CHARACTERISTICS OF FERROCEMENT SANDWICH AERATED CONCRETE WALL ELEMENTS INCORPORATING POZZOLANIC WASTE MATERIALS

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To My Lovely Parents

Dr. Hossin Ali Mehman navaz and Zahra Abooata

And

My Wife and Daughter

Fereshteh Moayed and Parimah Mehman navaz

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ABSTRACT

Sandwich construction is defined as a structure that is constructed using ferrocement and aerated concrete. In contrast to the conventional concrete system, it is usually made of thin face sheets or encasement of high performance material and a thick, lightweight and low strength material as core element. Partial substitution of cement with pozzolanic materials and replacement of fine aggregate with bottom ash in this sandwich system could, be a viable strategy for reducing cement and fine aggregate consumption without impairing the performance of the system. However, the main problem of a sandwich construction is the delamination of the face sheets leading to their premature failure which is believed can be avoided by providing encasement over the core. This research focuses on the development and the characteristics of ferrocement sandwich aerated concrete wall elements by partial substitution of cement with palm oil fuel ash (POFA), pulverized fuel ash (PFA) and fine aggregate with bottom ash (BA) at varying proportions. The tests conducted involved the optimization of POFA, PFA and BA in binary and ternary cement blends in producing self-compacting and aerated concrete of desired properties for ferrocement encasement and core. In addition, the development of ferrocement encased lightweight aerated concrete sandwich wall elements as well as the investigation of strength characteristics and the durability properties were also conducted. The performance of the mixes was studied in terms of the workability, density and compressive strength. The partial replacement of cement with pozzolanic materials was done by weight in the range of 0 to 50% of the cement. Other aspects of the study included, failure mode, flexural behaviour, load-deflection behaviour, load-deformation behaviour and load-strain behaviour. From the study, it was observed that the workability of the mixes containing POFA and PFA were significantly improved by 116%, as well as the compressive strength (93%) and unit weight by 45%. The performance of one layer wire mesh (WM) and plastic mesh (PM) showed satisfactory results in ductility and deformation. An increase of 166% (WM) and 66% (PM) for compressive were observed. At the same time, for flexure strength an increase of 39% (WM) and 95% (PM) were achieved. No delamination were found for both WM and PM wall element. In addition, the durability test on the wall elements in terms of permeability, acid attack and elevated temperature demonstrated high potentials of the specimens to be used under aggressive environment. Furthermore, the deformations of wall elements were validated with Finite element model using ANSYS software and the values predicted from the ANSYS software models were 85% - 90% accuracy compared to the experimental results. Finally, the sandwich incorporating one layer of plastic mesh can be used as a wall unit with minimum risk of delamination.

ABSTRAK

Pembinaan elemen terapit ditakrifkan sebagai satu struktur yang terbina daripada simen ferro dan konkrit berudara. Ianya berbeza dengan sistem konkrit konvensional di mana kepingan kebiasaannya diperbuat daripada permukaan yang nipis atau salutan bahan berprestasi tinggi dan penggunaan bahan yang tebal, bahan ringan dan kekuatan rendah sebagai teras. Penggantian separa simen dengan bahan-bahan pozolana dan penggantian batu halus dengan abu bawah dalam sistem panel apitan boleh menjadi strategi yang berdaya maju untuk mengurangkan simen dan penggunaan batu halus tanpa menganggu prestasi sistem. Selain itu, masalah utama bagi pembinaan panel terapit ialah penyahikatan bagi lembaran muka yang membawa kepada kegagalan pramatang yang dipercayai boleh dielakkan dengan menyediakan lebih lapisan pada teras. Oleh itu, kajian ini memberi tumpuan kepada pembangunan ciri-ciri elemen dinding konkrit berudara terapit simen ferro yang mengabungkan abu bahan api kelapa sawit (POFA) dan abu bahan api terhancur (PFA) sebagai bahan-bahan buangan pozolana dan abu bawah (BA) sebagai gantian batu halus. Ujian yang dijalankan melibatkan pengoptimuman POFA, PFA dan BA dalam campuran simen binari dan ternari untuk menghasilkan konkrit padat sendiri dan berliang yang masing-masing bertujuan untuk membungkus simen ferro dan teras. Lain-lain termasuk pembangunan dan pemeriksaan ciri-ciri kekuatan simen ferro bersalut elemen berudara dinding terapit konkrit ringan dan ujian ketahanlasakan juga dijalankan. Prestasi campuran telah diuji dari segi kebolehkerjaan, ketumpatan dan kekuatan mampatan. Penggantian separa simen dengan bahan-bahan pozolana mengikut berat dalam lingkungan 0 hingga 50% daripada simen. Aspek lain yang dikaji ialah lenturan, mod kegagalan, kelakuan beban-pesongan, kelakuan beban-ubah bentuk dan tingkah laku beban-keterikan. Dari kajian ini diperhatikan bahawa kebolehkerjaan campuran yang mengandungi POFA dan PFA telah bertambah baik dengan ketara sehingga 116% dan begitu juga 45% unit berat dan kekuatan mampatan 93%. Prestasi satu lapisan jejaring wayar (WM) dan jejaring geogrid (PM) menunjukkan keputusan memuaskan dari segi kemuluran dan tingkah laku ubah bentuk. penigkatan sebanyak 166% (WM) dan 66% (PM) untuk kekuatan mampatan telah dicapai. pada masa yang sama, kekuatan patah meningkat sebanyak 39% (WM) dan 95% (PM). Tidak ada penyahikatan berlaku tahadap kedua-dua elemen dinding WM dan PM. Selain itu, ujian ketahanlasakan pada elemen apitan dari segi kebolehtelapan, serangan asid dan suhu tinggi menunjukkan potensi yang tinggi penggunaan spesimen ini dalam persekitaran yang agresif. Tambahan pula, keputusan ubah bentuk elemen dinding telah disahkan dengan model unsur terhingga menggunakan perisian ANSYS dan nilai-nilai yang diramalkan daripada model perisian ANSYS adalah 85% - 90% tepat berbanding dengan keputusan ujikaji. Akhir sekali, penggunaan satu lapisan jejaring plastik dalam elemen apitan boleh digunakan sebagai unit dinding dengan risiko penyahikatan yang minimum.

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LIST OF ABBREVIATION

AAC	-	Autoclaved Aerated Concrete
AC	-	Aerated Concrete
ACI	-	American Concrete Institute
ASTM	-	American Standards for Testing of materials
BA	-	Bottom Ash
BS	-	British Standards
C-S-H	-	Calcium Silicate Hydrate
FC	-	Ferrocement
FFB	-	Fresh fruit bunches
FRP	-	Fibre Reinforced Polymer
IBS	-	Industrialized building systems
IFS	-	International Ferrocement Society
ISAT	-	Initial Surface Absorption Test
LVDT	-	Linear Variable Differential Transformer
MOE	-	Modulus of Elasticity
MOR	-	Modulus of Rupture
NAAC	-	Non-Autoclaved Aerated Concrete
OER	-	Oil Extraction Ratio
OPC	-	Ordinary Portland Cement
PCI	-	Precast/Prestressed Concrete Institute
PCSP	-	Precast Concrete Sandwich Panels
PFA	-	Pulverized Fuel Ash
PM	-	Plastic mesh
POFA	-	Palm Oil Fuel Ash
RC	-	Reinforced Concrete
RHA	-	Rice Husk Ash

RILEM	-	International Union of Testing and Research Laboratories for Materials and Structures
RM	-	Ringgit Malaysia
SCC	-	Self-compacting concrete
SCM	-	Supplementary cementing material
SD	-	Standard deviation
WM	-	Wire mesh
SP	-	Superplasticizer
UPV	-	Ultrasonic Pulse Velocity
USA	-	United States of America
UTM	-	University Technology Malaysia
W/b	-	Water-Binder Ratio
w.r.t	-	With respect to
GUI	-	Graphical User Interface
FEA	-	Finite Element Analyses
FE	-	Finite Element

LIST OF SYMBOLS

a	-	Average distance between line of fracture and the nearest support measured in the tension surface of the beam
A_{ci}	-	Cross-sectional area perpendicular to loading direction (mm^2)
b	-	Average width of specimen
d	-	Average depth of specimen
Ec	-	Modulus of elasticity of the concrete
EX	-	Modulus of elasticity of the concrete (Ec) in ANSYS
f	-	Stress at any strain(ε), psi
f_{ci}	-	Compressive strength (MPa)
F_i	-	Ultimate load in compression (N)
fy	-	Yield stress
f_0	-	Initial strength of concrete at 27 °C
f_T	-	Residual strength after heating at T °C
H	-	Height
H/L	-	Aspect ratio
H/t	-	Slenderness ratio
L	-	Span length
L	-	Length
P	-	Maximum applied load
P_r	-	Porosity
PRXY	-	Poisson's ratio (μ) in ANSYS
R	-	Modulus of rupture
T	-	Effective transit time (s)
t	-	Thickness

V	-	Pulse velocity ($\frac{m}{s}$)
V	-	Total volume
V_c	-	Core volume
V_e	-	Encasement volume
V_T	-	Pulse velocity after heating at T °C
V_{27}	-	initial pulse velocity of concrete at 27 °C
W_a	-	Percentage of water absorption
W_{od}	-	Weight of oven dry specimen
W_{ssd}	-	Weight of saturated surface dry specimen
W_s	-	Weight of submerged specimen
μ	-	Poisson's ratio
ε	-	Strain at stress f,
ε_0	-	Strain at the ultimate compressive strength, f_c'
σ	-	Stress

CHAPTER 1

INTRODUCTION

1.1 General Introduction

Malaysia is undoubtedly one of the fast developing countries in the world (Razak, 2010). The pace of construction activity which is commensurable to the development has been in exponential pattern over the last three decades (Sumadi and Ramli, 2008). This necessitates the exploration of sustainable construction techniques/systems that meet the demand for environmental friendly, safe, fast, cost-effective, and quality housing and infrastructures for the well-being of the society (Sambasivan and Soon, 2007). Despite the rate of development, the provision of housings is still in deficit form (Thanoon *et al.*, 2004). The high cost of construction materials and the labour intensity nature of the conventional building system contribute immensely on the deficit in housing (Cabeza *et al.*, 2013). Exploration of other sources of construction materials become imperative in other to meet the housing and development needs of the country. Agro and industrial waste have been seen to play an important role in this regards, among which are palm oil fuel ash and pulverised fuel ash. Application of these wastes in building production system such as industrialized building system (IBS) could provide a viable approach for adequate housing provision.

The IBS denotes the concept of the prefabrication and industrialization of building components (Kamar *et al.*, 2011). In this system, the elements are installed with a minimum time period and labour at the site as compare to the conventional

system of cement or concrete blocks which are heavier in weight. Application of light-weight elements such as aerated concrete reinforced with ferrocement for walling system would not only reduce the dead load of the structure, but also improves its performance and reduces the cost of construction (Sakthivel and Jagannathan, 2013). The use of agro and industrial wastes to partially substitute ordinary Portland cement (OPC) in aerated concrete and self-compacting mortar to produce ferrocement sandwich wall system would improve the performance of the concrete. Furthermore, the environmental threat sequel to disposal of these wastes to landfills will be curtailed (Raut *et al.*, 2011).

According to Sumathi *et al.* (2008), some of the tropical climate countries in the world have palm oil plants but Malaysia is ranked as the world's largest producer of palm oil, give a report for 52% of the total world oils and the industry is the main agricultural industry in the country. The country strives to maintain this leading role in the next decades. This development leads to increase in palm oil plantation in 1920 with 400 hectares to year 2002 which accounted for about 3.6 million hectares and with a targeted expansion in the year 2020 to be around 5.2 million hectares (Basiron *et al.*, 2005). In the year 2006, the country recorded production worth over 15 million tons of crude palm oil (MPOB, 2006). Therefore, it is expected that higher quantities of waste will be discharged to the environment from the industry in the near future (Shehu and Abdul Awal, 2012). It is interesting to note that palm oil industry giant effort to restrain the excess of solid waste (Palm shell, bunch and fibre) generated is its used as a fuel in the electricity generation, making the industry self-sustained in term of energy generation and utilization. Though, further by-product emerges in the form of ash known as palm oil fuel ash (POFA) which is believed to be about 5% of the total solid waste fed into boiler mills (Borhan *et al.*, 2010). Innovation of new product through integration of this freely available waste would be one of the solutions to sustainably use this environmentally degrading by-product into beneficial material so as to meet up the housing needs and housing demands of the people at a very minimal cost of construction.

The basic concept of sandwich structures consists of two thin skins (faces) and a lightweight thicker core. This practice is found common in construction industry owing to its lightness and versatility and is adopted as a new innovation in building construction (La Rosa *et al.*, 2014). The product also has the capability of dead load reduction thereby resulting in more economically and friendly structural design (Narayanan and Ramamurthy, 2000a). The incorporation of palm oil fuel ash (POFA) and pulverized fuel ash (PFA) as partial cement replacement material in the lightweight and ferrocement composite as construction materials concrete mix would decrease the amount of cement used as compared to ordinary aerated and ferrocement concrete hence reduce the high dependency on cement. This approach for industrial or agricultural waste replacement cement has been reported in the previous researches (Abdul Awal, 1998; Khairunisa, 2009; Sumadi and Hussin, 1993). Therefore, the creation of a new material is not only expected to offer an extra incoming profit for industry of POFA and PFA and reducing ash ending at landfill as well as bringing improvement to Malaysian construction technology.

1.2 Problem Statement

The rapid development of lightweight, low cost, durable, industrialized and sustainable housing system as per IBS is ever demanding problem (Mydin *et al.*, 2014; Yunus and Yang, 2011). Developing low cost and environmental friendly construction materials is a challenging issue at present. The presence of IBS usually focuses on the use of cement or concrete blocks for the infill or to certain extent, serves as non-load bearing walls which are heavier in weight. The development of ferrocement, aerated concrete and self-compacting mortar as encasement of ferrocement with the aid of pozzolanic materials as partial cement replacement is relatively new. Ferrocement structural elements are high performance composite material and its advantageous lightweight makes it a replaceable conventional material for building construction. Interestingly, ferrocement structural elements have not gained much popularity because of their thin section causing transferable

heat, noise and also perceived corrosion problem particularly in the tropical environments.

Considering the demand for shelter globally there is the need to improve the quality of the ferrocement structurally. Therefore the challenge of looking inward to the use of environmental friendly materials could be a possible solution in overcoming the disadvantages associated with the use of OPC in the production of ferrocement component.

However, evaluation of aerated concrete as a core and self-compacting mortar as encasing of ferrocement using POFA and PFA as cement replacement materials may lead to higher quality product that require adequate investigations. Thus, sandwich composite construction system with newly developed composites made of ternary materials (cement, POFA and PFA) presents one of the potential solutions in which the ferrocement is applied as face sheets/encasement and lightweight aerated concrete as core.

1.3 Aim and Objectives of the Research

The aim of the research is to investigate ferrocement characteristics of sandwich aerated concrete wall elements incorporating pozzolanic waste materials (POFA & PFA).

The following objectives are set out to achieve the targeted aim.

1. To evaluate the physical, chemical and microstructural characteristics of POFA and PFA.
2. To determine the optimum mix proportion for mortar incorporating POFA and PFA for aerated concrete sandwich wall elements.

3. To investigate the suitability of the blend of POFA and PFA for thin ferrocement encasement by evaluating the flow-ability of the formulated self-compacting cement mortar.

4. To investigate the effect of mesh type, number of mesh layer and orientation on the failure behaviour associated with sandwich aerated concrete material including compression, flexural and delamination.

5. To assess the durability performance of the aerated concrete and sandwich specimens, including water absorption, ISAT tests, resistance to acid attack and elevated temperature.

6. To investigate the failure behaviour (compression and flexural) of large size ferrocement encased lightweight aerated concrete wall elements based on the optimum mesh content.

7. To validate the experimental study of sandwich wall element with finite element software in terms of compression and flexural strength obtain the maximum deformation.

1.4 Scope of the Research

This experimental project consists of two phases. The first phase focused on the development of optimum mix for aerated concrete and self-compacting mortar containing POFA and PFA. Self-compacting mortar allowed for casting the thin ferrocement skin boxes over aerated concrete in single operation. The compressive strength and unit weight of the mortar were used as parameters for optimization. The effect of POFA and PFA as the replacement of cement in mortar for making affordable product is also a part of focused objectives.

The second phase of the experimental study included; the behaviour of sandwich specimens, cubes, blocks prism beams and wall elements of relatively large

size. These were investigated under compression as major parameter and bending as an additional effect. Two types of mesh namely square wire mesh, and square plastic (geogrid) mesh were incorporated in ferrocement box by varying the number of layers; 0, 1, 2 and 3. Furthermore, the performance of the sandwich specimens was examined based on unit weight, load-axial deformation, load-lateral deformation under compression, ultimate compressive strength and flexural strength. In addition, load-deflection and load-strain relationship in the presence of bending was also investigated. The failure mode and composite action of sandwich elements with respect to loading conditions were studied. Consequently, efforts were made to achieve affordable ferrocement lightweight aerated concrete with POFA and PFA. Investigation into the material uniformity of sandwich wall elements applying UPV test was also carried out. Finally, finite element analysis was carried out to validate the experimental study.

1.5 Significance of the Research

Palm oil fuel ash and pulverized fuel ash are the common wastes generated from palm oil mills and power generation plant in Malaysia. At present these wastes are disposed as land fill material without any economic benefit, and large amount of money is expended in disposal operation. POFA and PFA can be used considerably to enrich the properties of concrete and other related construction materials which will reduce the pressure on the domestic and industrial consumption of OPC and also promote the sustainability of natural environment.

Furthermore, the outcome of the study would also provide more information on the performance of POFA and PFA cement based aerated concrete and self-compacting mortar for producing ferrocement sandwich wall elements in term of engineering properties.

The research finding is expected to encourage the use of the new approach for producing lightweight composite wall elements for construction industry. This in

turn, will be useful for promoting better quality of construction and innovative systems in the construction industry. The present study is surely a step forward to achieve quality products which will be affordable and durable in environment friendly way.

1.6 Structure of the Thesis

The thesis will be organized in different chapters as follows:

Chapter One: The general appraisal and overview of the study with regards to the introduction, study background, aim & objective were also established. It further significance of the study and briefly layout of the thesis are also described in this chapter.

Chapter Two: Examines the bodies of literature relevant to this research based on the theoretical applicability and presents the findings logically. Hence, it focused on the previous work done on the past research work on the use of pozzolanic materials, aerated concrete, self-compacting concrete and ferrocement, its properties and in the field of civil engineering profession. Finally this chapter is concluded with comprehensive but precise concluding remarks which summarize the review and established justification for the study.

Chapter Three: discusses the methodological choices made in the study to achieve the research objectives bearing it in mind the primary aim of the study. It describes the materials and experimental approach adopted in two phase. The approaches were illustrated and discussed step-by-step. The remaining parts of the chapter focus on description of subjects, the description of instrument and materials, study procedures and laboratory experiments in accordance to the procedures outlined by various standards like ASTM and BS.

Chapter Four: Discusses the results obtained from the first phase of the experimental programme. The results comprise of the development and optimum of the best percentage of POFA and PFA for use in aerated concrete as core and flow-ability of self-compacting mortar as encasing. This would be suitable for casting the thin ferrocement making with POFA and PFA for skin boxes over aerated concrete is discussed.

Chapter Five: Present the results of the second phase of the experimental studies based on the behaviour of sandwich specimens, cubes, blocks prism beams and wall elements in term of compressive strength, flexural strength, acid attack, elevated temperature, UPV test and type and layer of meshes.

Chapter Six: Validate of the experimental study of sandwich wall element with finite element software in term of maximum deformation in compression and flexural.

Chapter Seven: Concludes the results of the study and discussions are made on the achievement and finding of the objectives of the study and the contribution of the research to the existing knowledge. This also outlines the recommendations made for future research.

REFERENCES

Abdul Awal, A. S. M. (1998). *A study of strength and durability performances of concrete containing Palm oil fuel ash.* Doctor of Philosophy Thesis (Civil Engineering), Universiti Teknologi Malaysia, Skudai.

Abdul Awal, A. S. M. and Hussin, M. W. (1996). Properties of fresh and hardened concrete containing Palm Oil Fuel Ash. *Proceedings of the 1996 3rd Asia-Pacific Conference on Structural and construction.* Johor Bahru, Malaysia, 359-367.

Abdul Awal, A. S. M. and Hussin, M. W. (1997a). Effect of palm oil fuel ash on durability of concrete. *Proceedings of the 1997 5th International Conference on Concrete Engineering and Technology*. Kuala Lumpur, Malaysia, 299-306.

Abdul Awal, A. S. M. and Hussin, M. W. (1997b). Some Aspects of Durability Performances of Concrete Incorporating Palm Oil Fuel Ash. *Proceeding of Fifth International Conference On Structural Failure, Durability And Retrofitting.* 27- 28 November Singapore, 210-217.

Abdul Awal, A. S. M. and Nguong, S. K. (2010). A Short-Term Investigation on High Volume Palm Oil Fuel Ash (POFA) Concrete. *Proceedings of the 2010 35th Conferenece on our World in Concrete and Structure*. 25- 27 November Singapore, 185-192.

Abdul Awal, A. S. M. and Shehu, I. A. (2013). Evaluation of heat of hydration of concrete containing high volume palm oil fuel ash. *Fuel*. 105(0), 728-731.

Abdullah and Katsuki, T. (2002). Strength and behavior of concrete confined by ferrocement boxes. *Journal of Ferrocement*. 32(4), 304-314.

Abdullah, K., Hussin, M. W., Zakaria, F., Muhamad, R. and Abdul Hamid, Z. (2006). POFA: A potential partial cement replacement material in aerated concrete. *Proceedings of the 2006 6th Asia-Pacific Structural Engineering and Construction Conference (APSEC 2006)*. 5- 6 September, Kuala Lumpur, Malaysia.

ACI Committee 318 (2005). *Building Code Requirements for Reinforced Concrete ACI 318*. American Concrete Institute.

ACI Committee 549 (1997). *State-of-the-Art report on ferrocement ACI 549*. American Concrete Institute.

ACI Committee 549.1R (1988). *Guide for the design, construction and repair of ferrocement ACI 549.1R*. American Concrete Institute.

Adámek, J., Juranková, V., Kadlecová, Z. and Stehlík, M. (2013). Three NDT Methods for the Assessment of the Concrete Permeability as a Measure of Durability. *Nondestructive Testing of Materials and Structures*, (pp. 293-302) Springer.

Adekunle, S. K. (2012). *A study on developing Self-Consolidating Concrete (SCC) utilizing indigenous natural and industrial waste materials*. Master Thesis (Civil Engineering), King Fahd University of Petroleum and Minerals, Saudi Arabia.

Al-Rifaie, W. (2006). Ferrocement Wall: Penetration Testing. *The Eighth International Symposium and Workshop on Ferrocement and Thin Reinforced Cement Composites*, 6- 8 February Bangkok Thailand, 210-217.

Al-Rifaie, W. and Al-Shukur, A. (2001). Effects of wetting and drying cycles in fresh water on the flexural strength of ferrocement. *Journal of ferrocement*. 31(2), 101-108.

Alexander, R. C. K. (2004). Technical aspects for the construction of a ferrocement diffuser augmented wind turbine. *Journal of Ferrocement*. 34(1), 306-317.

Allen, H. G. (1969). *Analysis and design of structural sandwich panels*. (Vol. 51)Pergamon press Oxford.

Altwair, N. M., Johari, M. A. M. and Hashim, S. F. S. (2011). Strength Activity Index and Microstructural Characteristics of Treated Palm Oil Fuel Ash. *International Journal of Civil and Environmental Engineering*. 11(5), 6.

Arif, M., Pankaj and Kaushik, S. K. (1999). Mechanical behaviour of ferrocement composites: an experimental investigation. *Cement and Concrete Composites*. 21(4), 301-312.

Ariffin, M. A. M., Bhutta, M. A. R., Hussin, M. W., Mohd Tahir, M. and Aziah, N. (2013). Sulfuric acid resistance of blended ash geopolymer concrete. *Construction and Building Materials*. 43(0), 80-86.

Arreshvhina, N. (2002). *Application of slag cement-based aerated lightweight concrete in non-load bearing wall panels*. Master Thesis (Civil Engineering), Universiti Teknologi Malaysia, Skudai.

ASTM C33 / C33M - 13 (2013). *Standard Specification for Concrete Aggregates*. Philadelphia: American Society for Testing and Materials.

ASTM C78 / C78M - 10 (2010). *Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)*. Philadelphia: American Society for Testing and Materials.

ASTM C109 / C109M - 12 (2012). *Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)*. Philadelphia: American Society for Testing and Materials.

ASTM C230 / C230 M - 08 (2008). *Standard Specification for Flow Table for Use in Tests of Hydraulic Cement*. Philadelphia: American Society for Testing and Materials.

ASTM C 231 - 04 (2004). *Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method*. Philadelphia: American Society for Testing and Materials.

ASTM C305 - 13 (2013). *Standard Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency*. Philadelphia: American Society for Testing and Materials.

ASTM C373 - 14 (2014). *Standard Test Method for Water Absorption, Bulk Density, Apparent Porosity, and Apparent Specific Gravity of Fired Whiteware Products,Ceramic Tiles, and Glass Tiles*. Philadelphia: American Society for Testing and Materials.

ASTM C494 / C494 M - 05 (2005). *Standard Specification for Chemical Admixtures for Concrete*. Philadelphia: American Society for Testing and Materials.

ASTM C778 - 13 (2013). *Standard Specification for Standard Sand*. Philadelphia: American Society for Testing and Materials.

ASTM C1437 - 13 (2013). *Standard Test Method for Flow of Hydraulic Cement Mortar*. Philadelphia: American Society for Testing and Materials.

ASTM C90 - 13 (2013). *Standard Specification for Loadbearing Concrete Masonry Units*. Philadelphia: American Society for Testing and Materials.

ASTM C129 - 11 (2011). *Standard Specification for Nonloadbearing Concrete Masonry Units*. Philadelphia: American Society for Testing and Materials.

ASTM C150 - 05 (2005). *Standard Specification for Portland Cement*. Philadelphia: American Society for Testing and Materials.

ASTM C597 - 09 (2009). *Standard Test Method for Pulse Velocity Through Concrete*. Philadelphia: American Society for Testing and Materials.

ASTM C618 - 12A (2012). *Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete*. Philadelphia: American Society for Testing and Materials.

ASTM E119 - 12a (2012). *Standard Test Methods for Fire Tests of Building Construction and Materials*. Philadelphia: American Society for Testing and Materials.

Awal, A. S. M. (1987). Ferrocement: A unique material of construction and its use in agriculture. *Bangla J Agric. Eng*. 1(2), 35-40.

Azarmi, F. (2008). *Sandwich structures for high temperature applications: Microstructural development and mechanical performance.* Doctor of Philosophy Thesis (Materials science and Engineering), University of Toronto (Canada), Ann Arbor.

Azarmi, F., Coyle, T. W. and Mostaghimi, J. (2010). Evaluation of the Flexural Rigidity of Sandwich Structures Using Experimentally Obtained Mechanical Properties of the Constituents. *Journal of Thermal Spray Technology*. 19(1-2), 429-438.

Balakrishnan, B., Abdul Awal, A. S. M. and Shehu, I. A. (2013). Influence of High Volume Fly Ash in Controlling Heat of Hydration of Concrete. *International Journal of Engineering Research and Applications (IJERA)*. 3(2), 932-936.

Basiron, Y., Simeh, M. A., Alias, M., Tang, T. C., Zen, Z., McCarthy, J., Barlow, C., Nordin, A. B. A., Venugopal, R. and Amiruddin, N. (2005). Vision 2020–The palm oil phenomenon. *Oil Palm Industry Economic Journal*. 5(2).

Bave, G. (1983). Regional Climatic Conditions, Building Physics and Economics. Autoclaved Aerated Concrete, Moisture and Properties. *Proceedings Of The 1983 RILEM International Symposium on Autoclaved Aerated Concrete*. Swiis, Development In Civil Engineering. Vol 25 1-12

Benayoune, A., Samad, A. A. A., Abang Ali, A. A. and Trikha, D. N. (2007). Response of pre-cast reinforced composite sandwich panels to axial loading. *Construction and Building Materials*. 21(3), 677-685.

Benayoune, A., Samad, A. A. A., Trikha, D. N., Abang Ali, A. A. and Ashrabov, A. A. (2006). Structural behaviour of eccentrically loaded precast sandwich panels. *Construction and Building Materials*. 20(9), 713-724.

Benayoune, A., Samad, A. A. A., Trikha, D. N., Ali, A. A. A. and Ellinna, S. H. M. (2008). Flexural behaviour of pre-cast concrete sandwich composite panel – Experimental and theoretical investigations. *Construction and Building Materials*. 22(4), 580-592.

Benazzouk, A., Douzane, O., Mezreb, K. and Quéneudec, M. (2006). Physico-mechanical properties of aerated cement composites containing shredded rubber waste. *Cement and Concrete Composites*. 28(7), 650-657.

BIBM, C. and ERMCO, E (2005). *The European guidelines for self-compacting concrete*.

Borhan, M. N., Ismail, A. and Rahmat, R. A. (2010). Evaluation of palm oil fuel ash (POFA) on asphalt mixtures. *Australian Journal of Basic and Applied Sciences*. 4(10), 5456-5463.

Bosiljkov, V. B. (2003). SCC mixes with poorly graded aggregate and high volume of limestone filler. *Cement and Concrete Research*. 33(9), 1279-1286.

Bouzoubaâ, N. and Lachemi, M. (2001). Self-compacting concrete incorporating high volumes of class F fly ash: Preliminary results. *Cement and Concrete Research*. 31(3), 413-420.

BS 1881-5 (1970). *Methods of testing hardened concrete for other than strength*. British Standard Institution.

BS 1881-122 (2011). *Method for determination of water absorption*. British Standard Institution.

Bush, T. D. and Zhiq, W. (1998). Flexural analysis of prestressed concrete sandwich panels with truss connectors. *Precast/Prestressed Concrete Institute journal (PCI)*. Chicago. P. 76-86.

Cabeza, L. F., Barreneche, C., Miró, L., Martínez, M., Fernández, A. I. and Urge-Vorsatz, D. (2013). Affordable construction towards sustainable buildings: review on embodied energy in building materials. *Current Opinion in Environmental Sustainability*. 5(2), 229-236.

Cabrillac, R., Fiorio, B., Beaucour, A., Dumontet, H. and Ortola, S. (2006). Experimental study of the mechanical anisotropy of aerated concretes and of the adjustment parameters of the introduced porosity. *Construction and Building Materials*. 20(5), 286-295.

Caprino, G. and Teti, R. (1989). *Sandwich structures*: handbook. Prato della valle Padua, Italy.

Castillo, C. and Durrani, A. J. (1987). Effect of transient high temperature on high-strength concrete. *ACI Materials Journal*. 87(1).

Davies, J. M. (2008). *Lightweight sandwich construction*. Paric, France: Wiley. com.

Dehn, F., Holschemacher, K. and Weiße, D. (2000). Self-compacting concrete (SCC) time development of the material properties and the bond behaviour. *Selbstverdichtendem Beton*. LACER No. 5.

Dhir, R. K., Hubbard, F. H., Munday, J. G. L., Jones, M. R. and Duerden, S. L. (1988). Contribution of PFA to concrete workability and strength development. *Cement and Concrete Research*. 18(2), 277-289.

Dinakar, P., Babu, K. G. and Santhanam, M. (2008). Durability properties of high volume fly ash self compacting concretes. *Cement and Concrete Composites*. 30(10), 880-886.

Edamatsu, Y., Nishida, N. and Ouchi, M. (1999). A rational mix-design method for self-compacting concrete considering interaction between coarse aggregate and mortar particles. *Proceedings of the 1999 first international RILEM symposium on self-compacting concrete*. Stockholm, Sweden: 309-320.

EFNARC (2002). European Federation of National Associations Representing for Concrete. *Guidelines for self-compacting concrete*.

Einea, A., Salmon, D. C., Fogarasi, G. J., Culp, T. D. and Tadros, M. K. (1991). State-of the-Art of Precast Concrete Sandwich Panels. *PCI Journal*. 36(6), 78-98.

El Debs, M. K., Machado, E. F., De Hanai, J. B. and Takeya, T. (2000). Ferrocement sandwich walls. *Journal of ferrocement*. 30(1), 45-58.

Fanning, P. (2001). Nonlinear models of reinforced and post-tensioned concrete beams. *Electronic Journal of Structural Engineering*. 1, 111-119.

Fattuhi, N. I. and Hughes, B. (1988). The performance of cement paste and concrete subjected to sulphuric acid attack. *Cement and Concrete Research*. 18(4), 545-553.

Frostig, Y. and Thomsen, O. T. (2005). Non-linear behavior of delaminated unidirectional sandwich panels with partial contact and a transversely flexible core. *International Journal of Non-Linear Mechanics*. 40(5), 633-651.

Gaiotti, M. and Rizzo, C. M. (2013). Finite element modeling strategies for sandwich composite laminates under compressive loading. *Ocean Engineering*. 63(0), 44-51.

Gambhir, M. L. (2004). *Concrete technology, 3rd Edition*. Tata McGraw-Hill publishing Company Limited, New Delhi.

Giancaspro, J. W. (2004). *Influence of reinforcement type on the mechanical behavior and fire response of hybrid composites and sandwich structures*. Doctor of Philosophy Thesis (Civil Engineering), Rutgers The State University of New Jersey, New Brunswick.

Gowda, M., Narasimhan, M. and Karisiddappa (2011). Development and Study of the Strength of Self-Compacting Mortar Mixes Using Local Materials. *Journal of Materials in Civil Engineering*. 23(5), 526-532.

Hassett, D. J., Pflughoeft-Hassett, D. F. and Heebink, L. V. (2005). Leaching of CCBs: observations from over 25 years of research. *Fuel*. 84(11), 1378-1383.

Hauser, A., Eggenberger, U. and Mumenthaler, T. (1999). Fly ash from cellulose industry as secondary raw material in autoclaved aerated concrete. *Cement and Concrete Research*. 29(3), 297-302.

Hawlader, M. N. A., Mansur, M. A. and Rahman, M. (1990). Thermal behaviour of ferrocement. *Journal of Ferrocement*. 20(3), 231-239.

Holt, E. and Raivio, P. (2005). Use of gasification residues in aerated autoclaved concrete. *Cement and Concrete Research*. 35(4), 796-802.

Hossain, K. M. A., Ahmed, S. and Lachemi, M. (2011). Lightweight concrete incorporating pumice based blended cement and aggregate: Mechanical and durability characteristics. *Construction and Building Materials*. 25(3), 1186-1195.

Hossain M, Z. and Inoue, S. (2000). A comparison of the mechanical properties of ferrocement elements under compression for square and chicken meshes. *Journal of Ferrocement*. 30(4), 319-343.

Houst, Y., Alou, F. and Wittmann, F. (1983). Influence of moisture content on the mechanical properties of autoclaved aerated concrete. *Proceedings Autoclaved Aerated Concrete, Moisture and Properties.* Amsterdam: Elsevier. 219-233.

Hussin, M. W. and Abdul Awal, A. S. M. (1997). Palm oil fuel ash: A potential pozzolanic material in concrete construction. *Journal of ferrocement*. 27(4), 321-327.

Hussin, M. W. and Abdullah, K. (2009). Properties of palm oil fuel ash cement based aerated concrete panel subjected to different curing regimes. *Malaysian Journal of Civil Engineering*. 21(1), 17-31.

Hussin, M. W., Muthusamy, K. and Zakaria, F. (2010). Effect of mixing constituent toward engineering properties of pofa cement-based aerated concrete. *Journal of Materials in Civil Engineering*. 22(4), 287-295.

Ibrahim, H. M. H. (2011). Shear capacity of ferrocement plates in flexure. *Engineering Structures*. 33(5), 1680-1686.

IFS-10 (2001). International Ferrocement Society, *Ferrocement Model Code*. Thailand: Asian Institute of Technology (AIT), International Ferrocement information Centre (IFIC).

Isaia, G. C., Gastaldini, A. L. G. and Moraes, R. (2003). Physical and pozzolanic action of mineral additions on the mechanical strength of high-performance concrete. *Cement and Concrete Composites*. 25(1), 69-76.

Ismail, M., Ismail, M. E. 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.

Iureş, L. and Bob, C. (2010). The Future Concrete: Self-Compacting Concrete. *Bulletin of the Polytechnic Institute of Jassy, Constructions, Architechture Section*. 56.

Jacobs, F. and Hunkeler, F. (1999). Design of self-compacting concrete for durable concrete structures. *Proceedings of the 1999 First International RILEM Symposium on Self-Compacting Concrete*. RILEM Publications SARL, 397-407.

Jones, M. R. and McCarthy, A. (2005). Utilising unprocessed low-lime coal fly ash in foamed concrete. *Fuel*. 84(11), 1398-1409.

Kachlakev, D., Miller, T., Yim, S., Chansawat, K. and Potisuk, T. (2001). *Finite element modeling of concrete structures strengthened with FRP laminates: final report*. Oregon Department of Transportation Research Group (SPR 316).

Kamar, K. A. M., Hamid, Z. A., Azman, M. N. A. and Ahamad, M. S. S. (2011). Industrialized Building System (IBS): Revisiting Issues of Definition and Classification. *International Journal of Emerging Sciences*. 1(2), 120.

Kandaswamy, S. and Ramachandraiah, A. (2002). Sound transmission performance on ferrocement panels. *Journal of ferrocement*. 32(1), 59-67.

Kapoor, Y. (2003). Self Compacting Concrete An Economical Approach. *7th International Conference on Concrete in Hot & Aggressive Environments*. 2003. Manama, Kingdom of Bahrain, (pp. 509-520).

Kearsley, E. P. and Wainwright, P. J. (2001). Porosity and permeability of foamed concrete. *Cement and Concrete Research*. 31(5), 805-812.

Keefer, R. F. and Sajwan, K. S. (1993). *Trace elements in coal and coal combustion residues*. West Virginia University, Morgantown: Lewis Publisher.

Khairunisa, M. (2009). *Properties of palm oil fuel ash cement based aerated concrete*. Doctor of Philosophy Thesis (Civil Engineering), Universiti Teknologi Malaysia, Skudai.

Khayat, K. H., Assaad, J. and Daczko, J. (2004). Comparison of field-oriented test methods to assess dynamic stability of self-consolidating concrete. *ACI Materials Journal*. 101(2).

Kim, H. K. and Lee, H. K. (2011). Use of power plant bottom ash as fine and coarse aggregates in high-strength concrete. *Construction and Building Materials*. 25(2), 1115-1122.

Kindinger, J. (2001). *Lightweight Structural Cores*. MRS Bulletin 2001; 26:790–797.

Kumar, P., Haq, M. A. and Kaushik, S. (2004). Early age strength of SCC with large volumes of fly ash. *Indian concrete journal*. 78(6), 25-29.

Kus, H. and Carlsson, T. (2003). Microstructural investigations of naturally and artificially weathered autoclaved aerated concrete. *Cement and Concrete Research*. 33(9), 1423-1432.

La Rosa, A. D., Recca, A., Gagliano, A., Summerscales, J., Latteri, A., Cozzo, G. and Cicala, G. (2014). Environmental impacts and thermal insulation performance of innovative composite solutions for building applications. *Construction and Building Materials*. 55(0), 406-414.

Lee, B. and Pessiki, S. (2006). Thermal Behavior of Precast Prestressed Concrete Three-Wythe Sandwich Wall Panels. *Building Integration Solutions* (doi:10.1061/40798(190)3pp. 1-15).

Li, G. and Zhao, X. (2003). Properties of concrete incorporating fly ash and ground granulated blast-furnace slag. *Cement and Concrete Composites*. 25(3), 293-299.

Li, M., Qian, C. and Sun, W. (2004). Mechanical properties of high-strength concrete after fire. *Cement and Concrete Research*. 34(6), 1001-1005.

Liang, S. and Chen, H. L. (2006). Investigation on the square cell honeycomb structures under axial loading. *Composite Structures*. 72(4), 446-454.

Lok, T. S. and Cheng, Q. H. (2000). Elastic stiffness properties and behavior of truss-core sandwich panel. *Journal of Structural Engineering*. 126(5), 552-559.

Loser, R. and Leemann, A. (2009). Shrinkage and restrained shrinkage cracking of self-compacting concrete compared to conventionally vibrated concrete. *Materials and Structures*. 42(1), 71-82.

MPOB (2006). Overview of the Malaysian palm oil board industry 2006.

MacGregor, J. G., Wight, J. K., Teng, S. and Irawan, P. (1997). *Reinforced concrete: Mechanics and design*. (Vol. 3) Prentice Hall Upper Saddle River, NJ.

Mahfuz, H., Islam, M. S., Rangari, V. K., Saha, M. C. and Jeelani, S. (2004). Response of sandwich composites with nanophased cores under flexural loading. *Composites Part B: Engineering*. 35(6–8), 543-550.

Mansur, M. (2001). Effect of mesh orientation on tensile response of ferrocement. *Journal of ferrocement*. 31(4), 289-298.

Mansur, M., Ahmad, I. and Paramasivam, P. (2001). Punching Shear Strength of Simply Supported Ferrocement Slabs. *Journal of Materials in Civil Engineering*. 13(6), 418-426.

Mansur, M. and Ong, K. (1987). Shear strength of ferrocement beams. *ACI Structural Journal*. 84(1).

Mansur, M. and Ong, K. (1991). Shear strength of ferrocement I-beams. *ACI Structural Journal*. 88(4).

Mansur, M. A. and Abdullah., A. (1998). Constitutive laws of ferrocement under biaxial tension-compression. *Journal of Ferrocement*. 28(1), 1-25.

Mansur, M. A. and Kiritharan, T. (2001). Shear strength of ferrocement structural sections. *Journal of Ferrocement*. 31(3), 195-211.

Mansur, M. A. and Paramasivam, P. (1986). Cracking behaviour and ultimate strength of ferrocement in flexure. *Journal of Ferrocement*. 16(4), 405-415.

Mansur, M. A., Paramasivam, P., Wee, T. H. and Lim H, B. (1996). Durability of ferrocement - A case study. *Journal of Ferrocement*. 26(1), 11-19.

Masood, A., Arif, M., Akhtar, S. and Haquie, M. (2003). Performance of ferrocement panels in different environments. *Cement and Concrete Research*. 33(4), 555-562.

Mata, L. A. (2004). *Implementation of Self-Consolidating Concrete (SCC) for Prestressed Concrete Girders*. Master Thesis (Civil Engineering), North Carolina State University, Raleigh.

McCarthy, M. J. and Dhir, R. K. (2005). Development of high volume fly ash cements for use in concrete construction. *Fuel*. 84(11), 1423-1432.

McCarthy, M. J., Tittle, P. A. J. and Dhir, R. K. (2000). Influences of conditioned pulverized-fuel ash as a cement component on the properties of concrete. *Magazine of Concrete Research*. 52(5), 329-343.

Melo, K. A. and Carneiro, A. M. P. (2010). Effect of Metakaolin's finesses and content in self-consolidating concrete. *Construction and Building Materials*. 24(8), 1529-1535.

Memon, N. A., Sumadi, S. R. and Ramli, M. (2006). Lightweight aerated concrete incorporating various percentages of slag and PFA. *Journal of Applied Sciences*. 6(7), 1560-1565.

Memon, N. A., Sumadi, S. R. and Ramli, M. (2007). Ferrocement encased lightweight aerated concrete: A novel approach to produce sandwich composite. *Materials Letters*. 61(19–20), 4035-4038.

Mostafa, N. Y. (2005). Influence of air-cooled slag on physicochemical properties of autoclaved aerated concrete. *Cement and Concrete Research*. 35(7), 1349-1357.

Mourad, S. M. and Shannag, M. J. (2012). Repair and strengthening of reinforced concrete square columns using ferrocement jackets. *Cement and Concrete Composites*. 34(2), 288-294.

MS 1064:Part10 (2001). *Guide To Modular Coordination in Buildings:Part 10:Coordinating Sizes and Preferred Sizes for Reinforced Concrete Components*. Malaysia Standard.

Mydin, M. O., Sani, N. M. and Taib, M. (2014). Industrialised Building System in Malaysia: A Review. *Proceedings of the 2014 MATEC Web of Conferences*: EDP Sciences, 01002.

Naaman, A. E. (2000). *Ferrocement and laminated cementitious composites*. (Vol. 3000) Ann Arbor, Michigan, USA: Techno Press.

Naaman, A. E. (2005). Ferrocement and thin fiber reinforced cement composites : Looking back, looking ahead. *Journal of Ferrocement*. 35(1), 500-513.

Naaman, A. E. (2012). Evolution in Ferrocement and Thin Reinforced Cementitious Composites. *Arabian Journal for Science and Engineering*. 37(2), 421-441.

Naik, T. R., Singh, S. and Hu, W. (1992). *High-volume fly ash concrete technology*. Electric Power Research Inst., Palo Alto, CA (United States); Wisconsin Univ., Milwaukee, WI (United States). Center for By-Products Utilization.

Narayanan, N. and Ramamurthy, K. (2000a). Structure and properties of aerated concrete: a review. *Cement and Concrete Composites*. 22(5), 321-329.

Narayanan, N. and Ramamurthy, K. (2000b). Microstructural investigations on aerated concrete. *Cement and Concrete Research*. 30(3), 457-464.

Nedwell P, J. (2000). Ferrocement research at UMIST. *Journal of Ferrocement*. 30(4), 379-388.

Nehdi, M., Pardhan, M. and Koshowski, S. (2004). Durability of self-consolidating concrete incorporating high-volume replacement composite cements. *Cement and Concrete Research*. 34(11), 2103-2112.

Neville, A. M. (1995). *Properties of concrete*. Longman Group UK Limited.

Noor Ahmed, M. (2007). *Characteristics of Ferrocement Encased Aerated Concrete Sandwich Wall Elements.* Doctor of Philosophy Thesis (Civil Engineering), Universiti Teknologi Malaysia, Skudai.

Okamura, H. and Ouchi, M. (1998). Self-compacting high performance concrete. *Progress in Structural Engineering and Materials*. 1(4), 378-383.

Okamura, H. and Ozawa, K. (1995). Mix design for self-compacting concrete. *Concrete library of JSCE*. 25(6), 107-120.

Ouchi, M. and Hibino, M. (2000). Development, Applications and Investigations of Self-compacting Concrete. *Proceedings of the 2000 International Workshop*. Kochi, Japan.

Oucho, M., Nakamura, S. A., Osterberg, T., Hallberg, S. E. and Lwin, M. (2003). Applications of self-compacting concrete in Japan, Europe and the United States. *Proceedings of the 2003 3rd PCI/FHWA International Symposium on High Performance Concrete*. US Department of Transportation and Federal Highway Transportation (FHWA), Orlando, Florida, USA.

Paramasivam, P. and Ravindrarajah, R. S. (1988). Effect of arrangements of reinforcements on mechanical properties of ferrocement. *ACI Structural journal*. 85(1).

Parra-Montesinos, G. and Naaman A, E. (2004). Parametric evaluation of the bending response of ferrocement and hybrid composites with FRP reinforcements. *Journal of Ferrocement*. 34(2), 341-352.

Paryati, N. (2013). The using of aerated lightweight concrete as an alternative substitution for solid red brick. *Jurnal Fakultas Teknik: RESULTAN*. 13(2).

Patel, R., Hossain, K., Shehata, M., Bouzoubaa, N. and Lachemi, M. (2004). Development of statistical models for mixture design of high-volume fly ash self-consolidating concrete. *ACI Materials Journal*. 101(4).

PCI J (1997). *Committee on Pre-cast Concrete Sandwich Wall Panels, State of the Art of Precast/prestresses Sandwich Wall Panels*.42(2),92–133.

Pheeraphan, T., Joyklad, P. and Nimityongskul, P. (2006). Experimental study on blast load resistance of ferrocement panels. *Journal of Ferrocement*. 36(2), 808-817.

Rafeeqi, S. and Ayub, T. (2011). Investigation of versatility of theoretical prediction models for plain concrete confined with Ferrocement. *ASIAN JOURNAL OF CIVIL ENGINEERING (BUILDING AND HOUSING)*. 12(3), 337-352.

Ramli, M. and Tabassi, A. A. (2012). Mechanical behaviour of polymer-modified ferrocement under different exposure conditions: An experimental study. *Composites Part B: Engineering*. 43(2), 447-456.

Rao, G. A. (2001a). Generalization of Abrams law for cement mortars. *Cement and Concrete Research*. 31(3), 495-502.

Rao, G. A. (2001b). Long-term drying shrinkage of mortar - influence of silica fume and size of fine aggregate. *Cement and Concrete Research*. 31(2), 171-175.

Rao, S., Das, R. and Bhattacharyya, D. (2013). Investigation of bond strength and energy absorption capabilities in recyclable sandwich panels. *Composites Part A: Applied Science and Manufacturing*. 45(0), 6-13.

Raut, S. P., Ralegaonkar, R. V. and Mandavgane, S. A. (2011). Development of sustainable construction material using industrial and agricultural solid waste: A review of waste-create bricks. *Construction and Building Materials*. 25(10), 4037-4042.

Razak., Dato' Sri Mohd Najib Bin Tun Abdul Razak (2010). *Tenth malaysia plan 2011-2015*. Putrajaya: Prime minister's department. Malaysia.

RILEM (1994). *Autoclaved Aerated Concrete - Properties, Testing And Design. Recommended Practice*, London. E&FN SPON Rivas, H.W. (1994). Low Cost Housing Built with Ferrocement Precast Elements. *Journal of Ferrocement*. 24(1): 29-34.

Rivas H, W., Ramos B, A. and Vega B, E. (2004). Model seismoresistant ferrocement house. *Journal of Ferrocement*. 34(2), 363-371.

Roels, S., Sermijn, J. and Carmeliet, J. (2002). Modelling unsaturated moisture transport in autoclaved aerated concrete: a microstructural approach. *Proceedings of the 2002 6th symposium on Building Physics in the Nordic countries*. Trondheim, Norway.

Russo, A. and Zuccarello, B. (2007). Experimental and numerical evaluation of the mechanical behaviour of GFRP sandwich panels. *Composite Structures*. 81(4), 575-586.

Safiuddin, M., West, J. S. and Soudki, K. A. (2011). Flowing ability of the mortars formulated from self-compacting concretes incorporating rice husk ash. *Construction and Building Materials*. 25(2), 973-978.

Sakthivel, P. and Jagannathan, A. (2013). Ferrocement Construction Technology and its Applications - A Review. *Proceedings of the 2013 International Conference on Structural Engineering, Construction and Management (ICSECM-2011).* Kandy, SriLanka.

Salami, B. A. (2011). *Self compacting concrete utilizing local materials.* Master Thesis (Civil Engineering), King Fahd University of Petroleum and Minerals, Saudi Arabia.

Salmon, D. and Einea, A. (1995). Partially Composite Sandwich Panel Deflections. *Journal of Structural Engineering*. 121(4), 778-783.

Sambasivan, M. and Soon, Y. W. (2007). Causes and effects of delays in Malaysian construction industry. *International Journal of Project Management*. 25(5), 517-526.

Sasiekalaa, K. and Malathy, R. (2012). A Review Report On Mechanical Properties Of Ferrocement With Cementitious Materials. *International Journal of Engineering*. 1(9).

Sata, V., Jaturapitakkul, C. and Kiattikomol, K. (2007). Influence of pozzolan from various by-product materials on mechanical properties of high-strength concrete. *Construction and Building Materials*. 21(7), 1589-1598.

Savva, A., Manita, P. and Sideris, K. K. (2005). Influence of elevated temperatures on the mechanical properties of blended cement concretes prepared with limestone and siliceous aggregates. *Cement and Concrete Composites*. 27(2), 239-248.

Schobert, H. H. (1987). *Coal: the energy source of the past and Future*. United States: review in Journal of the American Chemical Society .

Schutter, G. and Audenaert, K. (2004). Evaluation of water absorption of concrete as a measure for resistance against carbonation and chloride migration. *Materials and Structures*. 37(9), 591-596.

Senthilkumar, P. and Kandaswamy, S. (2010). Performance of Sound Transmission on Coconut Fiber Impregnated Cavity Ferro Cement Panels with and without Absorptive Material. *International Journal of Engineering*. 3(3), 561-570.

Serrano-Perez, J. C., Vaidya, U. K. and Uddin, N. (2007). Low velocity impact response of autoclaved aerated concrete/CFRP sandwich plates. *Composite Structures*. 80(4), 621-630.

Shaheen, Y. B. and Ramadan, A. G. (2012). Pre-and Post-Fire Strength Assessment of Ferrocement beams. *Concrete Research Letters*. 3(3).

Shannag, M. J. and Mourad, S. M. (2012). Flowable high strength cementitious matrices for ferrocement applications. *Construction and Building Materials*. 36(0), 933-939.

Sharma P, C. (2000). Ferrocement technology-commercial viability in India. *Journal of Ferrocement*. 30(3), 249-259.

Shehu, I. A. and Abdul Awal, A. S. M. (2012). Mechanical properties of concrete incorporating high volume palm oil fuel ash. *Advanced Materials Research*. 599, 537-540.

Shetty, M. (2008). *Concrete Technology (ME)*. New Delhi: S. Chand and company Ltd.

Short, A. and Kinniburgh, W. (1978). *Lightweight concrete*. Applied Science Publishers.

Shrivastava, O. P. (1977). Lightweight aerated or cellular concrete: a review. *Indian Concrete Journal*. 51, 18-23.

Society, I. F. (2001). *Ferrocement Model Code: Building Code Recommendations for the Ferrocement (IFS 10-01)*. International Ferrocement Society.

Soleymani Ashtiani, M., Dhakal, R. P. and Scott, A. N. (2013). Post-yield bond behaviour of deformed bars in high-strength self-compacting concrete. *Construction and Building Materials*. 44(0), 236-248.

SP Systems (2001). *Guide To Composites*. Structural Polymer Systems Limited, Isle of Wight, United Kingdom.

Suksawang, N., Nassif, H. and Sanders, M. (2006). Analysis of Ferrocement-Laminated Concrete Beams. *Ferrocement and Thin Reinforced Cement Composites (Ferro-8)*. 6-8.

Sumadi, R. S. and Hussin, M. W. (1993). Agricultural Ash (AA) - Construction Material for the Future. *Kongres Sains & Teknologi Malaysia*. 1, 105-114.

Sumadi, S. and Ramli, M. (2008). *Development of lightweight ferrocement sandwich panels for modular housing and industralized building system*. Project Report. Faculty of Civil Engineering, Skudai, Johor.

Sumadi, S. R. (1993). *Relationships Between Engineering Properties and Microstructural Characteristics of Mortar Containing Agricultural Ash*. Doctor of Philosophy Thesis (Civil Engineering), Universiti Teknologi Malaysia, Skudai.

Sumadi, S. R., Hussin, M. W. and Bonner, D. (1996). Strength, Pozzolanic Reaction and Microstructures of Hardened Mortar Pastes Containing Palm Oil Fuel Ash (POFA). *Proceedings of the 1996 3rd Asia-Pacific Concrete on Structural Engineering and Construction*. Johor Bahru, Malaysia. 405-416.

Sumathi, S., Chai, S. and Mohamed, A. (2008). Utilization of oil palm as a source of renewable energy in Malaysia. *Renewable and Sustainable Energy Reviews*. 12(9), 2404-2421.

Svanholm, G. (1983). Influence of water content on properties of aerated concrete. In: Wittmann FH, editor. *Proceedings of the 1983 RILEM International Symposium on Autoclaved Aerated Concrete, Moisture and Properties*. Amsterdam: Elsevier. 119-129.

Sypeck, D. J. (2005). Wrought aluminum truss core sandwich structures. *Metallurgical and Materials Transactions B*. 36(1), 125-131.

Tada, S. and Nakano, S. (1983). Microstructural approach to properties of moist cellular concrete. In: Wittmann FH, editor. *Proceedings of the 1983 RILEM International Symposium on Autoclaved Aerated Concrete, Moisture and Properties*. Amsterdam: Elsevier. 71-89.

Talib, N. R. B. A. (2009). *Engineering Characteristics of Bottom Ash from Power Plants in Malaysia*. Bachelor Thesis (Civil Engineering), Universiti Teknologi Malaysia, Skudai.

Tangchirapat, W., Jaturapitakkul, C. and Chindaprasirt, P. (2009). Use of palm oil fuel ash as a supplementary cementitious material for producing high-strength concrete. *Construction and Building Materials*. 23(7), 2641-2646.

Tavarez, F. A. (2001). *Simulation of behavior of composite grid reinforced concrete beams using explicit finite element methods.* Master Thesis (Civil Engineering), University of Wisconsin, Madison, Wisconsin.

Tay, J. H. (1990). Ash from Oil Palm Waste as a Concrete Material. *Journal of Materials in Civil Engineering*. 2, 96-105.

Taylor, G. D. (2000). *Materials in construction: An introduction*. Longman Group UK Limited.

Thanoon, W. A., Jaafar, M. S., Abdul Kadir, M. R., Abang Ali, A. A., Trikha, D. N. and Najm, A. M. S. (2004). Development of an innovative interlocking load bearing hollow block system in Malaysia. *Construction and Building Materials*. 18(6), 445-454.

Torii, K. and Kawamura, M. (1994). Effects of fly ash and silica fume on the resistance of mortar to sulfuric acid and sulfate attack. *Cement and Concrete Research*. 24(2), 361-370.

Wadley, H. N. G., Fleck, N. A. and Evans, A. G. (2003). Fabrication and structural performance of periodic cellular metal sandwich structures. *Composites Science and Technology*. 63(16), 2331-2343.

Wainshtok, R. H. (2005). Ferrocement swimming pool at the Paradiso Punta Arenas hotel, Varadero, Cuba. *Journal of Ferrocement*. 35(2), 582-588.

Wang, K. S., Chiou, I. J., Chen, C. H. and Wang, D. (2005). Lightweight properties and pore structure of foamed material made from sewage sludge ash. *Construction and Building Materials*. 19(8), 627-633.

Warid Hussin, M. and Sam A. R, M. (1995). Ferrocement construction - UTM experience. *Journal of Ferrocement*. 25(2), 137-148.

Wight, J. K. and MacGregor, J. G. (2009). Reinforced concrete: mechanics and design. *Pearson Education, Inc., Upper Saddle River. New Jersey*. 7458, 1157.

Wolanski, A. J. (2004). *Flexural behavior of reinforced and prestressed concrete beams using finite element analysis*. Master Thesis (Civil Engineering), Marquette University, Milwaukee, Wisconsin.

Xiao, J. and König, G. (2004). Study on concrete at high temperature in China-an overview. *Fire Safety Journal*. 39(1), 89-103.

Xie, Y., Liu, B., Yin, J. and Zhou, S. (2002). Optimum mix parameters of high-strength self-compacting concrete with ultrapulverized fly ash. *Cement and concrete research*. 32(3), 477-480.

Xiong, G., Ip, M. L. and Singh, G. (1997). Review of the fatigue behavior of ferrocement in a corrosive environment. *Journal of ferrocement*. 27(1), 7-18.

Xu, M. and Qiu, Z. (2013). Free vibration analysis and optimization of composite lattice truss core sandwich beams with interval parameters. *Composite Structures*. 106(0), 85-95.

Yang, J., Xiong, J., Ma, L., Wang, B., Zhang, G. and Wu, L. (2013a). Vibration and damping characteristics of hybrid carbon fiber composite pyramidal truss sandwich panels with viscoelastic layers. *Composite Structures*. 106(0), 570-580.

Yang, L., Yan, Y. and Hu, Z. (2013b). Utilization of phosphogypsum for the preparation of non-autoclaved aerated concrete. *Construction and Building Materials*. 44(0), 600-606.

Yardim, Y., Thanoon, W., Jafaar, M., Noorzaei, J., Khan, S. R. and Kamal, N. (2008). Performance of Precast Ferrocement Panel for Composite Masonry Slab System. *Proceedings of the 2008 International Conference on Construction and Building Technology (ICCBT 2008)*. Kuala Lumpur.

Yunus, R. and Yang, J. (2011). Sustainability Criteria for Industrialised Building Systems (IBS) in Malaysia. Procedia Engineering. 14(0), 1590-1598.

Yusoff, S. (2006). Renewable energy from palm oil - innovation on effective utilization of waste. *Journal of Cleaner Production*. 14(1), 87-93.

Zha, X. X., Qin, P. C. and Wang, H. X. (2011). Experiment and Finite Element Study on the Structural Behavior of Steel Sandwich Panels. *Advanced Materials Research*. 168, 1051-1054.

Zhu, W. and Bartos, P. J. M. (2003). Permeation properties of self-compacting concrete. *Cement and Concrete Research*. 33(6), 921-926.