PERFORMANCE OF GEOPOLYMER SELF COMPACTING CONCRETE USING SPENT GARNET AS SAND REPLACEMENT

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All Praise for Allah, Creator of This Universe
Thanks for The Precious Iman & Islam You Blessed on Me
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And, Peace Be Upon the Holy Prophet Muhammad SAW.
Thanks

I dedicated this work to:
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ABSTRACT

Robust engineering properties of spent garnet offer a recycling alternative to create efficient construction materials. Recycling of spent garnet provides a cost-effective and environmentally responsible solution rather than dumping it as industrial waste. In this context, the present work evaluated the capacity of spent garnet as sand replacement to achieve self-compacting geopolymer concrete. The self-compacting geopolymer concrete was prepared using ground granulated blast furnace slag whereas the river sand was replaced by spent garnet of varying contents in the range of 0 to 100% under constant Liquid/Binder mass ratio of 0.4. Experiments were carried out to evaluate the leaching performance, microstructure, physical and chemical behaviour of the spent garnet specimens. Furthermore, mix design combined with the fresh and hardened features of the spent garnet based self-compacting geopolymer concrete were performed. Performance evaluations of the developed self-compacting geopolymer concrete were made using various tests such as compressive, splitting tensile, flexural, durability and workability (slump, L-box, V-box and T50) consistent with the requirements and guiding principles of European Federation of National Associations representing concrete. Meanwhile, the morphology, bonding and thermal properties of self-compacting geopolymer concrete were determined using X-ray diffraction, field emission scanning electron microscopy, Fourier transform infrared spectroscopy, and thermo gravimetric analysis. Experimental results revealed an enhancement in the workability of the proposed self-compacting geopolymer concrete specimens due to the increase in spent garnet contents. However, the mechanical strength of the proposed self-compacting geopolymer concrete was discerned to be lower compared to the control sample at every garnet content ratio replacement stage. Concretes prepared with sand replaced spent garnet demonstrated excellent resistance to carbonation than the control sample. Based on the analysis, the results suggest that the spent garnet is proven to be a suitable replacement of sand.

ABSTRAK

Ciri-ciri kejuruteraan garnet terpakai yang kukuh menawarkan alternatif kitar semula untuk mencipta bahan pembinaan yang cekap. Kitar semula garnet terpakai menyediakan penyelesaian kos yang efektif dan bertanggungjawab terhadap alam sekitar berbanding dengan membuangnya sebagai sisa industri. Dalam konteks ini, kajian terkini menilai kemampuan garnet terpakai sebagai pengganti pasir untuk mendapatkan konkrit geopolimer terpadat sendiri. Konkrit geopolimer terpadat sendiri disediakan dengan menggunakan sanga relau bagas dikisar manakala pasir sungai digantikan dengan garnet terpakai pada pelbagai kandungan dalam julat 0 hingga 100% di bawah nisbah jisim Cecair/Pengikat malar 0.4. Kajian dijalankan untuk menilai prestasi larut lesap, mikrostruktur, tingkah laku fizikal dan kimia spesimen garnet terpakai. Selain itu, reka bentuk campuran digabungkan dengan ciri-ciri segar dan keras garnet terpakai daripada konkrit geopolimer terpadat sendiri. Penilaian prestasi konkrit geopolimer terpadat sendiri telah dibuat dengan menggunakan pelbagai ujian seperti mampatan, pemisahan tegangan, lenturan, ketahanlasakan, dan kebolehkerjaan (ujian runtuhan, *L-box*, *V-box*, dan T50) selaras dengan keperluan dan prinsip-prinsip panduan Persekutuan Persatuan Kebangsaan Eropah yang mewakili konkrit. Sementara itu, sifat morfologi, ciri-ciri terma dan ikatan konkrit geopolimer terpadat sendiri ditentukan dengan menggunakan analisis pembelauan sinar-X, mikroskop elektron pengimbasan pancaran medan, spektroskop inframerah jelmaan Fourier dan terma gravimetri. Dapatan kajian menunjukkan terdapat peningkatan dalam kebolehkerjaan spesimen konkrit geopolimer terpadat sendiri akibat peningkatan kandungan garnet terpakai. Walau bagaimanapun, kekuatan mekanikal konkrit geopolimer terpadat sendiri yang dicadangkan adalah lebih rendah berbanding dengan konkrit sampel kawalan pada setiap peringkat penggantian nisbah kandungan garnet terpakai. Konkrit yang disediakan dengan garnet terpakai yang menggantikan pasir menunjukkan ketahanan yang sangat baik terhadap pengkarbonatan berbanding sampel kawalan. Berdasarkan analisis, hasil dapatan kajian menunjukkan bahawa garnet terpakai terbukti mampu menjadi pengganti pasir yang sesuai.

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LIST OF ABBREVIATIONS

ACI	-	American Concrete Institute
ASTM	-	American Society for Testing and Materials
BS	-	British Standard
Ca	-	Calcium
$CaCO_3$	-	Calcium Carbonate
CaO	-	Calcium Oxide
C-A-S-H	-	Calcium Alumina Silicate Hydrate
CO_2	-	Carbon Dioxide
GP	-	Geopolymer
GPC	-	Geopolymer Concrete
C-S-H	-	Calcium Silicate Hydrate
DTA	-	Differential Thermal Analysis
EFNARC	-	European Federation of National Associations Representing
FESEM	-	Field Emission Scanning Electron Microscope for Concrete
FTIR	-	Fourier Transform Infrared
GBFS	-	Granulated Blast Furnace Slag
GPC	-	Geopolymer Concrete
H_2SO_4	-	Sulphuric Acid
MoE	-	Modulus of Elasticity
NaOH	-	Sodium Hydroxide
Q	-	Quartz
SiO_2	-	Silica
SP	-	Super Plasticizer
TGA	-	Thermo Gravimetric Analysis

LIST OF SYMBOLS

m1	-	Mass of container
m2	-	Mass of container with fresh concrete
W	-	Percentage of water absorption
Wd	-	Weight of specimen dry
Ww	-	Weight of specimen wet
V	-	Volume of container

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CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Rapid industrial growth has witnessed the ever-increasing utilization of sand from rivers for various construction purposes, which caused an over-exploitation of rivers' beds and disturbed the eco-system. Numerous problems have emerged including the increase of river bed depth, lowering of the water table, increase of salinity and destruction of river embankments (Gourley,2003). Recently, intensive researches have proven that modified concretes obtained by incorporating waste materials can lead to sustainable product development. Such concrete structures not only allow for greener and environmentally sound construction but also protect the excessive consumption of natural fine aggregates that are non-renewable (Temuujin, 2010). Thus, proper use of fine aggregates in the concretes as alternative materials became an absolute necessity for the replacement of river sand. In this regard, utilization of spent garnets emerged as a promising alternative in its own right.

The so called "garnet" is a generic word that refers to an assemblage of multifaceted minerals of silicate compounds containing Calcium (Ca), Magnesium (Mg), Ferrous iron (Fe) or Manganese (Mn), Aluminium (Al), Chromium (Cr), Ferric iron (Fe) or even Titanium (Ti) having analogous crystal lattice structures and varied chemical formulas (Castel,2010). Interestingly, the angular fractures and hardness properties of garnets together with their ability to be recycled make them advantageous for numerous abrasive applications. The common chemical composition of garnet is $A_3B_2(SiO_4)_3$ wherein the element "A" may be Ca, Mg, ferrous iron, or Mn, Al, Cr, ferric iron or Ti (Rodina, 2013). Garnets have major industrial uses such as water jet cutting, abrasive blast medium and powder, granule for water filtration, and other (Lindtner, 2014).

A comprehensive assessment on a major shipyard industry in the southern province of Malaysia revealed that the country imported approximately 2000 MT of garnets in 2013 alone, and a large quantity was dumped as wastes. Generally, abrasive blasting technique is used to prepare the surfaces for coating and painting (Roskill Information Services Ltd., 2000). This technique is used for the construction of vessels, ship maintenance and repair activities. Thus, blasting process creates large quantities of exhausted garnet wastes mixed with surface elements such as paint chips and oil. Such garnet wastes cause many environmental and health hazards like water contamination when these materials enter the waterways during flood or through runoffs. Therefore, spent garnets pose a threat to the ecological balance and biodiversity. Garnets can be reused about 3 to 5 times keeping their overall properties intact. Garnets are discarded from the shipyards and nominated as "spent garnet" Moreover, these recycled garnets degrade at a level beyond which they are non-reusable for abrasive blast purposes. Afterwards, these inoperative garnets are abandoned from the shipyard and designated as "spent garnet" (Garnett, 2013). Recently, it has been recognized that utilization of these spent garnets as replacement for fine aggregates in self-compacting geopolymer concrete may offer greener alternative construction materials to the ordinary Portland cement (OPC) based concrete.

Universally, Ordinary Portland Cement (OPC) possessing excellent mechanical properties, moderately cheap and easy accessibility makes it the most commonly used binder for construction materials production. Thus, OPC based concretes is preferred in diversified purposes (Davidovits, 1991). Nonetheless, OPC manufacturing leads to the depletion of natural habitats, manufacturing of fossil fuels, and substantially high CO_2 emissions which our planet cannot afford to anymore. To overcome those threats, many dedicated efforts have been made to search for efficient alternative substances such as alkali-activated materials interpreted as geopolymer in short GP. The cost production of geopolymer concrete 1.7 % higher than OPC for the same grade (Thaarrini, 2016).

These alternative substances are proven to be advantageous for sustainable development when industrial by-products are partially applied as precursor matter as a substitute of main raw mineral binder including OPC. Moreover, the final product exhibits improved characteristics than OPC based concrete dependent on the implemented raw minerals and alkali activations. Factors such as the poorer heat of hydration, rapid development of early strength, formation of stronger aggregate to matrix interface, poorer thermal conduction (TC), and elevated resistance of acid and fire (Provis, 2010) also influence considerably the overall properties of the ultimate products. Generally, alkali activated materials are classified in two categories: (a) a high calcium system with granulated blast furnace slag as a usual precursor, where gel of calcium alumina silicate hydrate nature is the major product of reaction, (b) a low calcium product having Class F fly ash (FA) and metakaolin as constituent raw materials, where gel of sodium alumina silicate hydrate kind in the form of three-dimensional network is produced as the main product of reaction.

Categorically, the flow ability of self-compacting concretes' (SCC) under their own weight without requiring any exterior compaction vibration has modernized the placement of concretes. A group of researchers from Japan in the late 1980s first introduced the concept of SCC (Domone, 2006). It was established that a greatly workable concrete such as SCC display a flow under its own weight via constrained segments in the absence of any segregation or bleeding. Such concretes must possess comparatively a small yield to guarantee enhanced flow capacity, reasonable viscosity to oppose separation and bleeding. Furthermore, it must retain the homogeneity during transport, placement and curing to guarantee sufficient structure performance and long-standing endurance.

Despite many researches toward sand replacements for concrete infrastructures, exploitation of spent garnet waste as construction material product is seldom focussed. Considering those notable engineering properties of spent garnet waste this research explored the feasibility of incorporating different levels of spent garnet as a replacement for river sand to achieve an enhanced self-compacting geopolymer concrete (SCGPC). self-compacting geopolymer concrete specimens were thoroughly characterized to determine their compressive, flexural, workability durability and microstructure as a function of varying percentages of spent garnet inclusion.

1.2 Problem Statement

There are three main research questions in this study:

1. What are the effects of spent garnet on the fresh and hardened characteristics of the self-compacting geopolymer concrete in terms of workability and mechanical strength.
2. What are the effects of spent garnet on self-compacting geopolymer concrete durability such us carbonation, sulphate attack, acid attack.
3. What are the effects of spent garnet on the morphology of self-compacting geopolymer concrete such us bonding and thermal analysis.

1.3 Aim and Objectives

This study aims at developing self-compacting geopolymer concrete incorporating spent garnet as fine aggregate. three objectives were formulated to achieve the aim of the study, they are:

1- To determine the physical and chemical properties of spent garnet according to standard requirements of sand set by EFNARC, ASTM and BS.
2- To determine the effects of spent garnet on the fresh and hardened characteristics of the self-compacting geopolymer concrete in terms of workability and mechanical strength.
3- To determine the effects of spent garnet on self-compacting geopolymer concrete durability such us carbonation, sulphate attack, acid attack and microstructural properties.

1.4 Scope of the Research

This work conducted several experiments (for synthesis, characterization and performance evaluation) and mainly focused to develop the sustainable SCGPC containing spent garnet with varying level (25%, 50%, 75% and 100%) of replacement to river sand. The properties of the constituent concrete materials including leaching behaviour, carbonation, thermal and mechanical characteristics and microstructures of the garnet were examined.

The workability, mechanical strengths, deformation (modulus of elasticity) and durability characteristics of the developed SCGPC were evaluated to make a comparison with that of traditional concretes. Tests such as L-Box, Slump, U-Box, T50, compressive strengths, flexural strengths, indirect tensile strengths, drying shrinkage, modulus of elasticity, carbonation, acid and sulphate resistance were carried out to determine the performance of formulated SCGPC. The hardened SCGPC with optimum composition was selected to examine the crystallinity, microstructure, bonding and thermal properties using X-ray diffraction, field emission scanning electron microscopy, fourier transform infrared spectroscopy, thermo gravimetric analysis/differential thermal analysis.

1.5 Significance of the Research

Certainly, the use of spent garnet in self-compacting geopolymer concrete as an alternative to river sand is beneficial in terms of saving the environmental pollution and over exploitation of natural resources. Most of the recycling efforts that limits the wastes disposal can be overcome by properly using the spent garnets in making SCGPC (Lottermoser, 2011). Use of spent garnets directly contributes to the sustainable development, cost-effective way of SCGPC manufacturing and preservation of natural sand from further degradation. Currently, enormous amount of spent garnet is regularly disposed and used for land filling that require high transportation cost and is labour intensive. This not only pollutes the environment but have no monetary gain. Present work will solve these existing problems by systematically incorporating the spent garnet in place of sand to prepare new composition of sustainable SCGPC. This kind of SCGPC will be economically viable because of high abundance, non-toxic nature and cost-effectiveness of spent garnets as main constituent of self-compacting geopolymer concrete. It is demonstrated that spent garnets are potential substitute material to river sand in the building and structural engineering. Thus, use of spent garnet in place of fine aggregates to make concrete will avoid the over-usage of natural sand. This research effort is expected to bring modernization in the Malaysian construction industries, encourage builders and engineers to use eco-friendly spent garnet based SCGPC than the conventional one made of natural river sand.

1.6 Thesis Organisation

The present thesis is composed of seven chapters as follows:

Chapter 1 provides a brief background and overview of the research to identify the research gap, clarifies the problem statement and rationale of the research. Based on the problem to be solved it sets the goal and relevant objectives. Furthermore, it discusses the research scope and significance.

Chapter 2 presents a comprehensive literature review to justify the problem statement. Past development in SCGPC, ongoing activities in the field of spent garnet based concrete production and future trends in SCGPC based on spent garnets as a replacement to river sand is emphasized.

Chapter 3 describes the experimental research methodology in detail starting from raw materials selection, GPC preparation using spent garnet (fine aggregates) of varying contents by replacing river sand, SCGPC composition optimization, samples characterizations and performance evaluations. All the tests and methods applied to determine the fresh and hardened properties of synthesized SCGPC and their durability issues are explained to fulfil the proposed research objectives.

Chapter 4 presents the experimental results in terms of analyses, discussions, evaluations and comparisons with other works on similar SCGPC. Results on physiochemical properties of spent garnets and their effects on the fresh as well as hardened properties of SCGPC are highlighted. Results obtained on workability using the tests such as slump, L-box, V-box, T50 and hardened properties are discussed in terms of compressive, flexural, tensile strength, DS and modulus of elasticity.

Chapter 5 explains and discusses the results obtained from different tests on durability performed on control specimen as well as spent garnet based geopolymer concrete. Results from the durability tests on SCGPC such as drying shrinkage, water absorption, accelerated carbonation, resistance to acid and sulphate attack are investigated.

Chapter 6 presented the results on thermal properties, bonding vibrations, crystalline structures, surface morphology and microstructures of spent garnets obtained via TGA/DTA, FESEM, FTIR and XRD analysis. Furthermore, results on microstructure studies of SCGPC are presented at 6 months and above of strength development.

Chapter 7 concludes the overall performance of spent garnet as sand replacement in self-compacting geopolymer concrete, major contributions, and novelties of the present study.

Chapter 8 concludes the conclusion of research objectives and some suggestions are underlined as recommendations for further research in this frontline area of civil engineering.

REFERENCES

ACI 211.4R-08. (2008). Guide for Selecting Proportions for High-Strength Concrete Using Portland Cement and Other Cementitious Materials, ACI Manual of Concrete Practice, part 1 (pp. 25). Farmington Hills, Michigan, USA, American Concrete Institute.

ACI 318-02 (1995). Building Code Requirements for Structural Concrete and Commentary. *American Concrete Institute, Farmington Hills, Michigan, USA.* 373.

ACI Committee 363 (1992). State of the Art Report on High-Strength Concrete.

Aggarwal, Y. and Siddique, R. (2014). Microstructure and Properties of Concrete Using Bottom Ash and Waste Foundry Sand as Partial Replacement of Fine Aggregates. *Construction and Building Materials.* 54 210-223.

Aggarwal, Y., Siddique, R., 2014. Microstructure and Properties of Concrete using Bottom Ash and Waste Foundry Sand as Partial Replacement of Fine Aggregates. Constr. Build. Mater. 54, 210–223.

Ako, A. M., Hewitt, I. J., Mereacre, V., Clérac, R., Wernsdorfer, W., Anson, C. E., & Powell, A. K. (2006). A Ferromagnetically Coupled Mn19 Aggregate with a Record S= 83/2 Ground Spin State. *Angewandte Chemie*, *118*(30), 5048-5051.

Al Qadi, Arabi NS, and Sleiman M. Al-Zaidyeen. Effect of Fibre Content and Specimen Shape on Residual Strength of Polypropylene Fibre Self-compacting Concrete Exposed to Elevated Temperatures. *Journal of King Saud University-Engineering Sciences* 26.1 (2014): 33-39.

Ali, M. A., Krishnan, S., & Banerjee, D. C. (2001). Beach and Inland Heavy Mineral Sand Investigations and Deposits in India—An Overview. *Exploration and Research for Atomic Minerals*, *13*, 1-21.

Al-Jabri, K.S., Al-Saidy, A.H., Taha, R., 2011. Effect of Copper Slag as a Fine Aggregate on the Properties of Cement Mortars and Concrete. Constr. Build. Mater. 25, 933–938.

Al-Saleh, S. A. and Al-Zaid, R. Z. (2006). Effects of Drying Conditions, Admixtures and Specimen Size on Shrinkage Strains. *Cement and Concrete Research.* 36(10), 1985-1991.American Concrete Institute, Detroit, USA.

Anastasiou, E., Georgiadis Filikas, K. and Stefanidou, M. (2014). Utilization of Fine Recycled Aggregates in Concrete with Fly Ash and Steel Slag. *Construction and Building Materials.* 50 154-161.

Andersson, B. A. (2000). Materials Availability for Large-Scale Thin-Film

Ariffin, M. A. M., & Hussin, M. W. (2015). Chloride Resistance of Blended Ash Geopolymer Concrete. *Journal of Civil Engineering*, *6*(2).

Arioz, O. (2007). Effects of Elevated Temperatures on Properties of Concrete. *Fire Safety Journal.* 42(8), 516-522.

Ashraf, M. A., Maah, M. J., Yusoff, I., Wajid, A., & Mahmood, K. (2011). Sand Mining Effects, Causes and Concerns: A Case Study from Bestari Jaya, Selangor, Peninsular Malaysia. *Scientific Research and Essays*, *6*(6), 1216-1231.

ASTM C1202 (2012). American Standard Testing of Materials - Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration. *American Society of Testing and Materials Publication.*

ASTM C157 (2008). American Standard Testing of Materials - Specification for Length Change of Hardened Hydraulic-Cement Mortar and Concrete. *American society of testing and materials Publication.*

ASTM C33 (2003). American Standard Testing of Materials - Specification for Concrete Aggregates. *American society of Testing and Materials Publication.* 11.

ASTM C494 (2013). American Standard Testing of Materials - Standard Specification for Chemical Admixtures for Concrete. *American society of testing and materials Publication.* 10.

ASTM C597 (2009). American Standard Test Method for Pulse Velocity Through Concrete, *Annual book of ASTM Standard*. Philadelphia, USA: *American Society of Testing and Materials Publication,vol. 04.02 (pp.4)*

Bai, Y., Darcy, F. and Basheer, P. A. M. (2005). Strength and Drying Shrinkage

Properties of Concrete Containing Furnace Bottom Ash as Fine Aggregate. *Construction and Building Materials.* 19(9), 691-697.

Bakharev T. (2005) Resistance of Geopolymer Materials to Acid Attack, Cem. Concr. Res. 35 (4) 658–670.

Bakharev, T. (2005). Geopolymeric Materials Prepared using Class F Fly Ash and Elevated Temperature Curing. *Cement and Concrete Research*, *35*(6), 1224-1232.

Bakharev, T. (2005). Geopolymeric Materials Prepared Using Class F Fly Ash and Elevated Temperature Curing. *Cement and Concrete Research.* 35(6), 1224-1232.

Bakharev, T., Sanjayan, J. G. and Cheng, Y. B. (2003). Resistance of Alkali-Activated Slag Concrete to Acid Attack. *Cement and Concrete Research.* 33(10), 1607-1611.

Barbosa, V. F., MacKenzie, K. J., & Thaumaturgo, C. (2000). Synthesis and Characterisation of Materials based on Inorganic Polymers of Alumina and Silica: Sodium Polysialate Polymers. *International Journal of Inorganic Materials*, *2*(4), 309-317.

Basheer, P. A. M., Russell, D. P. and Rankin, G. I. B. (1999). Design of Concrete to Resist Carbonation. *Durability of Building Materials and Components* Ottawa ON, K1A 0R6, Canada. 423-435.

Bassuoni, M. T. and Nehdi, M. L. (2007). Resistance of Self-Consolidating Concrete to Sulfuric Acid Attack with Consecutive Ph Reduction. *Cement and Concrete Research.* 37(7), 1070-1084

Bissonnette, B., Pierre, P., & Pigeon, M. (1999). Influence of Key Parameters on Drying Shrinkage of Cementitious Materials. *Cement and Concrete Research*, *29*(10), 1655-1662.

Bondar D., Lynsdale C.J., Milestone N., Hassani N., Ramezanianpour A. (2011) Effect of Type, Form, and Dosage of Activators on Strength of Alkali-Activated Natural Pozzolans, *Cem. Concr. Res.* 33 251–260.

BS 1881, P. (2011). Specification for Method for Determination of Water Absorption. *BSI Standards Publication.*

BS 5328-1 (2011). Guide to Specifying Concrete. *BSI Standards Publication.*

BS 5328-2 (2011). Methods for Specifying Concrete Mixes. *BSI Standards Publication.*

BS 8110- 2 (1985). Structural Use of Concrete: Code of Practice for Special Circumstances. *BSI Standards Publication.*

BS 812 - 103.1 (2011). Methods for Determination of Particle Size Distribution — Sieve Tests. *BSI Standards Publication.*

BS 8500- 2 (2006). Specification for Constituent Materials and Concrete. *BSI Standards Publication.*

BS 882 (2011). Specification for Aggregate from Natural Sources for Concrete. *BSI Standards Publication.* 14.

BS EN 1097-6 (2013). Determination of Particle Density and Water Absorption. *BSI Standards Publication, London.*

BS EN 12350-2 (2009). Testing Fresh Concrete (Slum Test). *BSI Standards Publication, London.*

BS EN 12350-6 (2009). Testing Fresh Concrete Density. *BSI Standards Publication, London.*

BS EN 12390-3 (2002). Testing Hardened Concrete - Compressive Strength of Test Specimens. *BSI Standards Publication, London.*

BS EN 12390-5 (2000). Testing Hardened Concrete - Flexural Strength of Test Specimens. *BSI Standards Publication, London.*

BS EN 12390-6 (2000). Testing Hardened Concrete - Tensile Splitting Strength of Test Specimens. *BSI Standards Publication, London.*

BS EN 12390-7 (2009). Density of Hardened Concrete. *BSI Standards Publication, London.*

BS EN 206 (2013). Concrete - Specification, Performance, Production and Conformity. *BSI Standards Publication, London.*

Cai, L., Ma, B., Li, X., Lv, Y., Liu, Z. and Jian, S. (2016). Mechanical and Hydration Characteristics of Autoclaved Aerated Concrete Containing Iron-Tailings: Effect of Content and Fineness. *Construction and Building Materials.* 128 361-372.

Castel, A. L., Cleary, J. D., & Pearson, C. E. (2010). Repeat Instability as the Basis for Human Diseases and as a Potential Target for Therapy. *Nature Reviews. Molecular Cell Biology, 11*(3), 165.

Chan, D. and Sun, P. C. (2013). Effects of Fine Recycled Aggregate as Sand Replacement in Concrete. *Taylor & Francis.* 13(4), 2-7.

Cree, D., Green, M. and Noumowé, A. (2013). Residual Strength of Concrete

Containing Recycled Materials after Exposure to Fire: A Review. *Construction and Building Materials.* 45 208-223.

Criado, M., Fernández-Jiménez, A., De La Torre, A. G., Aranda, M. A. G., & Palomo, A. (2007). An XRD Study of the Effect of the SiO 2/Na 2 O Ratio on the Alkali Activation of Fly Ash. *Cement and Concrete Research, 37*(5), 671-679.

Das, B., et al. (2007) An Overview of Utilization of Slag and Sludge from Steel Industries. *Resources, Conservation and Recycling* 50.1: 40-57.

Davidovits, J. (1991). Geopolymers: Inorganic Polymeric New Materials. *Journal of Thermal Analysis and Calorimetry, 37*(8), 1633-1656.

Davidovits, J. (2002, October). Years of Successes and Failures in Geopolymer Applications. Market Trends and Potential Breakthroughs. In *Keynote Conference on Geopolymer Conference*.

Davidovits, J. (Ed.). (2005). *Geopolymer, Green Chemistry and Sustainable Development Solutions: Proceedings of the World Congress Geopolymer 2005*. Geopolymer Institute. (2),945-951

Demirel, B. and Keleştemur, O. (2010). Effect of Elevated Temperature on the Mechanical Properties of Concrete Produced with Finely Ground Pumice and Silica Fume. *Fire Safety Journal.* 45(6–8), 385-391.

Devi, V.S., Gnanavel, B.K. (2014). Properties of Concrete Manufactured using Steel Slag. Procedia Eng. 97, 95–104.

Dinakar, P., Sethy, K. P., & Sahoo, U. C. (2013). Design of Self-Compacting Concrete with Ground Granulated Blast Furnace Slag. *Materials & Design*, *43*, 161-169.

Domone, P. L. (2006). Self-compacting Concrete: An Analysis of 11 Years of Case Studies. *Cement and Concrete Composites*, *28*(2), 197-208.

Duan, P., Yan, C., Zhou, W., Luo, W., & Shen, C. (2015). An Investigation of the Microstructure and Durability of a Fluidized Bed Fly Ash–Metakaolin Geopolymer After Heat and Acid Exposure. *Materials & Design*, *74*, 125-137.

Duxson P., Fernadez-Jimenez A., Provis J.L, Lukey G.C., Palomo A. and Van Deventer J.S.J. (2006). Geopolymer Technology: The Current State of the Art. *Journal of Materials Science*, 42(9),2917–2933.

EFNARC, S. (2002). Guidelines for Self-Compacting Concrete. *EFNARC, UK (www. efnarc. org)*, 1-32.

Evangelista, L. and De Brito, J. (2010). Durability Performance of Concrete Made with Fine Recycled Concrete Aggregates. *Cement and Concrete Composites.* 32(1), 9-14.

Evangelista, L., & De Brito, J. (2007). Mechanical Behaviour of Concrete Made with Fine Recycled Concrete Aggregates. *Cement and Concrete Composites, 29*(5), 397-401.

Evans, J. G., Spiess, P. E., Kamat, A. M., Wood, C. G., Hernandez, M., Pettaway, C. A., ... & Pisters, L. L. (2006). Chylous Ascites After Post-Chemotherapy Retroperitoneal Lymph Node Dissection: Review of the MD Anderson Experience. *The Journal of urology*, *176*(4), 1463-1467.

Fares, Hanaa, et al. (2010) High Temperature Behaviour of Self-consolidating Concrete: Microstructure and Physicochemical Properties. *Cement and Concrete Research* 40.3: 488-496.

Feng, X. X., Xi, X. L., Cai, J. W., Chai, H. J., & Song, Y. Z. (2011). Investigation of drying shrinkage of concrete prepared with iron mine tailings. In *Key Engineering Materials* (Vol. 477, 37-41). Trans Tech Publications.

Fernandez-jimenez, Duxson P., Provis J.L, Lukey G.C, Palomo A. and van Deventer J.S.J. (2007). Geopolymer Technology: The Current State of the Art. *Journal of Materials Science*, 42(9),2917–2933.

Fernández-Jiménez, A., & Palomo, A. (2005). Mid-infrared spectroscopic studies of alkali-activated fly ash structure. *Microporous and Mesoporous Materials, 86*(1-3), 207-214.

Fernández-Jiménez A.M and Palomo A. (2006). The Role Played by the Reactive Alumina Content in the Alkaline Activation of Fly Ashes. *Microporous and Mesoporous Materials*, 91(1-3),111–119. Elsevier Ltd.

Fernandez-Jimenez, A. M., Palomo, A., & Lopez-Hombrados, C. (2006). Engineering Properties of Alkali-Activated Fly Ash Concrete. *ACI Materials Journal, 103*(2), 106.

Fernández-Jiménez, a.and Palomo (2005). Composition and Microstructure of Alkali Activated Fly Ash Binder: Effect of the Activator. *Cement and Concrete Research*, 35(10), pp.1984–1992.

Flatt, R. J., Roussel, N., & Cheeseman, C. R. (2012). Concrete: An Eco Material That Needs to be Improved. *Journal of the European Ceramic Society*, *32*(11), 2787-2798.

Gao, X. F., Lo, Y., Tam, C. M. and Chung, C. Y. (1999). Analysis of the Infrared Spectrum and Microstructure of Hardened Cement Paste. *Cement and*

Concrete Research. 29(805–812).

Garnett, T., Appleby, M. C., Balmford, A., Bateman, I. J., Benton, T. G., Bloomer, Herrero, M. (2013). Sustainable Intensification in Agriculture: Premises and Policies. *Science, 341*(6141), 33-34.

Giergiczny, Z. and Krol, A. (2008). Immobilization of Heavy Metals (Pb, Cu, Cr, Zn, Cd, Mn) in the Mineral Additions Containing Concrete Composites. *Hazard Materials.* 160(2-3), 247-255.

Gonen, T. and Yazicioglu, S. (2007). The Influence of Compaction Pores on Sorptivity and Carbonation of Concrete. *Construction and Building Materials.* 21(5), 1040-1045.

Gorhan G, Kurklu G. (2013) The Influence of the NaOH Solution on the Properties of the Fly Ash – Based Geopolymer Mortar Cured at Different Temperatures. Composites B Eng.

Gorrill, Lindsay. 2003. Global Garnet Market Review: Mineral Price Watch. 97(January): 7-10.

Gourley, J. J., & Calvert, C. M. (2003). Automated Detection of the Bright Band Using WSR-88D Data. *Weather and Forecasting*, 18(4), 585-599.

Haranki, B., 2009. Strength, Modulus of Elasticity, Creep and Shrinkage of concrete used in Florida (Master of Engineering Thesis). University of Florida

Hardjito, D., & Rangan, B. V. (2005). Development and Properties of Low-Calcium Fly Ash-Based Geopolymer Concrete.

Hardjito, D., Wallah, S.E., Sumajouw, D.M.J, Rangan, B.V. (2004). On the Development of Fly Ash-Based Geopolymer Concrete. *ACI Material Journal*, 101(6), 467-472.

Harris, Paul. 2000. At the Cutting Edge—Abrasives & Their Markets: Industrial Minerals. 388(January): 19-27.

Holt, E. and Leivo, M. (2004). Cracking Risks Associated with Early Age Shrinkage. *Cement and Concrete Composites.* 26(5), 521-530.

Huang, X., Ranade, R. and Li, V. C. (2013). Feasibility Study of Developing Green Ecc Using Iron Ore Tailings Powder as Cement Replacement. *Journal of Materials In Civil Engineering.* 25(7), 923-931.

HuM, Zhu X, Long F. Alkali-activated fly ash-based geopolymers with zeolite or bentonite as additives. Cem Concr Compos 2009;31(10):762–8.

Ismail, M., Elgelany Ismail, M. and Muhammad, B. (2011). Influence of Elevated

Temperatures on Physical and Compressive Strength Properties of Concrete Containing Palm Oil Fuel Ash. *Construction and Building Materials.* 25(5), 2358-2364.

Ismail, S., Hoe, K. W. and Ramli, M. (2013). Sustainable Aggregates: The Potential and Challenge for Natural Resources Conservation. *Procedia - Social and Behavioral Sciences.* (101) ,100-109.

Jeffrey, K. (2006). Classification of Industrial Minerals and Rocks. *Industrial Minerals & Rocks: Commodities, Markets, and Uses*, 7.

Jiminez, A. M. F., Lachowski, E. E., Palomo, A., & Macphee, D. E. (2004). Microstructural Characterisation of Alkali-Activated PFA Matrices for Waste Immobilisation. *Cement and Concrete Composites*, *26*(8), 1001-1006.

Kang, H. Z., Jia, K. W. and Yao, L. (2011). Experimental Study on Properties of Concrete Mixed with Ferrous Mill Tailing. *Applied Mechanics and Materials.* 148-149 ,904-907.

Kaufhold, S., Hein, M., Dohrmann, R. and Ufer, K. (2012). Quantification of the Mineralogical Composition of Clays Using Ftir Spectroscopy. *Vibrational Spectroscopy.* 59, 29-39.

Khatib, J. M. and Ellis, D. J. (2001). Mechanical Properties of Concrete Containing Foundry Sand. *Special Publication.* 200 733-748.

Khunthongkeaw, J., Tangtermsirikul, S. and Leelawat, T. (2006). A Study on Carbonation Depth Prediction for Fly Ash Concrete. *Construction and Building Materials.* 20(9), 744-753.

Kondolf, G. M., Angermeier, P. L., Cummins, K., Dunne, T., Healey, M., Kimmerer, W., ... & Reed, D. J. (2008). Projecting Cumulative Benefits of Multiple River Restoration Projects: An Example from the Sacramento-San Joaquin River System in California. *Environmental Management*, *42*(6), 933-945.

Kong, F. R., Pan, L. S., Wang, C. M., & Xu, N. (2016). Effects of Polycarboxylate Superplasticizers with Different Molecular Structure on the Hydration Behavior of Cement Paste. *Construction and Building Materials*, *105*, 545-553.

Konrad-Schmolke, M., Babist, J., Handy, M. R., & O'brien, P. J. (2006). The Physico-Chemical Properties of a Subducted Slab from Garnet Zonation Patterns (Sesia Zone, Western Alps). *Journal of Petrology*, *47*(11), 2123-2148.

Kori, E., & Mathada, H. (2012). An Assessment of Environmental Impacts of Sand

and Gravel Mining in Nzhelele Valley, Limpopo Province, South Africa. In *Proceeding of the Third International Conference on Biology, Environment and Chemistry* (137-141).

Kosmatka, S. H., Panarese, W. C., & Kerkhoff, B. (2002). *Design and control of concrete mixtures* (Vol. 5420, pp. 60077-1083). Skokie, IL: Portland Cement Association.

Kosmatka, S. H., Panarese, W. C., & Kerkhoff, B. (2002). *Design and Control of Concrete Mixtures* (Vol. 5420, 60077-1083). Skokie, IL: Portland Cement Association.

Kou, S. C., & Poon, C. S. (2009). Properties of Self-Compacting Concrete Prepared with Coarse and Fine Recycled Concrete Aggregates. *Cement and Concrete Composites*, *31*(9), 622-627.

Krishna, K. M., Reddy, K. S. N., Sekhar, C. R., Naidu, K. B., Rao, P. G., & Reddy, G. V. R. (2016). Heavy Mineral Studies on Late Quaternary Red Sediments of Bhimunipatnam, Andhra Pradesh, East Coast of India. *Journal of the Geological Society of India*, *88*(5), 637-647.

Kristof, J., Frost, R. L., Felinger, A. and Mink, J. (1997). Ftir Spectroscopic Study of Intercalated Kaolinite. *Journal of Molecular Structure*. 411, 119-122.

Łaźniewska-Piekarczyk, Beata. (2014) The Methodology for Assessing the Impact of New Generation Superplasticizers on Air Content in Self-compacting Concrete. *Construction and Building Materials* 53: 488-502.

Levy, S. M. and Helene, P. (2004). Durability of Recycled Aggregates Concrete: A Safe Way to Sustainable Development. *Cement and Concrete Research*. 34(11), 1975-1980.

Li, G., Chen, Y. J. and Di, H. (2013a). The Study on Used Properties of Mine Tailings Sand. *Advanced Materials Research*. 859, 87-90.

Lin, Y., Hsiao, C., Yang, H. and Lin, Y. F. (2011). The Effect of Post-Fire-Curing on Strength–Velocity Relationship for Nondestructive Assessment of Fire-Damaged Concrete Strength. *Fire Safety Journal*. 46(4), 178-185.

Lindtner, S., Hertz, G. D., & Dourish, P. (2014). Emerging Sites of HCI Innovation: Hackerspaces, Hardware Startups & Incubators. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 439-448). Lottermoser, B. G. (2011). Recycling, Reuse and Rehabilitation of Mine Wastes. *Elements*, *7*(6), 405-410.

M. F. Nuruddin, A. Kusbiantoro, S. Qazi, N. Shafiq, (2011) Compressive Strength and Interfacial Transition Zone Characteristic of Geopolymer Concrete with Different Cast In-Situ Curing Condition, World Academy of Science, Engineering and Technology (WASET), Dubai, 25-28 Jan 2011.

Maifala, B. and Tabbiruka, N. M. S. (2007). Chemical and Thermal Characterization of a Clayey Material Found near Gaborone Dam. *Applied Science Environmental Management.* 11(4), 77 - 80.

Malhotra, V. M., Mineral, C. C. F., Technology, E. and Institute, A. C. (1995). *Advances in Concrete Technology: Proceedings, Second Canmet/Aci International Symposium, Las Vegas, Nevada, USA, 1995.* American Concrete Institute.

Meenakshi, S.S., Ilangovan, R., (2011). Performance of Copper Slag and Ferrous Slag as Partial Replacement of Sand in Concrete. Int. J. Civ. Struct. Eng. 1 (4), 918–927.

Mehta, P. K. and Monteiro, P. J. M. (2013). *Concrete: Microstructure, Properties, and Materials.* McGraw-Hill Education.

Mehta, S. R., Yusuf, S., Peters, R. J., Bertrand, M. E., Lewis, B. S., Natarajan, M. K., Copland, I. (2001). Effects of Pretreatment with Clopidogrel and Aspirin Followed by Long-Term Therapy in Patients Undergoing Percutaneous Coronary Intervention: The PCI-CURE Study. *The Lancet*, *358*(9281), 527-533.

Memon, F. A., Nuruddin, M. F., Demie, S., & Shafiq, N. (2012). Effect of Superplasticizer and Extra Water on Workability and Compressive Strength of Self-Compacting Geopolymer Concrete. *Research Journal of Applied Sciences, Engineering and Technology*, *4*(5), 407-414.

Meyer, C. (2009). The Greening of the Concrete Industry. *Cement and Concrete Composites.* 31(8), 601-605.

Miranda, J. C. (2005). On Tuned Mass Dampers for Reducing the Seismic Response of Structures. *Earthquake Engineering & Structural Dynamics*, *34*(7), 847-865.

Mollah, M. Y. A., Yu, W., Schennach, R. and Cocke, D. L. (2000). A Fourier Transform Infrared Spectroscopic Investigation of the Early Hydration of Portland Cement and the Influence of Sodium Lignosulfonate. *Cement and*

Concrete Research. 30, 267–273.

Monteny, J., Vincke, E., Beeldens, A., De Belie, N., Taerwe, L., Van Gemert, D. and Verstraete, W. (2000). Chemical, Microbiological, and in Situ Test Methods for Biogenic Sulfuric Acid Corrosion of Concrete. *Cement and Concrete Research.* 30(4), 623-634.

Muttashar, H. L., Mohd Ariffin, M. A., Hussin, M. W., & Ishaq, S. B. (2017). Realisation of Enhanced Self-Compacting Geopolymer Concrete using Spent Garnet as Sand Replacement. *Magazine of Concrete Research*, 1-12.

Nagral, M. R., Ostwal, T., & Chitawadagi, M. V. (2014). Effect of Curing Temperature And Curing Hours On The Properties Of Geo-Polymer Concrete. *International Journal of Computational Engineering Research*, *4*, 2250-3005.

Nazari, A. (2012). Fuzzy Logic for Prediction Water Absorption of Lightweight Geopolymers Produced from Waste Materials. *Ceramic International*, 38, 4729–4736.

Nematzadeh, M., & Fallah-Valukolaee, S. (2017). Erosion Resistance of High-Strength Concrete Containing Forta-Ferro Fibers against Sulfuric Acid Attack with an Optimum Design. *Construction and Building Materials*, 154, 675-686.

Neville, A. M. (2011). *Properties of Concrete.* London: Pearson Education Limited.

Neville, A. M. and Brooks, J. J. (2010). *Concrete Technology*. Essex, England, UK: Pearson Education Limited.

Nikolov A., Rostovsky I., (2014) *Structural Study of Geopolymers based on Natural Zeolite and Sodium Silicate After Thermal Treatment of Up to 1000 °C*, Annual of the University of Architecture, Civil Engineering and Geodesy, Sofia, Fascicule VIII-A, Scientific Research-I, 2014–2015, University of Architecture, Sofia, 2014,1310-814.

Nuruddin, M. F., & Memon, F. A. (2015). Properties of Self-Compacting Geopolymer Concrete. In *Materials Science Forum* (Vol. 803, 99-109). Trans Tech Publications.

Oh J.E., Moon J., Mancio M., Clark S.M and Monterio P.J.M, (2011). Bulk Modulus of Basic Sodalite, $Na_8[AlSiO_4]6(OH)_2 2H_2O$, a Possible Zeolitic Precursor in Coal-Fly-Ash-Based Geopolymers. *Cement and Concrete Research*, 41(1),107–112.

Olson, D. W. (2001). Garnet, Industrial. *US Geological Survey Minerals Yearbook*, 30-1.

Olson, D.W., 2005a, Garnet (industrial): U.S. Geological Survey Mineral Commodity Summaries, p. 66–67.

Onuf, N. G. (2012). *World of Our Making: Rules and Rule in Social Theory and International Relations*. Routledge.

Palomo, A., Grutzeck, M. W., & Blanco, M. T. (1999). Alkali-Activated Fly Ashes: A Cement for the Future. *Cement and Concrete Research*, *29*(8), 1323-1329.

Panda, C.R., Mishra, K.K., Panda, K.C., Nayak, B.D., Nayak, B.B., 2013. Environmental and Technical Assessment of Ferrochrome Slag as Concrete Aggregate Material. Constr. Build. Mater. 49, 262–271.

Panias D, Giannopoulou IP, Perraki T. (2007) Effect of Synthesis Parameters on the Mechanical Properties of Fly Ash-Based Geopolymers. *Colloids Surf A*;301(1–3):246–54.

Park, S. B., Lee, B. C. and Kim, J. H. (2004). Studies on Mechanical Properties of Concrete Containing Waste Glass Aggregate. *Cement and Concrete Research.* 34(12), 2181-2189.

Part, Wei Ken, Mahyuddin Ramli, and Chee Ban Cheah. (2015) An Overview on the Influence of Various Factors on the Properties of Geopolymer Concrete Derived from Industrial By-Products. *Construction and Building Materials* 77: 370-395.

Parthiban, K., Saravanarajamohan, K., Shobana, S., & Bhaskar, A. A. (2013). Effect of Replacement of Slag on the Mechanical Properties of Fly Ash based Geopolymer Concrete. *International Journal of Engineering and Technology 5*(3), 2555-2559.

Pettijohn, F. J., Potter, P. E., & Siever, R. (2012). *Sand and Sandstone*. Springer Science & Business Media.photovoltaics. *Progress in Photovoltaics: Research and Applications*, *8*(1), 61-76.

Point, M. (2002). Material Safety Data Sheet. *Emergency*, *510*, 732-2628.

Prabhu, G. G., Hyun, J. H., & Kim, Y. Y. (2014). Effects of Foundry Sand as a Fine Aggregate in Concrete Production. *Construction and Building Materials*, *70*, 514-521.

Prabhu, G.G., Hyun, J.H., Kim, Y.Y., 2014. Effects of foundry sand as a fine aggregate in concrete production. Constr. Build. Mater. 70, 514– 521.

Provis, J. L., Duxson, P., & van Deventer, J. S. (2010). The Role of Particle

Technology in Developing Sustainable Construction Materials. *Advanced Powder Technology*, *21*(1), 2-7.

Rajamanickam, G. V., Chandrasekar, N., Angusamy, N., & Loveson, V. J. (2004). Status of Beach Placer Mineral Exploration in India. *Sustainable Development of Coastal Placer Minerals (Eds) Loveson, VJ and Misra, DD Allied Publishers Pvt. Ltd. New Delhi*, 9-21.

Rangan, B. V, (2008). By Fly Ash-Based Geopolymer Concrete., GC4 of Curtin University ,1–44.

Rao, A., Jha, K. N. and Misra, S. (2007). Use of Aggregates from Recycled Construction and Demolition Waste in Concrete. *Resources, Conservation and Recycling.* 50(1), 71-81.

Richardson, A. E., Coventry, K. and Graham, S. (2009). Concrete Manufacture with Un-Graded Recycled Aggregates. *Structural Survey.* 27(1), 62 - 70.

Rodina, I. S., Kravtsova, A. N., Soldatov, A. V., Yalovega, G. E., Popov, Y. V., & Boyko, N. I. (2013). X-ray Spectroscopic Identification of Garnet from the Placer Deposits of the Taman peninsula. *Optics and Spectroscopy*, *115*(6), 858-862.

Roskill Information Services Ltd. 2000. The Economics of Garnet. 3d Ed. London, United Kingdom, Roskill Information Services Ltd. 88.

Ryan, J. M., & Harris, S. P. (2000). Using State of The Art Blast Modeling Software to Assist the Excavation of the Yucca Mountain Nuclear Waste Repository. In *High-Tech Seminar. State-of-the-Art Blasting Technology Instrumentation and Explosives Applications* (407-423).

Saetta, A. V., Schrefler, B. A. and Vitaliani, R. V. (1993). The Carbonation of Concrete and the Mechanism of Moisture, Heat and Carbon Dioxide Flow through Porous Materials. *Cement and Concrete Research.* 23(4), 761-772.

Sagoe, C. K. K., Brown, T. and Taylor, A. H. 2002. Durability and Performance Characteristics of Recycled Aggregate Concrete. *CSIRO Building Construction and Engineering.* Victoria Australia.

Saifuddin.K.P, B.M.purohit, (2014). Effects of Superplasticizer on Self-Compacting Geopolymer Concrete using Fly Ash and Ground Granulated Blast Furnace Slag. Journal of International Academic Research for Multidisciplinary. 2320-5083.

Sanni, S. H., & Khadiranaikar, R. B. (2013). Performance of Alkaline Solutions on

Grades of Geopolymer Concrete. *International Journal of Research in Engineering and Technology*, *2*(11), 366-371.

Shafiq, I., Azreen, M., & Hussin, M. W. (2017). Sulphuric Acid Resistant of Self-Compacted Geopolymer Concrete Containing Slag and Ceramic Waste. In *MATEC Web of Conferences* (Vol. 97, 01102).

Shettima, Ali Umara, et al. (2016) Evaluation of Iron Ore Tailings as Replacement for Fine Aggregate in Concrete. *Construction and Building Materials* 120: 72-79.

Shi, H.-S., Xu, B.-W. and Zhou, X.-C. (2009). Influence of Mineral Admixtures on Compressive Strength, Gas Permeability and Carbonation of High Performance Concrete. *Construction and Building Materials.* 23(5), 1980-1985.

Siddique, R., Aggarwal, Y., Aggarwal, P., Kadri, E.-H. and Bennacer, R. (2011). Strength, Durability, and Micro-Structural Properties of Concrete Made with Used-Foundry Sand (UFS). *Construction and Building Materials.* 25(4), 1916-1925.

Singh, M. and Siddique, R. (2013). Effect of Coal Bottom Ash as Partial Replacement of Sand on Properties of Concrete. *Resources, Conservation and Recycling.* 72 20-32.

Singh, M., Siddique, R., Ait-Mokhtar, K. and Belarbi, R. (2016). Durability Properties of Concrete Made with High Volumes of Low-Calcium Coal Bottom Ash as a Replacement of Two Types of Sand. *Journal of Materials in Civil Engineering.* 28(4), 04015175.

Somna K, Jaturapitakkul C, Kajitvichyanukul P, Chindaprasirt P. NaOHactivated ground fly ash geopolymer cured at ambient temperature. Fuel 2011;90(6):2118–24.

Sreebha, S., & Padmalal, D. (2011). Environmental Impact Assessment of Sand Mining from the Small Catchment Rivers in the Southwestern Coast of India: A Case Study. *Environmental Management*, *47*(1), 130-140.

Sreenivasulu, C., Guru Jawahar, J., Vijaya Sekhar Reddy, M., & Pavan Kumar, D. (2016). Effect of Fine Aggregate Blending on Short-Term Mechanical Properties of Geopolymer Concrete. *Asian Journal of Civil Engineering*, *17*(5), 537-550.

Sudarshan, D. Kore, and A. K. Vyas. (2017) Impact of fire on mechanical properties of concrete containing marble waste. *Journal of King Saud University-*

Engineering Sciences.

Swanepoel J.C., Strydom C.A., (2002) Utilisation of Fly Ash in a Geopolymeric Material, Appl. Geochem. 17 (8) 1143–1148.

Swanepoel, J. C., & Strydom, C. A. (2002). Utilisation of Fly Ash in a Geopolymeric Material. *Applied Geochemistry*, *17*(8), 1143-1148.

Tahri, W., Abdollahnejad, Z., Mendes, J., Pacheco-Torgal, F., & de Aguiar, J. B. (2017). Cost Efficiency and Resistance to Chemical Attack of a Fly Ash Geopolymeric Mortar versus Epoxy Resin and Acrylic Paint Coatings. *European Journal of Environmental and Civil Engineering*, 21(5), 555-571.

Temuujin, J., van Riessen, A., & MacKenzie, K. J. D. (2010). Preparation and Characterisation of Fly Ash Based Geopolymer Mortars. *Construction and Building Materials*, *24*(10), 1906-1910.

Teng, S., Lim, T. Y. D., & Divsholi, B. S. (2013). Durability and Mechanical Properties of High Strength Concrete Incorporating Ultra Fine Ground Granulated Blast-Furnace Slag. *Construction and Building Materials*, *40*, 875-881.

Thampi, T., Sreevidya, V., & Venkatasubramani, R. (2014). Strength Studies on Geopolymer Mortar for Ferro Geopolymer Water Tank. *International Journal of Advanced Structures and Geotechnical Engineering*, *3*, 102-105.

Tripathi, B., Misra, A., Chaudhary, S., (2013). Strength and Abrasion Characteristics of ISF Slag Concrete. *J. Mater. Civ. Eng*. 25, 1611–1618.

Ushaa, T. G., Anuradha, R., & Venkatasubramani, G. S. (2015). Performance of Self-Compacting Geopolymer Concrete Containing Different Mineral Admixtures.4, 543-551

Ushaa, T. G., R. Anuradha, and G. S. Venkatasubramani. (2015) Performance of Self-Compacting Geopolymer Concrete Containing Different Mineral Admixtures. *Indian Journal of Engineering & Materials Sciences*, 473-481.

Valcuende, M. and Parra, C. (2010). Natural Carbonation of Self-Compacting Concretes. *Construction and Building Materials.* 24(5), 848-853.

Van Jaarsveld, J. G. S., Van Deventer, J. S. J., & Lukey, G. C. (2003). The Characterisation of Source Materials in Fly Ash-Based Geopolymers. *Materials Letters*, *57*(7), 1272-1280.

Vardhan, K., Goyal, S., Siddique, R., & Singh, M. (2015). Mechanical Properties and

Microstructural Analysis of Cement Mortar Incorporating Marble Powder as Partial Replacement of Cement. *Construction and Building Materials, 96*, 615-621.

Xu, H., & Van Deventer, J. S. J. (2000). The Geopolymerisation of Alumino-Silicate Minerals. *International Journal of Mineral Processing*, *59*(3), 247-266.

Xu, H., & Van Deventer, J. S. J. (2000). The Geopolymerisation of Alumino-Silicate Minerals. *International Journal of Mineral Processing*, *59*(3), 247-266.

Yao, X., Zhang, Z., Zhu, H. and Chen, Y. (2009). Geopolymerization Process of Alkali–Metakaolinite Characterized by Isothermal Calorimetry. *Thermochimica Acta.* 493(1-2), 49-54.

Yehia, S., Helal, K., Abusharkh, A., Zaher, A. and Istaitiyeh, H. (2015). Strength and Durability Evaluation of Recycled Aggregate Concrete. *International Journal of Concrete Structures and Materials.* 9(2), 219-239.

Yousuf, M., Mollah, A., Lua, F. and Cocke, D. L. (1998). An X-Ray Diffraction Xrd and Fourier Transform Infrared Spectroscopic Ft-Ir Characterization of the Speciation of Arsenic V in Portland Cement Type-V. *Sci Total Environment.* 224 57-68.

Zaharieva, R., Buyle-Bodin, F. and Wirquin, E. (2004). Frost Resistance of Recycled Aggregate Concrete. *Cement and Concrete Research.* 34(10), 1927-1932.

Zhang, G. D., Zhang, X. Z., Zhou, Z. H. and Cheng, X. (2013). Preparation and Properties of Concrete Containing Iron Tailings/Manufactured Sand as Fine Aggregate. *Advanced Materials Research.* 838-841, 152-155.

Zhang, S., Bellinger, A. M., Glettig, D. L., Barman, R., Lee, Y. A. L., Zhu, Maitland, D. J. (2015). pH-responsive Supramolecular Polymer Gel as an Enteric Elastomer for Use in Gastric Devices. *Nature materials*, *14*(10), 1065.

Zhao, H., Sun, W., Wu, X., & Gao, B. (2015). The Properties of the Self-Compacting Concrete with Fly Ash and Ground Granulated Blast Furnace Slag Mineral Admixtures. *Journal of Cleaner Production*, *95*, 66-74.

Zhao, H., Sun, W., Wu, X., & Gao, B. (2017). The Effect of the Material Factors on the Concrete Resistance against Carbonation. *KSCE Journal of Civil Engineering*, 53,1-10.

Zhao, S., Fan, J., & Sun, W. (2014). Utilization of Iron Ore Tailings as Fine Aggregate in Ultra-High-Performance Concrete. *Construction and Building Materials*, *50*, 540-548.

Zhou, X. M., Slater, J. R., Wavell, S. E. and Oladiran, O. (2012). Effects of Pfa and Ggbs on Early-Ages Engineering Properties of Portland Cement Systems. *Journal of Advanced Concrete Technology*. 10 74-85.

Zia, P., S. Ahmad, M. Leming (1997). *High Performance Concretes; A State-of-Art Report (1989-1994). Report No. FHWA-RD-97-030, U.S. Department of Transportation, Federal Highway Administration*, McLean, VA, USA. Sashi dhar, C., Jawahar, J. G., Neelima, C., & Kumar, D. P. Fresh and Strength Properties of Self compacting Geopolymer Concrete Using Manufactured Sand. International Journal of ChemTech Research.8, No.7, pp 183-190.