofk.edu.