MyConcrete

Volume 12, Issue 10 November 2021

The Bulletin of the American Concrete Institute – Malaysia Chapter
(e-Bulletin)

American Concrete Institute
Malaysia Chapter

MyConcrete:
The Bulletin of the American Concrete Institute – Malaysia Chapter

Editor:
Dr. A. B. M. AMRUL KAISH
Department of Civil Engineering, Faculty of Engineering & Built Environment,
Universiti Kebangsaan Malaysia, UKM Bangi 43600, Selangor DE, Malaysia

http://www.acimalaysia.org
+6014 220 7138
admin@acimalaysia.org

Published in Malaysia by
American Concrete Institute - Malaysia Chapter
70-1, Jalan PJS 5/30, Petaling Jaya Commercial City (PJCC),
46150 Petaling Jaya, Malaysia.

CONTENT

EDITORIAL NOTE

Concrete, often known as “Manmade Stone”, is one of the most versatile construction materials. Due to its versatility in behaviour and application, concrete technologists have to be updated on latest knowledge in the field of concrete technology. With the aim of contributing valuable knowledge on cutting-edge research and case studies on concrete and related construction materials, ACI – Malaysia Chapter publishes MyConcrete as its official bulletin.

This issue contributes an article reporting a brief overview on carbon fibre reinforced polymer (CFRP) bar as reinforcement for concrete. Owing to the non-corrosiveness of polymeric material CFRP can be utilized as an alternative to conventional steel reinforcement for concrete in extreme weather conditions. The technical report discusses about the field application of ultra-high performance concrete (UHPC) in Malaysia. UHPC presents outstanding structural performance that constitute to the sustainable construction solution. This paper provides an overview on some successful projects with the application of UHPC technology in Malaysia. The case study reports the application of Enerpac strand jack technology in Cline Avenue Bridge, an elevated expressway in East Chicago, USA. Enerpac strand jack technology instead of a traditional crane approach to complete the span that needed to remain open to barge traffic during the construction of the bridge. This paper is reprinted from Concrete International (CI) magazine with permission.

We would like to express our gratitude to the individual contributing articles for this issue and would like to invite concrete technologist and engineers to contribute articles for the upcoming issues of MyConcrete bulletin. The premium sponsorship from the Structural Repairs (M) Sdn. Bhd. is highly cherished. We also would like to thank PLYTEC Holding Sdn. Bhd. as our loyal sponsor. The team hopes to get more sponsorship for the upcoming issues.

Thank you very much.

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

NOTE FROM MEDIA HEAD

Greetings concrete enthusiast! We are proud to present you the latest issue of My Concrete bulletin. On behalf of American Concrete Institute – Malaysia Chapter, we would like to thank all the supports from our fellow member. On top of that, as the head of Media group, I would also like to personally highlight how much I appreciate the effort from the editorial team to provide us this monthly bulletin with such informative articles and event updates.

With the effort of the entire ACI Malaysia team, our bulletin this month focuses on special mix concrete. Although it is not new but we still do not know enough about these topics. It is always good to see that there are professionals willing to share information on them. We are talking about CFRP and fortunately, our very own Dr. Shobana is willing to share her thesis that she spent years to research on. On top of that, another topic that I personally like is UHPC shared by Monash University. To my mind, it is a mix that still has a lot of potential to be used at different area.

Once again, we would like to remind that we have started to offer a platform for our ACI student member to seek for their internship while industry member could post up for internship hiring. With this effort by ACI Malaysia, we hope that we could narrow the gap between students and the industry by allowing them to be exposed to "practical concrete" rather than just "theoretical concrete" from their academy.

Apart from showing our gratitude to the contribution of the technical report, we must also thank our fellow sponsors for this month's successful sharing. Our premium sponsor of the month is STRUCTURAL REPAIRS (M) SDN.BHD. They specialize on investigation and structural repairs. Furthermore, our loyal sponsor this month is PLYTEC HOLDING SDN. BHD. They provide services including an academy that educates on BIM, fencing and also formwork. Without such sponsorship, we will not have been able to launch and share another successful bulletin.

To all members, we are continuously seeking for your sharing and contribution. Do contact our admin shall there be any enquiry.

Once again, we like to sincerely thank all our contributors and also the media team together with the editorial team for another month of successful sharing.

The pandemic is yet to be endemic. We also like to urge everyone to stay safe especially with the new variant. Please follow the required S.O.P and bring our nation back on the right track. Together, we can.

Oscar Teng
Head of Media Committee

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.

PAST PRESIDENTS

1997 - 1998: Ir. Tee Ah Heng (Protem)

1998 - 2000: Ir. Dr. Kribanandan G. Naidu

2000 - 2002: The Late Dr. Norzan Mohd Yusof

2002 - 2004: Ir. Soo Thong Phor

2004 - 2006: Mr. Seow Aik Guan

2006 - 2008: Ir. Boone Lim

2008 - 2010: Ir. Parnam Singh

2010 - 2012: Ir. Ng Kok Seng

2012 - 2014: Dr. Zack Lim

2014 - 2016: Dr. Zack Lim

2016 - 2018: Ms. Serina Ho

2018 - 2020: Dr. Sudharshan N. Raman

2020 - present: Mr. Martin David

MANAGEMENT FOR 2020-2022

BOARD OF DIRECTION (BOD) FOR 2020-2022


President:
Mr. Martin Gerard Joachim David


Secretary:
Prof. Dr. Hamidah Mohd. Saman


Treasurer:
Mr. Chris Yong


Board of Director I:
Dr. Zack Lim


Board of Director II:
Mr. Mike W. P. Lim


Immediate Past President:
Dr. Sudharshan N. Raman

NOTICE

Membership Subscription 2021
Gentle reminder that 2021 subscription is due.

Kindly note that payment can be made as follows:
Bank: Hong Leong Bank Berhad
Account Number: 291 0002 0936
Account Name: American Concrete Institute – Malaysia Chapter

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:*
WhatsApp: **+60 (14) 2207 138** or
E-mail: **admin@acimalaysia.org.my**

Digital Membership Certificate 2021
Members who have paid their subscription will receive their digital membership certificate.
See sample below.

Associate

Organisation

Student

Internship Programme For ACI Student Members

(Subject to Terms & Conditions Apply by Companies)

Company Name	Company Address	Person To Contact	Business Involved
PLYTEC FORMWORK SYSTEM INDUSTRIES SDN BHD	No. 19, Jalan Meranti Permai 3, Meranti Permai Industrial Park, Batu 15, Jalan Puchong, 47100 Puchong, Selangor.	012 - 691 2883 (Mr.Louis Tay)	BIM Engineering Specialist, CME Project Delivery, IBS & Prefabrication Construction.
CRT SPECIALIST (M) SDN BHD	E5-5-25, IOI Boulevard, Jalan Kenari 5, Bandar Puchong Jaya, 47170 Puchong, Selangor.	012 - 313 5991 (Mr.James Lim)	Waterproofing Work, Concrete Repair & Strengthening, Injection & Grouting.
REAL POINT SDN BHD	No. 2, Jalan Intan, Phase NU3A1, Nilai Utama Enterprise Park, 71800 Nilai, Negeri Sembilan.	016 - 227 6226 (Mr.Chris Yong)	Concrete Admixture Production.
JKS REPAIRS SDN BHD	Star Avenue Commercial Center, B-18-02, Jalan Zuhal U5/178, Seksyen U5, 40150 Shah Alam.	017 - 234 7070 (Mr.Kathiravan)	Structural Repair Works, Structural Strengthening, Waterproofing System, Injection & Sealing, Concrete Demolition Works, Protective Coating For Concrete And Steel.
ZACKLIM FLAT FLOOR SPECIALIST SDN BHD	70, Jalan PJS 5/30, Petaling Jaya Commercial City (PJCC), 46150 Petaling Jaya, Selangor.	603 - 7782 2996 (Mr.Zack Lim)	Concrete Flatfloors.
UFT STRUCTURE RE-ENGINEERING SDN BHD	No 46, Jalan Impian Emas 7, Taman Impian Emas, 81300 Skudai Johor.	012 - 780 1500 (Mr.Lee)	Structural Repair, Construction Chemical, Carbon Fibre Strengthening, Protective Coating, Industrial Flooring, Soil Settlement Solution, Civil & Structure Consultancy Services, Civil Testing & Site Investigation.
SINCT-LAB SDN BHD	No 46, Jalan Impian Emas 7, Taman Impian Emas, 81300 Skudai Johor.	012 - 780 1500 (Mr.Lee)	Structural Repairing, CFRP Strengthening, Site Investigation, Civil Testing, Soil Settlement Solution, Civil And Structural Design And Submission.
STRUCTURAL REPAIRS (M) SDN BHD	No. 1&3, Jalan 3/118 C, Desa Tun Razak, 56000 Wilayah Persekutuan, Kuala Lumpur	012 - 383 6516 (Mr.Robert Yong)	Carbon Fiber Reinforced Polymer System, Sealing Cracks With Resin Injection, Re-Structure Repairs and Upgrade, Diamond Wire & Diamond Blade Sawing System, Diamond Core Drilling, Non-Explosive Demolition Agent.

Important Notes:

i) ACI Malaysia is only a platform for our members to advertise for interns.

ii) All application to be made direct to companies and would be subject to their terms and conditions.

MyConcrete Volume 12, Issue 10 November 2021

UP COMING EVENTS

For more info:

www.acimalaysia.org

See you live at:

facebook.com/acimalaysia.org

PRECEDING EVENTS

ARTICLE

An Overview of CFRP Reinforcement in Concrete

Derived from excerpts of the PhD thesis of Dr. Shobana Sivanendran, University of Cambridge, 2017

Traditionally, concrete structures are internally reinforced with steel bars. However, there are many problems that result from the corrosion of this steel reinforcement. The corrosion products of the steel reinforcement occupy a greater volume than the original steel causing bursting forces to build up within the concrete cover. This leads to cracking and spalling of the concrete, which could significantly weaken the structure In prestressed concrete, corrosion could lead to sudden snapping of the pre-tensioned steel reinforcement, which has in some cases led to catastrophic damage of large structures. In 1985, a post-tensioned single span concrete bridge in Ynys-y-Gwas, Wales, collapsed suddenly with no signs of weakening prior to failure. The failure was attributed to severe localised corrosion of the prestressed tendons.

To this day, there has been extensive research conducted to find ways of mitigating this problem of corroding steel reinforcement. The addition of silica fume to concrete mixes significantly decreases the permeability of the concrete to water. This makes it more difficult for external moisture to penetrate into the concrete and instigate the corrosion process in the steel reinforcement. However, it does not prevent moisture from penetrating through cracks in the concrete. To solve this, research has also been conducted to find ways to initiate a self-healing process for cracked concrete that could prevent environmental moisture from reaching the reinforcement. However this idea is still in its infancy and has yet to produce crack healing at the required rate and robustness for field applications. The other main alternative to preventing corrosion in reinforced or prestressed concrete is to replace the steel entirely with a non-corrosive material. Following from the successful applications of fibre reinforced polymer (FRP) materials in the aeronautical and maritime industries, the idea for the use of such materials as construction materials has been explored. The three fibres commonly considered were glass (GFRP), carbon (CFRP) and aramid (AFRP).

The main challenge in using FRP rods as a replacement for steel lies in their inherently different material properties. FRPs fail in a brittle manner. This is unlike steel, which yields significantly prior to ultimate failure i.e. steel fails in a ductile manner. Therefore if a concrete structure were to be under-reinforced with FRP rods, there could be limited warning signs if the rods were close to their ultimate load capacity. Particularly for prestressed FRP rods, any failures could occur suddenly. Additionally, FRPs have a much higher strain capacity than steel, approximately 10 times higher, and are also significantly more expensive. Therefore the most economical method of utilising them would be as prestressed reinforcement. These considerations mean that a different design approach to that of steel reinforced concrete is required when using FRPs.

While CFRP rods with a high strength and stiffness offer an attractive alternative to steel as prestressed reinforcement because of their non-corrosive nature, other modes of deterioration of these rods when exposed to high moisture environments cannot be ruled out. Any deterioration over the long-term should be accounted for during the design stage to ensure safe structures for the duration of their design life.

The CFRP tendons used in pre-stressed applications are cylindrical in shape with diameters ranging from 3mm to 10mm. They are made of thousands of continuous unidirectional carbon fibres of diameter approximately 5-6μm set in an epoxy matrix.

The tendons are most commonly manufactured using the pultrusion method, where the carbon fibre strands are pulled through a resin bath and then through a heated die thus forming a continuous carbon-epoxy tendon. They are then surface treated to encourage better bond with the concrete. Spiral wound fibres, indentations and sand coatings may be added during the manufacturing process to improve the CFRP-concrete bond. Bundles of rods may be combined to form strands, also used in prestressed concrete members.

The tendons derive most of their strength from the fibres while the matrix functions primarily as a binder of the fibres and a distributor of the imposed loads. Because of the unidirectional orientation of the fibres, the resulting polymer is anisotropic and possesses different material properties in the longitudinal and transverse directions. Material properties in the direction parallel to the fibres are fibre dominated and material properties in the transverse orientation to the fibres are matrix dominated. Thus when considering the durability of CFRP tendons, it is important to take note of these directional effects in relation to the directions of the applied loads.

Currently in Malaysia, there are some applications of CFRP sheets for the strengthening of concrete structures, however the use of CFRP as internal prestressed reinforcement in concrete is still yet to be applied. Potentially with further research, the benefits of such applications for structures that are more prone to corrosion, such as sea bridges, could be better understood to pave the way to the use of CFRP as internal prestressed reinforcement here.

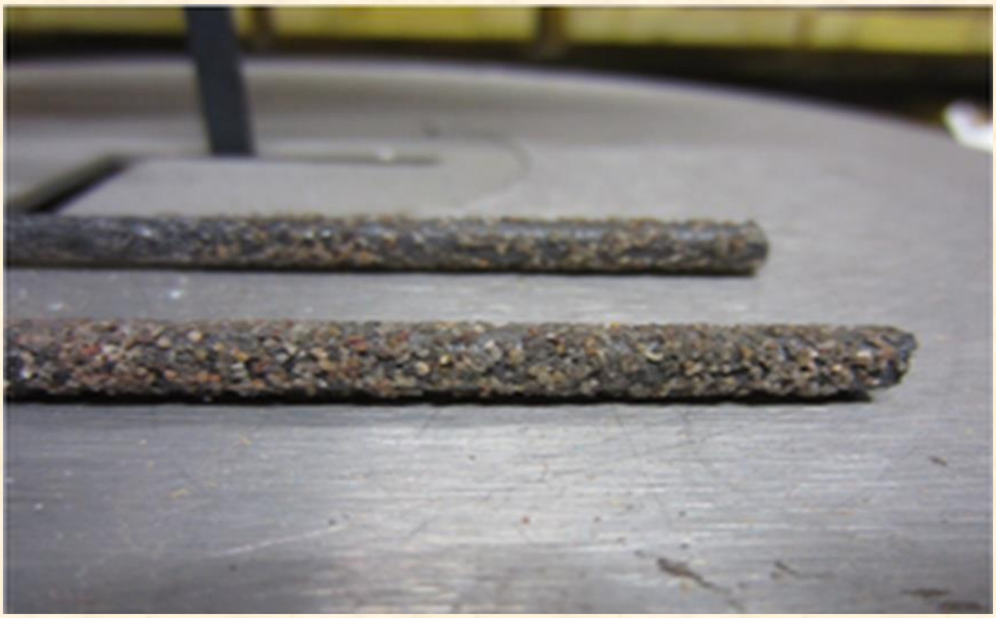


Image 1: Photograph of sand-coated CFRP tendons (Source: Dr. Shobana Sivanendran)

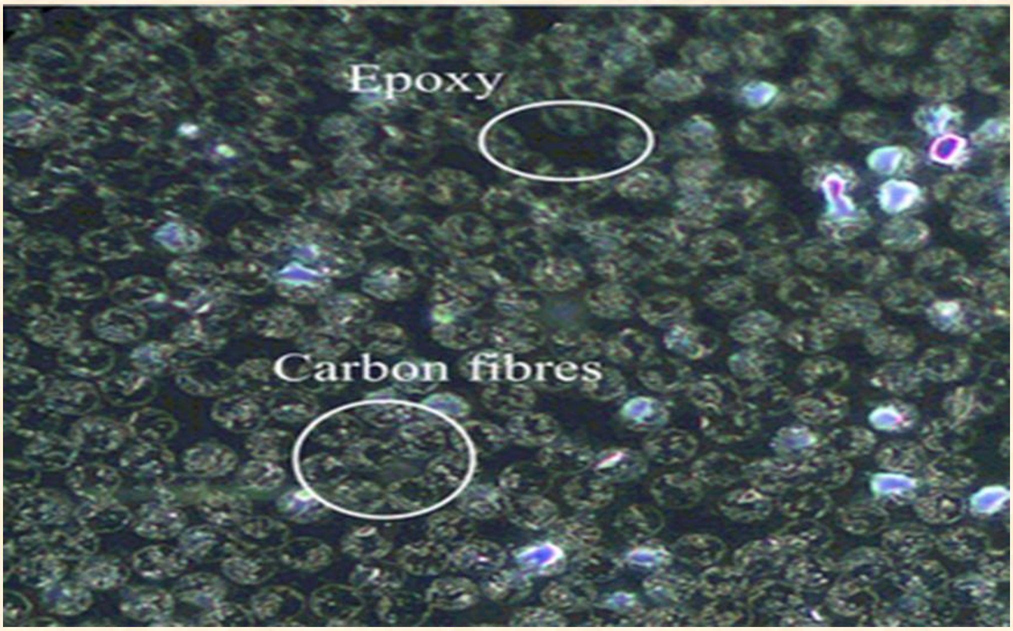


Image 2: 500x optical microscope photograph of transverse cross section of CFRP rod showing the carbon fibres and epoxy matrix (Source: Dr. Shobana Sivanendran)

TECHNICAL REPORT

UHPC Technology in Malaysia - A wide range of applications

Shack-Yee Hiew, Sudharshan N. Raman*, Daniel Kong
Civil Engineering Discipline, School of Engineering,
Monash University Malaysia
Jalan Lagoon Selatan, 47500 Bandar Sunway, Selangor, Malaysia
*Email: sudharshan.raman@monash.edu

Introduction

The increasing availability of non-proprietary ultra-high-performance concrete (UHPC) over the last two decades has contributed to the advancement of UHPC construction. With superior mechanical and durability properties, UHPC is becoming a game-changing material in the field of concrete technology. The applications have ranged from building components, bridges, repair and rehabilitation, architectural features and small-scale towers such as windmills and utilities towers for oil and gas industry, hydraulic structures and offshore structures [1]. Of all the applications, road and bridge constructions are the two most popular applications. Construction using UHPC material have been implemented in several countries including Australia, China, Canada, Austria, France, Japan, Germany, Czech Republic, Italy, Japan, South Korea, Netherlands, Slovenia, Switzerland, Malaysia and United States for bridge application. In the early 1990s, UHPC was first known as reactive powder concrete (RPC) which consisted of two different classes, that are Class 200 MPa and 800 MPa. Over the years, several types of proprietary and non-proprietary UHPC variations such as Ceracem®, BSI ®, multi-scale cement composite (MSCC), RPC and compact reinforced composition (CRC) have been produced by different manufacturers around the world [2].

In general, UHPC can be described as a combination of three different concrete technologies: fiber-reinforced concrete (FRC), high-performance concrete (HPC) and self-compacting concrete (SCC) as shown in Fig. 1 [3]. UHPC is distinguished from FRC by its higher tensile strength and strain hardening behaviour in the tensile stress-strain curve. To date, there is no universal definitions constituted from the mechanical properties across the standards. According to FHWA [4], UHPC is defined as a “cementitious composite material composed of an optimized gradation of granular constituents and discontinuous fiber reinforcements with water-to-binder ratio less than 0.25, compressive strength above 150 MPa and pre- and post-cracking tensile strength above 5 MPa”. ACI Committee 239 of the American Concrete Institute (ACI) [5] defines UHPC as “concrete that has a minimum specified compressive strength of 150 MPa with specified durability, tensile ductility and toughness requirements; fibers are generally included to achieve specified requirements”. AFGC recommendations provide the same definition but with a limit of compressive strength not exceeding 250 MPa and minimum fiber content of 2% [6].

In Malaysia, it appears that the use of UHPC materials is limited due to the perceived higher initial high cost. In addition, the lack of design codes and limited knowledge in practice limit the implementation of UHPC. However, positive trends have been indicated over the past decade with the emergence of a few local players who are willing to exploit the benefits of this advanced concrete technology. This paper provides an overview on some successful projects with the application of UHPC technology in Malaysia.

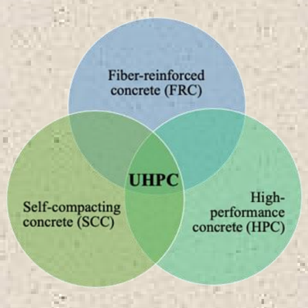


Fig. 1. Three type concrete technologies that defines UHPC.

The Malaysia's experience

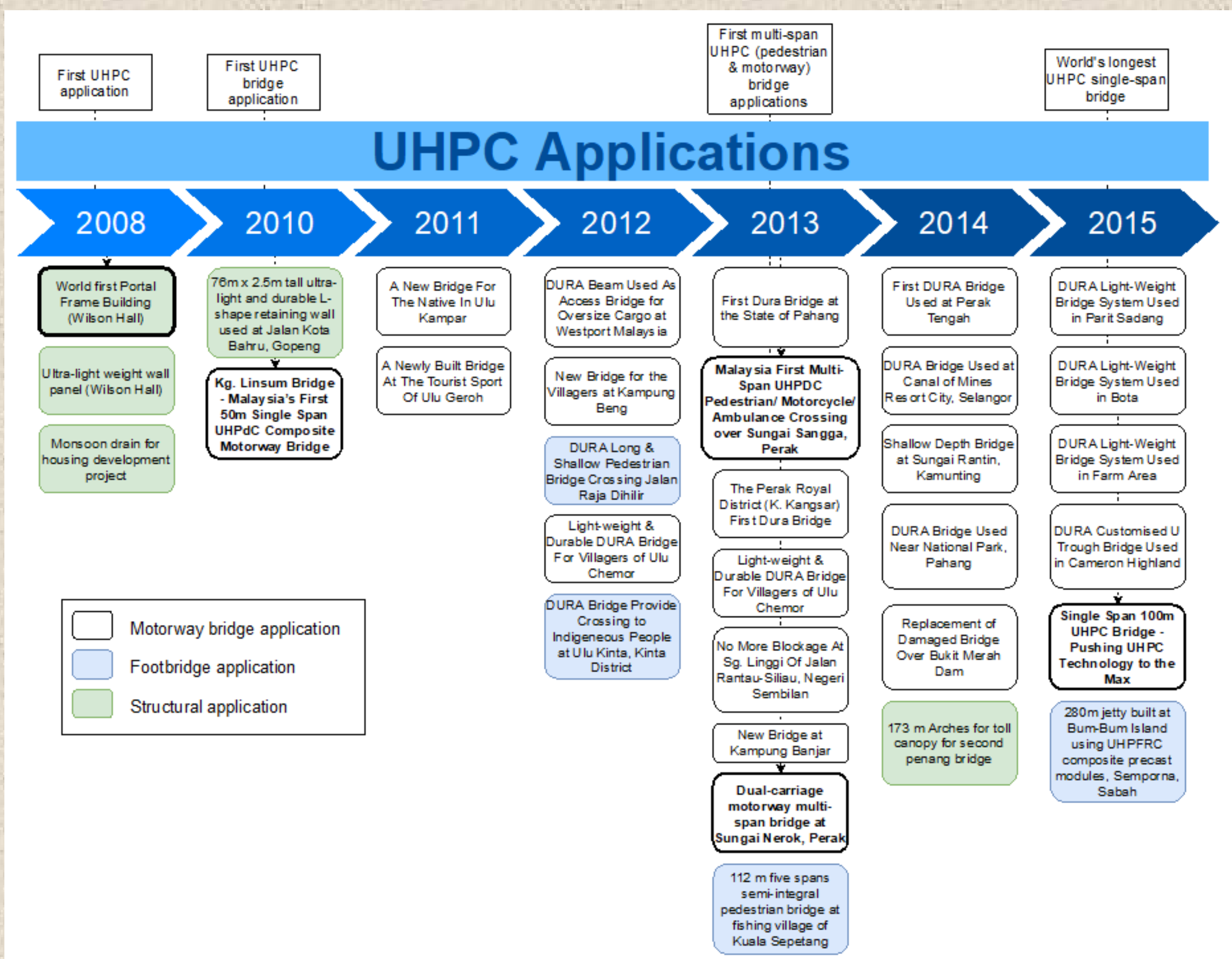
UHPC was first introduced in Malaysia in 2006 by a local player, Dura Technology Sdn. Bhd. (Dura), with a fabrication plant in Chemor, Perak, Malaysia. In the initial stage, UHPC was first introduced as a concrete material with compressive strength and flexural strength over 160 MPa and 30 MPa respectively [7]. After years of research, a more optimized version of UHPC was developed with the following improvements [8]:

1. Optimized material constituents into cement, silica fume, sand, high-range water-reducing (HRWR) admixtures and water.
2. Indoor facility with 12 m^3 mixer, optimized size of precast concrete products, enclosed protections and easy handling in construction
3. Four standardized cross-sections: pretensioned decked I-beams (short span), segmental U-girders and spliced I beams (medium span) and segmental box girders (long span) were produced
4. The use of straight pre-tensioning (where possible) and straight bottom flange post-tensioning with segment interfaces which are joint using match-cast, with shear-key joints.
5. Developed minimum requirement for each batch to achieve 1-day and 28-day average cube strength of 70 MPa and 165 MPa respectively with an average 28-day flexural strength of 25 MPa.
6. Simplified curing process without losing production efficiency.

Through several years of research, UHPC bridges were designed and built by Dura together with the Malaysian Public Works Department (JKR) that focused mainly on rural areas [8]. With the gradual domination of UHPC market and acceptance in the local practice, more than 90 bridges including those subjected to high traffic loads have been successfully completed by Dura by the year of 2018 [2].

Applications in Malaysia

Due to the broad network of road across rural areas, Malaysia was looking forward to durable and low maintenance construction material that would support to enhance the country's transport infrastructure. The successful application of UHPC allowed the development of a wide range of civil engineering applications including precast bridges, archi-structural features, portal frame structures, wall panels, durable components exposed to marine environments and as a strengthening material for repair/rehabilitation of reinforced concrete structures. Among all the applications, bridge application dominates the UHPC industry in Malaysia. In the recent years, UHPC has been adopted by multi-level governmental agencies and private sector as a feasible practice, based on the premise that UHPC will become the sustainable solution in the future. Fig. 2 presents the evolution of UHPC technology and various applications from 2008 to 2021.



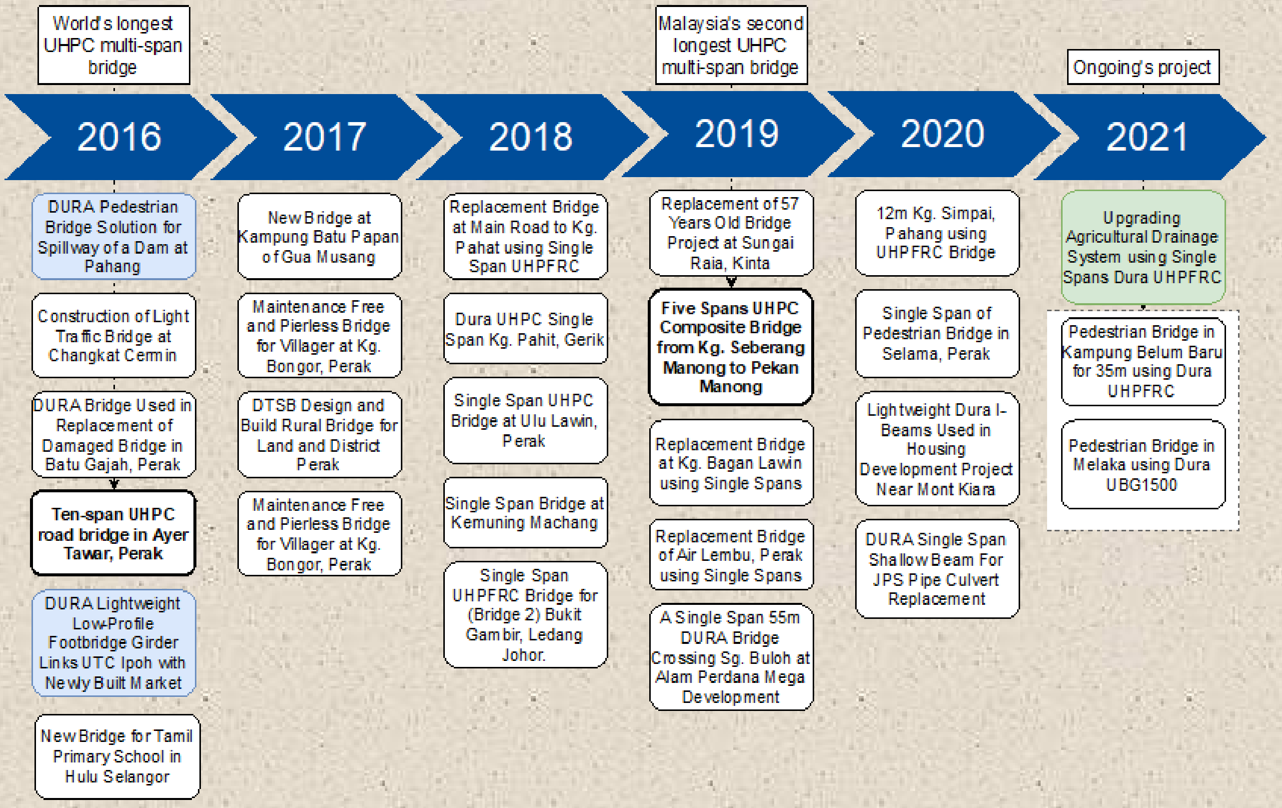


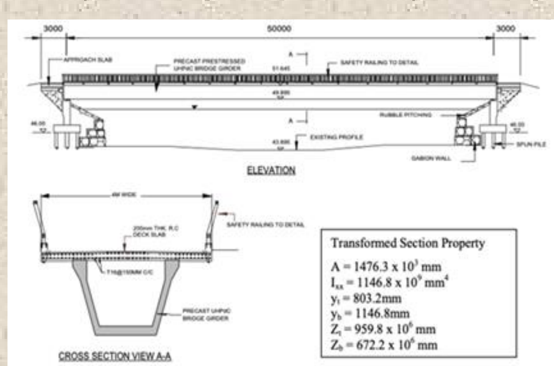
Fig. 2. Evolution of UHPC applications in Malaysia.

1) Bridge Application

The very first UHPC engineering structure in the world was a prestressed hybrid pedestrian bridge over the Magog River in Sherbrooke, Canada, which was constructed in 1997 [9]. Since then, over 200 UHPC bridges or bridge components have been implemented around the globe, in Canada, France, South Korea, US, Australia, Netherland and many others. To date, Malaysia has the most number of UHPC bridges built, with more than 100 across the country. A latest chart showing the cumulative number of UHPC bridges built by Dura and a scatter number of bridges across Malaysia are shown in Fig. 3a and b respectively [10]. Different types of bridges, ranging from footbridge, motorway bridge, jetty and submerged bridge were constructed. Precast/prestressed girders manufactured using Grade 140/150 with cast in-situ bridge deck using Grade 32/40 normal strength concrete is the most popular type of UHPC bridge used in the country. Of all the precast/prestressed UHPC beams, 61% were segmental girders that required assembling work at the construction site using post-tensioning, while the remaining 39% were precast pre-tensioned beams that required prefabrication [11].

In terms of ownership, over ninety percent of the bridges were under Malaysia government agencies with JKR having the largest ownership of 56.7%, followed by Department of Irrigation and Drainage Malaysia (JPS) having an ownership of 11.4%. Ministry of Rural and Regional Development (KKLW) and other governmental agencies owned the remaining 28.7% [11]. Malaysia's first UHPC bridge was a 50 m long single span-single lane motorway bridge crossing Sungai Linggi in Kampung Linsum, Negeri Sembilan (Fig. 4). The project was completed in year 2010. The bridge was built with precast/prestressed U-through girder composited with 4 m wide and 200 mm thick cast in-situ reinforced concrete deck [12]. The UHPC used for this project achieved a compressive strength and flexural strength up to 180 MPa and 30 MPa, respectively. Since then, a number of single span bridges were constructed across the state of Perak and expanded to Pahang in the year 2013.

Fig. 3. Number of bridges constructed over the year of 2009 to 2020 in Malaysia. (a) Cumulative line chart, and (b) Number of bridges across the different states in Malaysia [10]



Malaysia's first multi-span UHPC bridge was a pedestrian/motorcycle/ambulance bridge crossing over Sungai Sangga Besar in Perak. The structure was made up of one span 20m wide pedestrian-motorcycle bridge and two spans of 22.4 wide pedestrian-motorcycle ramps that make up a total bridge length of 112 m as shown in Fig. 5. The project was completed in the year 2013. For motorway or roadway bridge, the Sungai Nerok Bridge was the first built multi-span bridge in Malaysia. The Sungai Nerok Bridge which was completed in year 2012 comes with three 30 m long spans with each span consisting of 10 beams made of two UHPC decked bulb-tee halves [8]. In the year 2015, the world's longest single span 100 m road bridge was constructed in Batu 6, Gerik, Perak using UHPC segmental box girder. The record breaking 100-m long bridge was listed by the Malaysia Book of Records as the "Longest Single Span Bridge Constructed Using Ultra-High-Performance Concrete (UHPC)" replacing the previous record of

50 m Kampung Linsum Bridge in Negeri Sembilan [14]. This segmental box-girder bridge has a total of thirty-six 2.5 m long standard segments and four anchorage segments [8], [15]. Fig. 6 shows the world's longest UHPC single-span bridge crossing Perak River in Batu 6, Gerik, Perak. The current world's longest multiple span UHPC bridge is a ten-span road bridge crossing an estuary between Kampung Baharu and Kampung Teluk at Ayer Tawar, Perak [16]. With each span having a length of 42 m, the bridge has a total length of 420 m [11]. In 2017, another remarkable bridge project known as the Manong Bridge was designed by JKR. The Manong Bridge is the second longest five-span bridge with a total length of 308 m (45m + 70m + 70m + 70m + 45m) crossing the Perak River.

Fig. 5. Malaysia's first multi-span motorcycle-pedestrian bridge crossing Sg Sangga Besar, Perak [17].

Fig. 6. World's longest UHPC single-span bridge at Batu 6, Gerik, Perak [18].

2) Structural applications

In the early stage, UHPC was used to provide solutions for various structural applications such as warehouse, wall panels and retaining wall constructions. In the year 2008, UHPC technology was implemented in a portal frame structure known as "Wilson Hall" in Chemor, Perak. Fig. 7 shows the portal frame structure during and after the project completion in 2012. The portal frame was initially constructed to investigate the potential use of ductile UHPC as a substitute of steel members in portal frame structure. This building has also earned a place in the Malaysia Book of Records in year 2010 [19]. Wilson Hall was built with prefabricated UHPC system with a total roof coverage of 2861 m3, with a width and length of 67 m and 42.7 m respectively [20]. By the means of environmental impact calculation (EIC), the use of UHPC resulted in a comparatively lower material consumption, construction cost and environmental indexes (embodied energy and CO_2 emissions) than the conventional steel portal frame structure [19]. In addition to the portal frame structure, a total of 56 m long UHPC wall panels were also installed around the Wilson Hall. Each wall panel was 7 m high and 2 m wide which makes up a total self-weight of 2400 kg per piece. The installation of wall panels was relatively easy as no formwork is required and simple drop-in anchors or pre-positioned bolts and nuts were used to connect the wall panels to the floor [7].

Fig. 7. Wilson Hall portal frame in Perak. (a) during construction, (b) completed structure, (c) EIC comparison with conventional steel portal frame [19].

In year 2010, a series of L-shaped UHPC retaining walls were used in the construction of a 90 m long monsoon drain for residential project located in Ipoh, Perak. The monsoon drain included a total of 180 m long by 1.5 m high retaining walls as shown in Fig. 8a. Precast UHPC retaining wall which comes in 3 m lengths per piece with a smaller cross-section was five times lighter than conventional RC retaining wall which conventionally comes with 1 m length per piece (See Fig. 8b). A load proof test performed on the retaining wall showed excellent performance in satisfying the strength and serviceability requirements. Similar to the EIC result of portal frame structure, the lower material consumption, lower environmental indexes (embodied energy and CO_2 emissions) and lower 100-years Global Warming Potential (GWP) contributed to the potential of UHPC as a sustainable construction solution.

Fig. 8. (a) 90m monsoon drain using retaining wall, (b) comparison of conventional precast retaining wall with ultra-light weight UHPC retaining wall, and (C) EIC comparison with conventional retaining wall [19].

Due to the ultra-high strength and ultra-light weight properties featured by UHPC, this material was used for short retaining wall construction to provide geotechnical solution at Jalan Kota Bahru, Gopeng, Perak. Fig. 9a shows L-shaped cantilever retaining wall that makes up a total length of 76 m. The project was completed in year 2010. Each piece of retaining wall comes with a total height and width of 2.5 m and 2 m respectively [7]. This UHPC retaining wall distinguished from conventional RC wall by the type of reinforcement used in the concrete section. As shown in Fig. 9c, the major reinforcement in the wall was longitudinal reinforcements and transverse reinforcements or crack control bars are completely eliminated from the wall section. The longitudinal reinforcements are located in the ribs and base regions to resist the moment effect imposed by external loadings. The project has demonstrated a speedy construction process that the entire construction only takes approximately two weeks for completion.

Fig. 9. (a) Prototype of UHPC retaining wall, (b) 76 m long retaining wall at Jalan Kota Bahru, Gopeng, (c) Drawing detail of retaining wall [7]

Conclusions

Since the introduction of UHPC in the early 1990s, the initial high unit costs and the lack of experience has caused the slow adoption and limited success of UHPC. However, the increasing number of UHPC applications in Malaysia can be noted as a success of developing cost effective solutions. An overview of UHPC applications and some notable projects in Malaysia are presented in this paper. UHPC presents outstanding structural performance that constitute to the sustainable construction solution in the future.

References

[1] Y. L. Voo, "Ultra-High Performance Concrete (Uhpc) – Present & Future," *Proc. High Tech Concr. Where Technol. Eng. Meet*, 2017.

[2] N. M. Azmee and N. Shafiq, "Ultra-high performance concrete: From fundamental to applications," *Case Stud. Constr. Mater.*, vol. 9, 2018, doi: 10.1016/j.cscm.2018.e00197.

[3] E. C. Torregrosa, "Dosage optimization and bolted connections for UHPFRC ties - [Thesis]," *Riunet*, no. DEZEMBRO, pp. 1–276, 2013, [Online]. Available:https://riunet.upv.es/bitstream/handle/10251/34790/Camacho-Dosage optimization and bolted connections for UHPFRC ties.pdf?sequence=1%0A https://www.educacion.gob.es/teseo/imprimirFicheroTesis.do?idFichero=XLNMe%2F13E9w%3D.

[4] Z. B. Haber, I. D. la Varga, B. A. Graybeal, B. Nakashoji, and R. El-Helou, "Properties and Behavior of UHPC-Class Materials," *Fhwa-Hrt-18-036*, no. March, p. 153, 2018.

[5] American Concrete Institute, "Ultra-High-Performance Concrete: An Emerging Technology Report," *Am. Concr. Inst. ACI 239*, p. 5, 2018.

[6] NF 18-470, *UHPFRC (Specifications, performance, production and conformity)*. Association Française de Génie Civil (AFGC), 2017.

[7] Y. Lei Voo *et al.*, "Application of Ultra High Performance Fiber Reinforced Concrete-the Malaysia Perspective," *Int. J. Sustain. Constr. Eng. Technol.*, vol. 3, no. 1, pp. 2180–3242, 2012, [Online]. Available: http://penerbit.uthm.edu.my/ojs/index.php/IJSCET.

[8] Y. L. Voo and M. Tadros, "Taking Ultra-High-Performance Concrete to New Heights The Malaysian Wissahickon Memorial Bridge Philadelphia , Pennsylvania," no. July, 2016.

[9] P. Y. Blais and M. Couture, "Precast , Prestressed Pedestrian Bridge — World ' s First Reactive," *PCI J.*, vol. 44, no. 5, pp. 60–71, 1999.

[10] D. T. S. Bhd, "DURA Brochure 4th Edition.pdf." .

[11] Y. L. Voo, "Standard 70-meter long UHPC precast post-tensioned U-girder," *CPI – Concr. Plant Int. Precast Concr. Elem.*, pp. 110–114, 2020, [Online]. Available: www.cpi-worldwide.com.

[12] Y. L. Voo, P. C. Augustin, and T. A. J. Thamboe, "Design and Construction of a 50M Single Span Ultra- High Performance Ductile Concrete Composite Road Bridge," *Int. J. Sustain. Constr. Eng. Technol.*, vol. 3, no. 1, pp. 2180–3242, 2012, [Online]. Available: http://penerbit.uthm.edu.my/ojs/index.php/IJSCET.

[13] Y. L. Voo, P. C. Augustin, and T. A. J. Thamboe, "Construction and design of a 50m single span uhp ductile concrete composite road bridge," *Struct. Eng.*, vol. 89, no. 15–16, pp. 24–31, 2011.

[14] B. H. Ini, "Jambatan Batu 6 masuk Malaysia Book of Records." https://peraktoday.com.my/2015/07/jambatan-batu-6-masuk-malaysia-book-of-records/ (accessed Aug. 05, 2021).

[15] P. Illinois-Wisconsin, "Construction of 100M Single Span BATU 6 UHPC Bridge." https://pciiw-projects.interactivetwist.com/project/construction-of-100m- single-span-batu-6-uhpc-bridge/ (accessed Aug. 05, 2021).

[16] M. Hafezolghorani and Y. L. Voo, "Design of 38m Span Post-tensioned Ultra High Performance Fiber-Reinforced Concrete (UHPFRC) Composite Bridge," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 431, no. 4, 2018, doi: 10.1088/1757-899X/431/4/042007.

[17] D. Technology, "Dura Technology Sdn Bhd - 2013 Projects." https://dura.com.my/completed-projects/malaysia/2013-projects (accessed Oct. 14, 2021).

[18] D. Technology, "Dura Technology Sdn Bhd - 2015 Projects." https://dura.com.my/completed-projects/malaysia/2015-projects (accessed Oct. 14, 2021).

[19] Y. L. Voo, "Ultra-High Performance ' Ductile ' Concrete Technology Toward Sustainable Construction," *Int. J. Sustain. Constr. Eng. Technol.*, vol. 1, no. 2, 2010.

[20] Y. L. Voo, S. Foster, and L. G. Pek, "Ultra-high performance concrete - Technology for present and future," *High Tech Concr. Where Technol. Eng. Meet - Proc. 2017 fib Symp.*, pp. xxv–xlii, 2017.

CASE STUDY

Reprint from: CI Magazine

Enerpac Strand Jack Technology Used in Construction of Cline Avenue Bridge.

The bridge span was completed in just 16 days

The recently completed Cline Avenue Bridge is an elevated expressway in East Chicago, IN, USA, that connects the SR 912 to Interstate 90 (I-90). The bridge is 6236 ft (1901 m) long with a 316 ft (96 m) main span over the Indiana Harbor and Ship Canal, providing 100 ft (30 m) of vertical and 200 ft (61 m) of horizontal navigational clearance. The canal needed to remain open to barge traffic during the construction of the bridge, so heavy-lift specialist Engineered Rigging used Enerpac strand jack technology instead of a traditional crane approach to complete the span.

Project Background

The Cline Avenue Bridge project was privately funded. Low-maintenance concrete and a blend of traditional and new construction techniques were used to provide an expected lifespan of over 100 years. The bridge comprises 29 cast-in-place concrete piers supporting 685 post-tensioned concrete single-cell box girder segments, with typical spans that vary between 170 to 290 ft (52 to 88 m). The piers range in height from 24 to 86 ft (7 to 26 m). The bridge was constructed using the balanced cantilever method, in which precast segments are erected on each side of a pier in a balanced sequence to minimize bending in piers and foundations. To complete each span between adjacent piers, a nominal 4 ft (1.2 m) cast-in-place closure segment was placed at midspan, followed by stressing of continuity tendons across the closure segment. In total, 28 closure segment placements were required to complete the bridge. Most of the precast segments were lifted and set using two large-capacity, ground-based cranes. But because much of the span over the ship canal was beyond the reach of the ground-based cranes, a different approach was required.

Construction of the Canal Span

The span over the 130 ft (40 m) wide Indiana Harbor and Ship Canal comprises 19 precast segments stretching 380 ft (116 m) column to column. While a crane on a barge could have been used to erect precast segments beyond the reach of the ground-based cranes, this approach would have meant closing the canal to commercial barge traffic for weeks. Given the volume of maritime traffic that needs to use the canal, this was not a viable option. A creative yet pragmatic approach was needed. “Cranes are great for lifting heavy objects, but their sheer size and cost often makes them impractical for some applications. Both factors came into play for the Cline Avenue Bridge project,” says Christopher Cox, President of Engineered Rigging. “Engineered Rigging was consulted to develop a practical alternative, and our expert engineering team was up for the challenge,” he continues. Cox and his team had to account for factors such as the weight and size of each segment and the need to keep disruptions to the busy canal to a minimum. Each bridge segment measured 10 ft (3 m) high, 10 ft deep, and 25 to 30 ft (7.6 to 9.1 m) wide, and weighed 75 tons (68 tonnes). Engineered Rigging’s solution was to use Enerpac strand jacks to lift the segments into position.

The Cline Avenue Bridge under construction. The bridge crosses The Indiana Harbor and Ship Canal

Engineered Rigging chose Enerpac strand jack technology to complete the span over the canal

Strand jack technology

While strand jacks are not the quickest lifting method, they provide massive lifting power in a small package. Moreover, they are secure, and their operation makes them essentially fail-safe. A strand jack can be considered a linear winch. A bundle of steel strands are guided through a hollow hydraulic ram. Hydraulically actuated grip mechanisms (anchors) alternately grip each strand in the bundle above and below the ram. An electric-powered hydraulic pump is used to stroke the piston out and in while the grips are engaged in the anchors, and thus a lifting or lowering movement is achieved. For lifting, the top anchor engages to pull the strand bundle during the upstroke of the ram piston. When the piston reaches its maximum upstroke (out), the bottom anchor engages to hold the strand bundle and the top anchor releases. The piston then returns to its bottom (in) position. Over time, Enerpac has refined The strand jack technique, making it easier to deploy and manage with automated locking and unlocking operation, as well as enabling precision and synchronous lifting and lowering by a single operator. Engineered Rigging developed a customized cantilever segmental bridge lift platform using back span tie downs to counter the cantilever overhanging the bridge. Two beams, each with two 70 ton (63.5 tonne) strand jacks, extended from the platform. As each new segment was added, the platform was moved forward using a combination of Enerpac launching cylinders and a low-height skidding system.

The span construction involved placing a precast segment on a barge, moving the barge under the cantilever lift system, and attaching four strand bundles to the segment. Over The course of the next 2-1/2 hours, the strand jacks lifted the segment 130 ft into position. During the final lifting stages, the strand jacks were also used to tilt and manipulate the segment as it was attached to the previously placed segment. Initially, one segment was lifted and installed each day, but when canal traffic was light, up to three segments per day were added.

Engineered Rigging completed the bridge span in just 16 days. Mike Beres, Project Lead for Engineered Rigging, points to the importance of synchronized lifting when using multiple strand jacks. “Enerpac strand jacks were integral to the safe and on-time completion of the project. They pack tremendous lifting capacity into a small footprint,” he says. “Moreover, the system software can control up to 60 jack/pump combinations, so the potential for synchronous lifting is quite scalable. The flexibility of the strand jack system has allowed Engineered Rigging to use this equipment

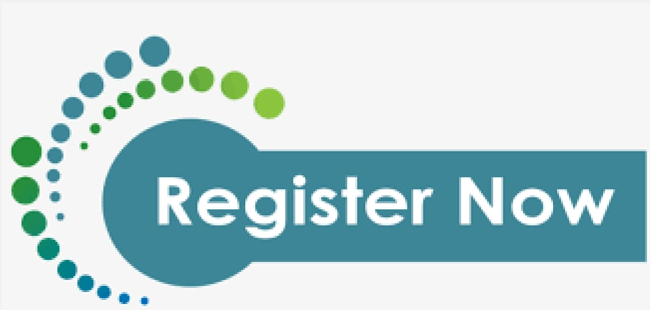
Project Completion

The new 1.7 mile (2.7 km) long Cline Avenue Bridge opened on December 23, 2020. The new bridge cost private operator United Bridge Partners more than $100 million to build as a link to the casinos and steel mills along Lake Michigan. The two-lane bridge is expected to carry 10,000 vehicles daily.

—Enerpac, **www.enerpac.com**

MEMBERSHIP


WE ARE A
CARING
ASSOCIATION
American Concrete Institute Malaysia Chapter
Benefits of Joining Us?
Benefit #1
Access to the ACI Membership Directory
Benefit #2
Digital subscription to Concrete International Magazine
Benefit #3
Three ACI University tokens
Benefit #4
Printable ACI Membership Certificate
We believe a long lasting business relationship is built on friendship.
About Us
America 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 authority in concrete technology.
Our membership is not only limited to engineers, in fact it includes educators, architects, consultants, corporate bodies, contractors, suppliers and experts in cement and concrete related fields.
Contact Us
www.acimalaysia.org
70-1, Jalan PJS 5/30,
Petaling Jaya Commercial City (PJCC)
46150 Selangor, Malaysia.
+60 (3) 7782 2996 (Admin-1)
+60 (14) 2207 138 (Admin-2)
Email: info@acimalaysia.org



We look forward to your kind support and, more importantly, to your participation and registration as a member of ACI-Malaysia Chapter. It is our firm belief your involvement and together with your commitments will go a long way in our quest to uphold all our objectives to mutually benefits for all members.

American Concrete Institute - Malaysia Chapter
70-1, Jalan PJS 5/30,
Petaling Jaya Commercial City (PJCC),
46150 Petaling Jaya,
Malaysia.

Website: http://www.acimalaysia.org
Phone: +6014 220 7138
Email: admin@acimalaysia.org

American Concrete Institute – Malaysia Chapter
70-1, Jalan PJS 5/30, Petaling Jaya Commercial City (PJCC),
46150 Petaling Jaya, Selangor. Malaysia.
Tel.: **+60 (3) 7782 2996** Fax.: **+60 (3) 7782 1196**
Website: **www.acimalaysia.org** eMail: **info@acimalaysia.org**

Membership Application Form

Type of Membership (please tick "☑" one option only)

	Joining Fees (Total)(RM)	(Entrance Fee +	Subscription Fee per annum)
❒ Organizational Member:	A Firm, Corporation, Society, Government Agency or other organizations. **RM800.00**	(RM500.00 +	RM300.00)
❒ Associate Member:	An individual who is not a member of **ACI International** but American Concrete Institute – Malaysia Chapter only. **RM200.00**	(RM100.00 +	RM100.00)
❒ Student Member:	**RM30.00**	(RM30.00 +	RM0.00)

To be admitted as a **Chapter Member**(*), return this form together with **Crossed-cheque** (any outstation cheque to include Bank Commission)/ **Online Bank Transfer/ Cash Deposit** made payable to:

Account Holder Name: **American Concrete Institute – Malaysia Chapter**
Bank: **Hong Leong Bank Berhad (HLB)**
Account Number: **291.0002.0936**

*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:*

WhatsApp: **+60 (14) 2207.138** (*ACI.my Administrative-2*); or
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**

PREMIUM SPONSORS

THE BUILDING DOCTOR

STRUCTURAL REPAIRS (M) SDN. BHD.

(132734-U)

No. 3, Jalan 3/118C, Desa Tun Razak, Cheras, 45000 Kuala Lumpur. Malaysia.
Tel: (+603) 9173 1728, 9173 1729, 9173 1730   Fax: (+603) 9173 1731
Email: strucruralrepairs@gmail.com

Over Our 35 Years Of Experience As The Leading Building Doctor In Malaysia, We Have Work On Various Large Scale Projects.

We Use Data Driven Methodology To Detect The Source Of Failure To Eliminates Operational Risks And Accelerates Repair Processes.

Structural Integrity Investigation and Assessment

Structural Repairs and Strengthening

Waterproofing Technology

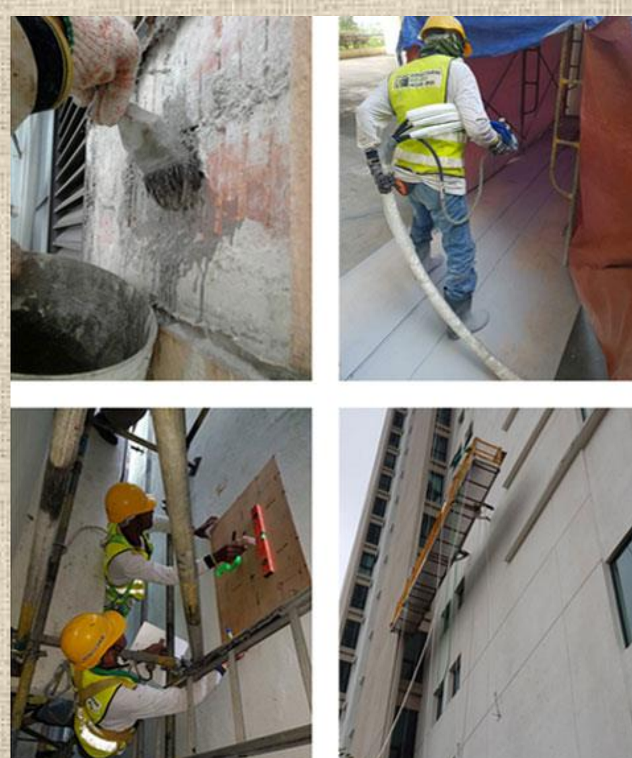
Helifix Facade Repair Technology

Expansion Joint Installation and Replacement

Heritage Building Conservation Technology

Flooring Coatings

3D Laser Scanning to Building Information Modelling (BIM)



LOYAL SPONSORS