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The Bulletin of the American Concrete Institute – Malaysia Chapter

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The Bulletin of the American Concrete Institute – Malaysia Chapter

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CONTENT

EDITORIAL NOTE

The editorial team is happy to present the sixth issue of volume twelve of MyConcrete bulletin. The bulletin is an official monthly publication of American Concrete Institute – Malaysia Chapter (ACI – Malaysia Chapter). The bulletin publishes three types of articles, namely, industry article, technical report and case study.

The first article of this issue provides an overview on types of cement and standards. It also provides a brief guideline for choosing the right type of cement for specific application. The technical report focuses on the thermal properties of concrete from the context of heat transfer in buildings. Thermal conductivity, specific heat and thermal diffusivity are also discussed in this article. The third article is a case study on precast concrete shear wall constructed for Seattle-Tacoma International Airport, USA. This article reports the design and erection challenges in constructing the precast shear walls.

The editorial team would like to express gratitude to all article contributors for making this issue a success and look forward to receive more interesting articles for our upcoming bulletins. We are most grateful to SINCT-Lab Sdn. Bhd. for their generous support as a premium sponsor for this issue.

The editorial team seek continuous support for sharing of articles and sponsorship both from the academicians and industries for all our upcoming issues.

Thank you very much. Stay Home, Stay Safe.

Dr. A. B. M. Amrul Kaish
Editor, MyConcrete Bulletin

INTRODUCTION TO ACI MALAYSIA CHAPTER

American Concrete Institute - Malaysia Chapter (ACI-Malaysia) is a non-profit technical and educational society representing ACI Global in Malaysia, which is one of the world's leading authorities on concrete technology. Our members are not confined to just engineers; in fact, our invitation is extended to educators, architects, consultants, corporate, contractors, suppliers, and leading experts in concrete related field. The purpose of this Chapter is to further the chartered objectives for which the ACI was organized; to further education and technical practice, scientific investigation, and research by organizing the efforts of its members for a non-profit, public service in gathering, correlating, and disseminating information for the improvement of the design, construction, manufacture, use and maintenance of concrete products and structures. This Chapter is accordingly organized and shall be operated exclusively for educational and scientific purposes.

Objectives of ACI-Malaysia are:

- ACI is a non-profitable technical and educational society formed with the primary intention of providing more in-depth knowledge and information pertaining to the best possible usage of concrete.

- To be a leader and to be recognized as one of Malaysia's top societies specializing in the field of concrete technology by maintaining a high standard of professional and technical ability supported by committee members comprising of educators, professionals and experts.

- Willingness of each individual member/organization to continually share, train and impart his or her experience and knowledge acquired to the benefit of the public at large.

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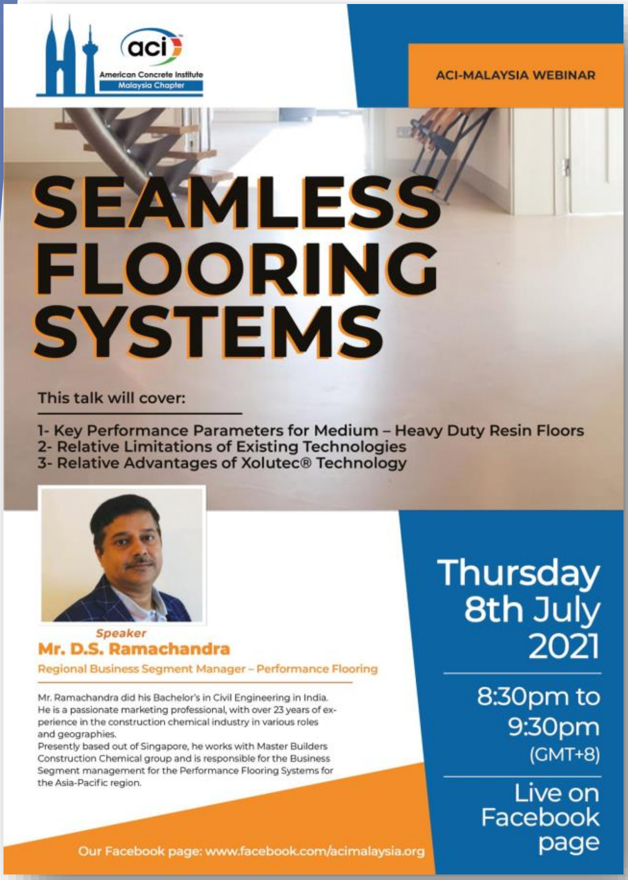

ARTICLE

How To Choose The Right Cement?

Cement is a common material in construction industry. It is so common that sometimes people do not border to study it. When you ask someone "What is cement?", probably he/ she will just answer "A grey powder to bind materials together".

The Malaysian Standard MSEN 197-1 defines cement as a hydraulic binder, i.e. a finely ground inorganic material which, when mixed with water, forms a paste which sets and hardens by means of hydration reactions and processes and which, after hardening, retains its strength and stability even under water. It is a versatile substance that is primarily used to bind aggregates together in mortar and concrete. When it is mixed with fine aggregates and water, it produces mortar. When it is mixed with fine and coarse aggregates, water and admixtures, it forms concrete.

Portland cement was developed in England by bricklayer Joseph Aspdin in 1824. It gets its name from its resemblance upon hardening to the famous Portland limestone obtained from quarries on the Isle of Portland. Portland cement is the most important cement in terms of the quantity produced. The main "raw material" to produce Portland cement is Portland cement clinker. Portland cement clinker is produced by heating a mixture of lime, iron, silica and alumina in a rotary kiln at temperature up to 1450oC. When the materials sinters, it partially fuses into clinker balls. The clinker balls are then cooled and ground to a fine powder together with a small amount of gypsum and the resulting product is Portland cement.

Cement Standards and Types of Cement

There is no universal international standard for cement because every country has its own standards. For example, the cement standard used in Malaysia is MSEN 197-1 (Malaysian Standard for Cement - Composition, specifications and conformity criteria for common cements) which is adopted from the European Standard. There are 27 types of common cement specified in MS EN 197-1 and they are grouped into 5 main cement types as below:

CEM I Portland cement
CEM II Portland-composite cement
CEM III Blastfurnace cement
CEM IV Pozzolanic cement
CEM V Composite cement

Although MSEN197-1 is the main cement standard used in Malaysia, the American Standard ASTM C150 (Standard Specification for Portland Cement) is also sometimes being specified in some projects. Both MSEN 197-1 and ASTM C150 classified cements into 5 main types namely Type I to V. However, the way these two standards classifying the type of cement is very different. MSEN classification is based on composition while ASTM classification is based on potential phase composition and application. Below is a summary of the types of cement classified in both standards for easy reference.

Type	MSEN 197-1	ASTM C150
I	Portland Cement	Normal
II	Portland-composite Cement	Moderate Sulfate Resistance
III	Blastfurnance Cement	High Early Strength
IV	Pozzolanic Cement	Low Heat of Hydration
V	Composite Cement	High Sulfate Resistance

Figure 1: Type of cement according to MSEN 197-1 and ASTM C150

In addition to the type of cement, it is important to know the strength class of the cement you are using as well. There are 3 standard strength classes specified in MSEN 197-1 i.e. 32.5, 42.5 and 52.5. On top of that, 3 classes of early strength (2 days or 7 days) are included for each class of standard strength, a class with ordinary early strength, indicated by N, a class with high early strength, indicated by R and a class with low early strength, indicated by L. Class L is only applicable for CEM III cements. These are the distinct low early strength blast furnace cements. Table below shows the strength requirement for each strength class specified in MSEN 197-1.

Strength Class	MSEN 196-1 Mortar Prism Compressive Strength (MPa)			
	Early Strength		Standard Strength	
	2 Days	7 Days	28 Days	
32.5 L*	-	≥ 12.0	≥ 32.5	≤ 52.5
32.5 N	-	≥ 16.0		
32.5 R	≥ 10.0	-		
42.5 L*	-	≥ 16.0	≥ 42.5	≤ 62.5
42.5 N	≥ 10.0	-		
42.5 R	≥ 20.0	-		
52.5 L*	≥ 10.0	-	≥ 52.5	-
52.5 N	≥ 20.0	-		
52.5 R	≥ 30.0	-		

* Strength class only defined for CEM III cements

Figure 2: Strength Class of Cement (Extracted from Table 3, MS EN 197-1)

Cement is sold both in bulk and bagged. The bagged cements sold in Malaysian market are generally classified into three types, namely the Ordinary Portland Cement, Portland Composite Cement and Masonry Cement. The Portland cements are general purpose cement which can be used for structural works and have to comply to MSEN 197-1. Masonry Cement which is used for plastering work has to comply to MSEN 413-1 (Malaysian Standard for Masonry Cement - Composition, specifications and conformity criteria) which is specifically for Masonry Cement. Masonry Cement is good for plastering work but cannot be use for structural work due to its low strength. In order to differentiate the Masonry Cement from the Portland cements, it is commonly associate with red bag in the packing.

Figure 3: In order to differentiate the Masonry Cement from Portland cements, it is commonly associate with red bag in the packing. In this picture, the Ordinary Portland Cement is in blue, Portland Composite Cement in green and Masonry Cement in red.

Factors to Consider

Different types of cement have different characteristics. The most important variables are the rate of hardening, the strength gain pattern, the heat of hydration, the resistance of the hardened cement to sulfate chloride attack and other durability aspects. Construction documents often specify a cement type based on the required performance of the concrete or the placement conditions. Factors to be considered when selecting the right cement are :

a) Type of construction
b) Speed of construction
c) Compressive strength requirement
d) Strength development
e) Specific requirements such as chloride & sulfate environment, permeability tests, control of ASR, etc.

Although the process for cement manufacturing is relatively similar across the world, the standards requirement can be vary. There are different types of cement and sometimes it can be difficult to determine the suitable cement for your project. When ordering cement for construction projects, do not extrapolate performance data for one cement as representing all cements. Work with your cement supplier to verify that the cement is suitable and meeting the requirements for the project and application.

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TECHNICAL REPORT

Thermal Properties of Concrete

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ABSTRACT

Thermal properties of building materials has a vital role on the amount of heat transfer in buildings. Thermal properties of concrete as the most consumed material in building sector affecting on the amount of energy consumption. Thermal conductivity (k-value) of concrete indicates its ability on heat transfer through conduction. Specific heat capacity(c-value) of concrete specifies the capability of concrete in heat storage. Thermal diffusivity of concrete as a function of its thermal conductivity and heat capacity indicates the rate of heat transfer in transient condition. Generally, concrete with low k-value and high c-value is desirable in building sectors to reduce energy consumption.

INTRODUCTION

More than ten billion tons of concrete is produces every year which as a common material is generally used in buildings, bridges, industrial pavements and other structures [1]. investigators have been considering the engineering properties of concrete due to its widespread usage [2]. Thermal properties of concrete have a vital role in the amount of heat transfer and thermal stress which are directly related to the energy saving in buildings and damage in structure, respectively. The key thermo-physical properties of concrete are: thermal conductivity, specific heat capacity and thermal diffusivity. It should be noted that around 30 % of greenhouse gas emission and one third of total energy consumption are attributed to the buildings sectors [3, 4]. Energy efficiency in buildings usually define as minimizing the energy usage in the form of heating and cooling. This is why using concrete with worthy thermo-physical properties can lead to the reduction in heat transfer and consequent! y energy consumption in building sectors.

THERMAL CONDUCTIVITY

Different types of heat transfer in buildings are categorized as conduction, convection and radiation (Fig. 1)

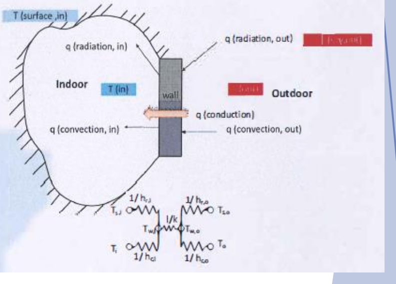

Figure 1: Principle of heat transfer in buildings

In conduction heat transfer in solids like as concrete is a mixture of vibrations of the molecules and energ r transport by free electrons [5]. Steady heat conduction is occurred when the temperature does not change with time and transient heat conduction is when it does. However, the heat transfer in buildings in real conditions is under transient conditions, but in some cases the heat transfer is considered m steady conditions because of easier analysis.

However, it is not possible to determine accurate heat transfer but we can achieve answer of our question to design HVAC system in critical conditions. The heat equation for a wall in steady state and transient conditions are:

$$\frac{d^2T}{dx^2} = 0 \text{ (Steady) (1)}$$

$$\frac{\partial^2 T}{\partial x^2} = \frac{1}{\propto}\frac{\partial T}{\partial t} \text{ (Transient)} \qquad (2)$$

Therefore, thermal conductivity (k-value) is a property of material, which demonstrated its capability in heat conduction [6, 7]. Further, the thermal conductivity value of materials, they are classified in different groups to use in different fields. The energy consumption in buildings extremely depends on the thermal conductivity value of the building materials [8]. The use of materials with low k-value is required to reduce energy usage in buildings.

The k-value of concrete in saturated conditions is higher than in dry conditions due to higher k-value of water compared to the air. Moreover, the measured k-value of concrete shows a declining trend with growing temperature. Using lightweight concrete is a valuable technique of reducing energy consumption due to the lower k-value of lightweight concretes (LWCs) compared to normal weight concrete (NWC). the application of structural lightweight aggregate concrete (SLW AC) in buildings located in European countries reduce 15% of heating energy compared to normal weight concrete (NWC) [9]. The relation between oven dry density and the k-value of concrete can be calculated using following equation [10]:

$$k = 0.0625e^{0\cdot0015P} \qquad (R^2 = 0.81) \text{ (3)}$$

SPECIFIC HEAT

Heat capacity of concrete shows its ability in the heat storage capability. However, specific heat states the heat storage capability of concrete per unit mass (J/kg oK). Specific heat is described as the amount of energy required to raise a unit of mass by one degree of temperature. Concrete with high specific heat is valuable for improving the temperature stability of buildings. On the other hand concrete with high specific heat is more stable against changing temperature. The specific heat of concrete is related to the c-value of each components. Therefore, using cementitious and aggregate with higher cvalue can increase the c-value of concrete. Also, incorporating the phase change material with concrete can be consider as another alternative to increase the specific heat through heat absorption and release during changing phase.

THERMAL DIFFUSIVITY

The transient conduction is related to the kvalue, c-value and density of material. These parameters are related each other based on thermal diffusivity as follow:

$$a = \frac{K}{pC} \qquad (4)$$

In fact *a* (m2/s) indicates the rate of heat spread through concrete. Therefore, concrete with low k-value and high c-value can be considered as a proper material for energy saving in building. The laser flash method is the most famous method of measuring thermal diffusivity. However, measuring k-value, cvalue and density and calculation the thermal diffusivity according Eqn 4 is an acceptable method.

CONCLUSIONS

Thermal properties of concrete are changing based on using different types of raw materials. According to the available literature the thermal conductivity of concrete is in the range of 0.2 w/m.°K to 3.8 w/m.0K. The specific heat is in the range of 0.741 Jig oK to 1.00 J/kg oK. The thermal diffusivity of concrete has been reported in the range of0.62 mm2/s to 1.17 mm2/s. T□ e general conclusion of this study can summarized as below:

a. The thermal conductivity of concrete is a function of its aggregate' s type, temperature and humidity, type of cementitious and density.

b. The thermal conductivity of concrete has a declining trend with rising temperature. Also, the k-value increased in saturated conditions due to higher k-value of water compared to the air. Lightweight concrete has the lower thermal conductivity compared to the normal weight concrete.

c. Using materials with high specific heat capacity as aggregate and/or cementitious material can increase the heat capacity of concrete.

d. Incorporation phase change material in concrete can increase the latent heat of concrete and its capability in heat storage.

e. Using concrete with low k-value and high c-value in structural and nonstructural part of building can reduce the amount of heat transfer in buildings and save the energy.

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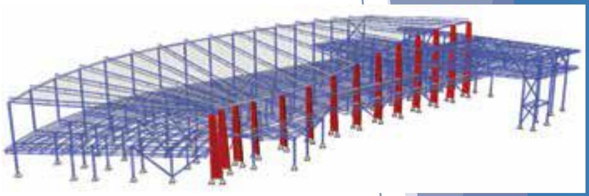
CASE STUDY

CONTRIBUTED BY: Anthony P. Harasimowicz

A Precast Shear Wall Case Study

Constructing the International Arrivals Facility for Seattle-Tacoma International Airport

The Port of Seattle's new, expanded International Arrivals Facility (IAF) at the Seattle-Tacoma International Airport in SeaTac, WA, USA, will address the facility's continued growth by significantly increasing the number of international-capable gates and passenger capacity. A unique feature of the IAF's main terminal building was the incorporation of 37 precast concrete shear walls along the west side of the structure. These walls are exposed to view at the interior and exterior of the building, so a quality finish was essential. The units are 2 ft (0.6 m) thick and 8 ft (2.4 m) wide at the base with rounded ends, and each wall has a unique height—up to a maximum of 80 ft (24 m).



Partial structural model of the IAF, looking southeast. The precast concrete shear walls, shown in red, varied in height to match the swooping roof geometry

Design and erection challenges included:

• The wall designs had varied geometry—one of the rounded ends was sloped over much of the height, and each wall was a different height to support the sloped/curved roof;

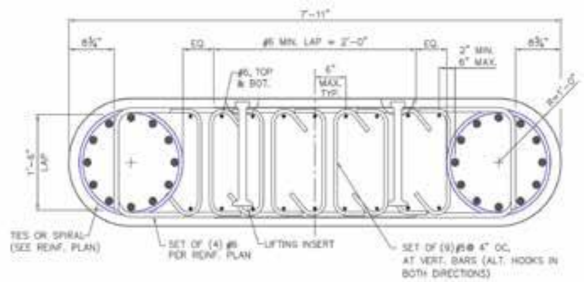
• Custom steel formwork was produced and modified for each wall;

• The walls contained welded bar couplers at the base, complicated reinforcing, and a variety of embeds for the connection of wide flange beams, collectors, and bracedframe gussets. Many of these embeds were required at the rounded ends of the walls;

• The structural engineering team worked closely with Concrete Technology Corporation, Tacoma, WA, throughout the design and detailing of the walls to allow the reinforcing bars to be configured to help ease construction of the cages;

• All walls were cast horizontally, with formed surfaces on one long side and the two radiused ends. The other long side was manually completed with a hard-troweled finish. The form-finished sides were designed to face into the passenger flow direction of the terminal. The manually finished surfaces (the "backs" of the walls) also incorporated lifting inserts used for handling and erection;

• The walls were delivered to the site using specialty



A typical concrete wall section and an assembled reinforcing cage

transport trailers and erection was completed using two sets of lifting inserts (one set for truck off-loading and one set for final lifting and setting); and • Each wall incorporated an additional base plate that was welded to the cast-in embed plate at the bottom of the wall.

This allowed each wall to be set and anchored to the foundation using traditional cast-in-place anchor rods. The walls were set rapidly with no issues, which was critical to the overall schedule as the steel framing erection followed closely behind each group of walls.

Shear-bolt couplers were welded to steel embed plates to connect longitudinal bars at the base of each wall

Workers are shown placing embeds in the steel form. After the reinforcing cage was installed, the top halves of the side forms were bolted in place to form the 180-degree radiused ends of the wall unit

Walls weighed from 45 to 93.5 tons (41 to 85 tonnes) and were delivered using special transports

Wall units were handled using rigging inserts placed on the manually finished side, and they were anchored to foundations using cast-inplace anchor rods

A view of the walls as the project nears completion

Project Credits

- **Architect:** Skidmore, Owings & Merrill
- **Engineer:** KPFF Consulting Engineers
- **Contractor:** Clark Construction Group, LLC
- **Precast Supplier:** Concrete Technology Corporation
- **Formwork Supplier:** Helser Industries

Selected for reader interest by the editors.

Anthony P. Harasimowicz is a Project Manager with KPFF Consulting Engineers, Seattle, WA, USA. He received his BS and MS in civil engineering from Syracuse University, Syracuse, NY, USA. Harasimowicz has over 24 years of experience in structural design and project management and is a licensed professional engineer in Washington.

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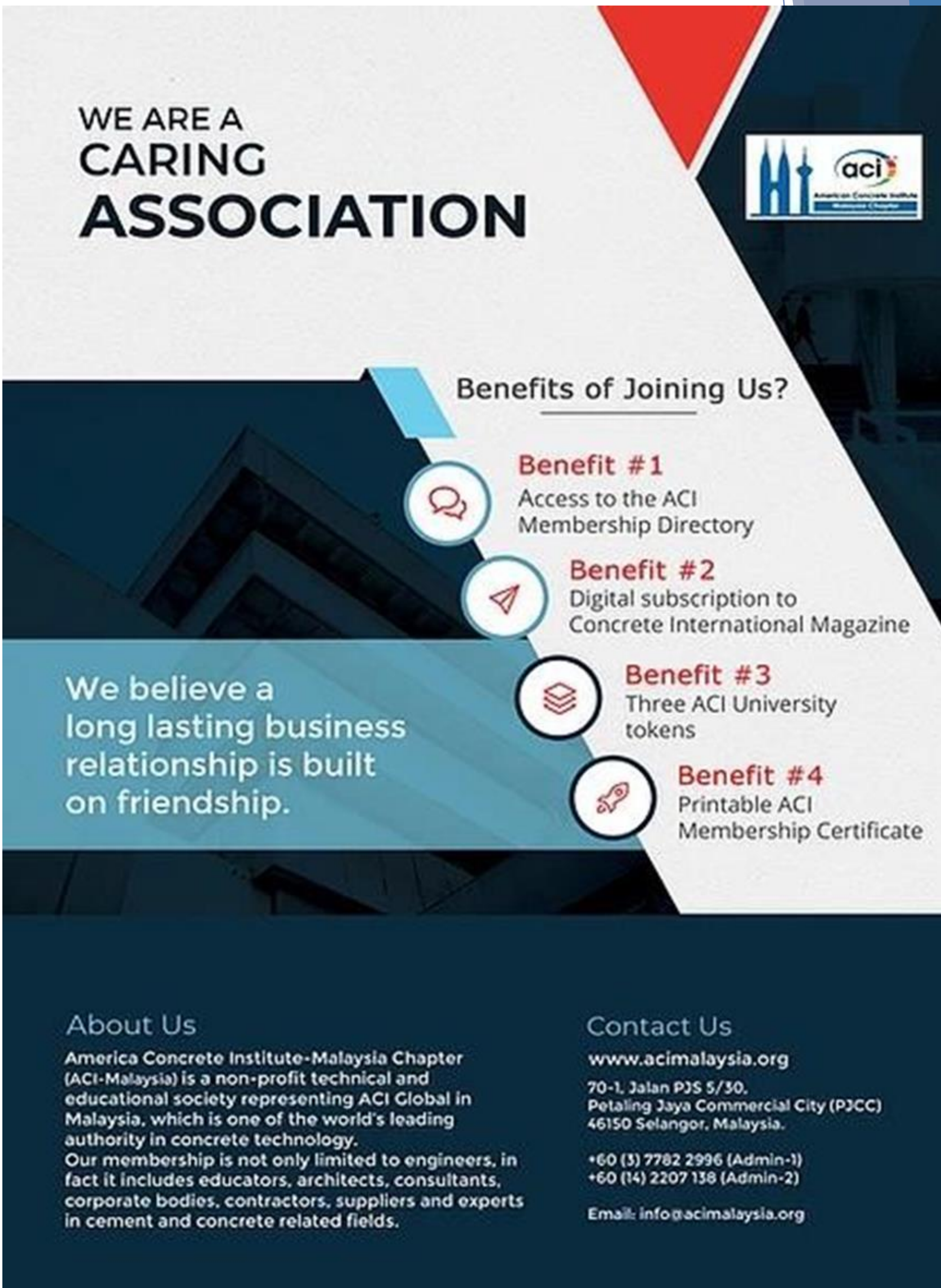
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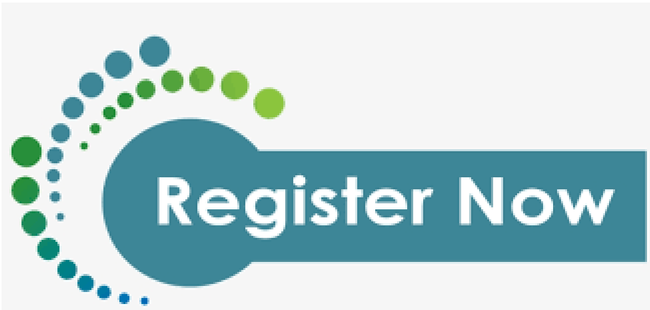

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*Once payment has been made, it is important to send **Remittance Slip/ Deposit Advice/ Bank Transfer Receipt** to our Administrative Office for confirmation, via these channels:*

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eMail: **admin@acimalaysia.org**

(*) Benefits provided by **ACI International** for Chapter Members:

1. Digital subscription to Concrete International magazine;
2. Access to the ACI Membership Directory; and
3. 3-Tokens to ACI University Courses;
4. Printable ACI Membership Certificate

Important Notes:

- Benefits will be accessible via Temporary Password sent to your email account either in the month of **June** or **December**, depend on time slot of **Chapter Member List** update to **ACI International**;
- All benefits are subject to change without prior notice.

Personal Particulars:

Are you a Member of **American Concrete Institute International** (ACI International)?

❒ No.
❒ Yes. (Please provide your ACI Int'l Membership Number: ____________ Since (Year): ________)

Name: ________________ (First) ________________ (Last)

Salutation / Title: ________ (Mr./ Ms./ Mdm./ Ir./ Ar./ Dr./ Prof./) Other: ________

NRIC/ Passport No: ________________ Nationality: ________

Mobile Number: +60 (1) - ________ Email: ________________

Company / Organization: ________________ Designation: ________

Postal Address: ________________________________

____

Postal code: ________ State: ________________

Tel.: ________ Fax: ________ Email: ________________

I am introduced to ACI-Malaysia Chapter by: ________________________

....

Applicant Signature Date

For Office Use Only

Membership No: | | - | | | | | Receipt No.: ________ Date: ________

Verified by: .... (Name: ________) Date: ________

❒ NF/ RF ❒ PoP ❒ DB ❒ MRR ❒ GgIC ❒ RvnT ❒ InvT ❒ I&R ❒ MF/PoP/I&R-F

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