



KUWAIT CHAPTER

CONCRETE NEWS

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CONCRETE NEWS

Concrete News is published periodically by ACI-Kuwait Chapter to share information between members, exchange technical knowledge and enhance the Chapter's position within the engineering community.

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FROM THE PRESIDENT



Dr. Moetaz El-Hawary
President - ACI | KC

Dissemination and exchange of knowledge and information is the main goal and objective of the American Concrete Institute- Kuwait Chapter, as information and know how, is the backbone for technology development and industry improvement. Knowledge and information can be transferred through books, internet, scientific journals and magazines. Direct contact, however, is still the best and most effective way to exchange experience and knowledge as it possesses the advantage of direct discussion and debating. Through discussion, great ideas may develop that may lead to mutual joined research, which will eventually lead to leaps in the industry development.

Scientific conferences, attended by experts and scientists from around the globe, are the only means of achieving direct contacts and discussion opportunity among peers and hence furnishing the way for research and development.

Driven by the success of the ACI-KC First International Conference that was held in September 2003, ACI-KC has started the planning and arrangements for its Second International Conference that will be held in March 2007. The theme for the conference this year is "Design and Sustainability of Structural Concrete in the Middle East; with emphasis on High Rise Buildings". More than thirty abstracts have been accepted by the scientific committee, so, far from countries as diverse as Australia, USA, Oman, Egypt, Algeria, Jordan, Lebanon, UAE, Iran, France, Mexico, Kosovo, Albania, and of course Kuwait. A number of renowned keynote speakers will be invited to share their experience with us. The conference will be also accompanied by other technical and social events. The conference is expected to achieve even more

success than the previous one.

ACI-KC members, along with others interested in the building and concrete industry, are advised not to miss this opportunity to benefit from such an event. Leading companies and firms in the industry, along with governmental departments, are also asked to encourage their engineers and affiliates to grab this opportunity to get introduced to new technologies, modern trends and recent research in the building industry. They are also encouraged to participate in the success of this event through endorsement and sponsorship.

With the combined effort and cooperation of all of us, the International American Concrete Institute – Kuwait Chapter Conference series will be recognized as one of the leading international conferences in the world and will be considered a landmark in the continuous scientific advancement and development in the building industry in Kuwait.

ABOUT

ACI – KUWAIT CHAPTER

There are main three bodies of the chapter: Members, Committees and Directors.

BOARD OF DIRECTORS

Members of the Board of Directors are elected by the Members of the Chapter after being nominated by the Nomination Committee. There are 9 members of the Board of Directors:

- President
- Vice President
- Past President
- Secretary
- Treasurer
- Directors (6)

The President and Vice President terms are limited to one year. Directors and other officers term is three years. Two Directors will be elected every year for three year term.

BOARD OF DIRECTORS 2006/2007

No	Name	Title
1	Dr. Moetaz El-Hawary (KISR)	President
2	Dr. Bader Al-Hoti (KUWAITI TECH)	VicePresident
3	Dr. Naji Al-Mutair (KFAS)	Past President
4	Eng. Ubedur Rahman Arain (GULF CONSULT)	Director/Secretary
5	Mr. Abdulwahab Rumani (KBRC)	Director/Treasurer
6	Eng. Anas A. Kassem (PARSONS BRINCKERHOFF)	Director
7	Dr. Khaldoun Rahal (KUWAIT UNIVERSITY)	Director
8	Eng. Ebtisam Al-Kazemi (NCCAL)	Director
9	Dr. Hasan Kamal (KISR)	Director

COMMITTEES

Membership Committee, the main activities for this committee are:

- Recruit new members as individuals and organizations
- Issue and renew membership certificates.
- Publish and update chapter directory of membership.
- Facilitate members communications and communicate their concerns to the board of directors and other committees.
- Establish students chapter and run its affairs.

Membership Committee's Members 2006/2007

No	Name	Title
1	Eng. Mohd. Herb Madbouly	Chairperson
2	Eng. Saeed Shamim Sulaimani	Member
3	Mr. Abdulwahab Rumani	Member
4	Eng. Ganesh Radhakrishnan	Member
5	Eng. Doaa Farid Issa	Member

Technical Committee, the main activities for this committee are:

- Identify technical topics of interest to Chapter members and make recommendations to the Chapter Board of Direction for seminars, short courses and workshops on these topics.
- Review and report to Chapter members on ACI International committee reports of relevance to Kuwait.
- Review proposed revision of ACI Standards and submit review comments to the Chapter Board of Direction for submission to ACI International.
- Promote local research and testing programs to resolve technical issues of importance for durable concrete construction in Kuwait.

Technical Committee's Members 2006/2007

No	Name	Title
1	Dr. Hasan Kamal	Chairperson
2	Dr. Moetaz El-Hawary	Member
3	Mr. Abdulwahab Rumani	Member
4	Eng. Mohd. Herb Madbouly	Member
5	Dr. Khaldoun Rahal	Member
6	Dr. Naji Al-Mutairi	Member
7	Eng. Hanaa Mohammed Hashem	Member

Publication Committee, the main activities for this committee are:

- Publish a periodic newsletter to inform members of Chapter activities and provide general information of use to the Chapter membership.
- Print and distribute copies of technical reports to Chapter members, as well as to interested individuals and concerned bodies.
- Prepare meeting reports and Chapter news for submission to ACI International for publication in Concrete International magazine.

Publication Committee's Members 2006/2007

No	Name	Title
1	Eng. Ebtisam Al-Kazemi	Chairperson
2	Eng. Nader Bahige El-Khatib	Member
3	Eng. Anas A. Kassem	Member
4	Mr. Abdulwahab Rumani	Member
5	Eng. Rakesh Kumar Vyas	Member
6	Eng. Saeed Shamim Sulimani	Member

Social Committee, the main activities for this committee are:

- Organize annual recreational activities for Chapter members.
- Organize representation of the Chapter at selected national events.
- Organize field trips to major construction projects for chapter members.

Social Committee's Members 2006/2007

No	Name	Title
1	Eng. Mohd. Herb Madbouly	Chairperson
2	Eng. Ebtisam Al-Kazemi	Member
3	Eng. Hanan Al-Mutairat	Member
4	Eng. Negolas Barakat	Member
5	Eng. Saeed Shamim Sulimani	Member
6	Eng. Hanaa Mohammed Hashem	Member
7	Eng. Dana Drobiova	Member
8	Eng. Aziz Ali Hitawala	Member
9	Eng. Doa Farid Issa	Member

Nomination Committee's Members 2006/2007

No	Name	Title
1	Dr. Naji Al-Mutairi	Chairperson
2	Eng. Anas A. Kassem	Member
3	Dr. Arif Al-Durbas	Member
4	Eng. Mansoor Rao	Member
5	Eng. Nader Al-Khateeb	Member

Exhibition Committee's Members 2006/2007

No	Name	Title
1	Dr. Naji Al-Mutairi	Chairperson
2	Dr. Moetaz El-Hawary	Member
3	Dr. Khaldoun Rahal	Member
4	Mr. Abdulwahab Rumani	Member
5	Mr. Ahmed Al-Jihayem	Member
6	Dr. Hasan Kamal	Member

Training Committee's Members 2006/2007

No	Name	Title
1	Dr. Khaldoun Rahal	Chairperson
2	Dr. Moetaz El-Hawary	Member
3	Mr. Abdulwahab Rumani	Member
4	Eng. Ebtisam Al-Kazemi	Member
5	Dr. Hasan Kamal	Member

Dr. Hussein Al-Khaiat



Dr. Hussein Al-Khaiat

Professor Hussein Al-Khaiat is one of the founder member and the first President of the ACI-Kuwait Chapter. He is known in the concrete community in Kuwait for his interest and contribution to concrete technology and construction.

Dr. Al-Khaiat is a Professor of Civil Engineering at the College of Engineering and Petroleum at Kuwait University, and has been working there for the past 23 years. He served as Chairman of the Civil Engineering Department, Vice Dean for Consultation and Career Development at the College of Engineering and Petroleum, and Vice Dean for Academic Affairs at the College of Graduate Studies.

His doctoral work at Pennsylvania State University was in structural engineering, relating to the behavior and analysis of plates. However, his subsequent research work focused more and more on concrete technology in general, and concrete durability in particular due to its direct impact on the concrete construction in Kuwait and the Gulf region. His research has received funding from Kuwait University, KFAS, Environmental Protection Council in excess of one hundred and fifty thousands Dinars. In total, he published forty two papers in refereed international journals, two books and about twenty reports and numerous conference papers. He was also the chairman of the seventh and tenth Arab Structural Engineering Conferences which took place in Kuwait in 1997 and 2006 respectively. Professor Al-Khaiat has taught thirteen different courses at Kuwait University, including a graduate course in concrete durability, and more than ninety intensive training courses in Kuwait and the United Arab Emirates.

Professor Al-Khaiat's consulting experience is as extensive as his academic experience. He was a consultant to the Public Works for more than ten years and the Executive Manager of Al-Bayan Consulting Group for about four years. He has also been involved in arbitration, damage assessment, structural evaluation, and design in more than fifty projects of various sizes and budgets. He is a Registered Arbitrator with the Kuwait Society of Engineers, Kuwait Chamber of Commerce and Industry and the Ministry of Justice since 1985, and a registered Consultant Engineer at the Kuwait Society of Engineers.

Professor Al-Khaiat was the recipient of the 1999 Kuwait award for Scientific Research from The Kuwait Foundation for the Advancement of Science.

PROFILE

Family:

Dr. Al-Khaiat has four children, Bashayer (16), Shahad (11), Ali (5) and Noor (3).

Education:

B.Sc. (1976), M.Sc. (1979) and Ph.D. (1983) all from the Pennsylvania State University.

ACI Kuwait Chapter:

Founding member, and first ACI-KC President

Membership in Professional

Organizations:

- ACI International
- ACI-Kuwait Chapter
- Kuwait Society of Engineers
- Prestressed Concrete Institute
- International Housing Institute

Other Activities:

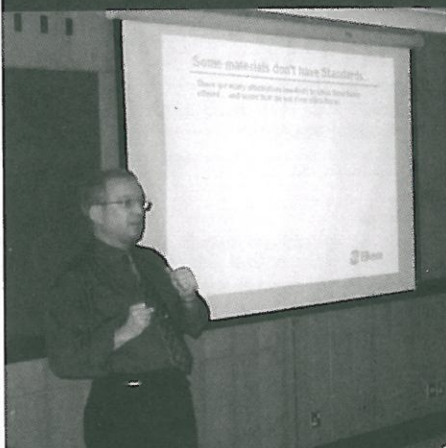
- Chairman, Tenth Arab Structural Engineering Conference, Kuwait, 2006
- Editor in Chief, Engineering Education Magazine, Federation of Arab Engineers (2000-present)
- Chairman, Engineering Education Committee, Federation of Arab Engineers (2000-present)
- Executive Committee, Deayah Cooperative Society
- Engineering Certificate Assessment Committee, Kuwait Society of Engineers

SEMINAR



The Technical Committee of the ACI –Kuwait Chapter has arranged a technical seminar entitled "Sustainability and Concrete Structures", presented by Prof. Moetaz El-Hawary, the President of ACI-Kuwait Chapter. The seminar was held in the Kuwait Society of Engineers on Tuesday, May 9th, 2006.

As the sustainability and green structures are now the focus of interest, due to global environmental problems and diminishing natural resources, international and local developments in this field along with codes, design requirements, maintenance, durability, recycling and other sustainability aspects were addressed in this seminar. Some of the points discussed in this seminar are mentioned in brief in the article entitled "From the President" in this issue.





(MUBARAK HOSPITAL)

Contributed By: Eng. Nabeela Al-Mishari, President . Kuwait Technical Consulting Bureau

Architectural Concept

Closed is the first impression you will get by the solid walls with its stone tiles arrangement and the semi opened metal mesh with its dynamic movement playing with shade through the day and the shaded entry which create a dramatic scene within the site and an attraction in the same time.

Inviting from the minute you approach the site from the parking by the mass itself with its colors, passing by the plaza having the landscape by the water pond and the palm trees as a background by how it looks and sound, which create a new attraction point and a rest area for all the Mubarak Al-Kabir hospital complex.

The contrast between solid and void is the main play in outer spaces and extend to the inner spaces beginning by the main void in the background for the main entry with its water falls and the penetrating sun rays which give a dynamic scene to the entry hall playing with your senses the time you see it and hear it, with its attraction guide you through the center and

connect you to all the departments from reception in the ground floor to the endoscopy unit and the ward sections.

As you pass through each floor you go through a smooth flow circulation always find some one to guide you a reception or a nurse counter and its always the first thing you have contact with .

The double height void with greenery used between the clinic offices in the output patient unit and the administration offices in the endoscopy unit, also used in the ward section for more peace in the patient rest rooms.

The sun rays with the tiled stone walls and water fall and the planted areas plays a very dramatic rule through the entire center giving a peaceful atmosphere for better treatment and a good place to work.



Spaces

The spaces are arranged according to their function and to its relation to the public passing by three zones

Zone 1

From the ground floor starting from the dropped plaza with its pond driving you through the center inside the main lobby starting the first contact with the main reception, along with Outpatient clinics department and the Administration offices in each side ending with the main void with the vertical connection (lifts and stair case) creating a main axis which leads the public through the center.

Zone 2

Endoscopy units the main function in the center are placed in one floor along with the supporting facilities in the first floor following a restricted circulation under the control of the nurse counters from public areas the main lobby with the connection with the existing building and the waiting area and patient meeting rooms then the semi private contain the tests rooms (x ray and enema room) then the private area with the operation units and the recovery units.



Zone 3

Wards section the last stage with two floors the second and the third floor divided between men and women, then each floor between public and private rooms with its supporting facilities in the core of the floor, containing a patient rest area with its planted space which will be the breeze for a short or a long stay.

Owner	Ministry of Health
Contractor	To be tendered soon
Project Value	2.27 Million KWD (Equipment Excluded)
Built-up Area	7,500 m ²
Year	2005 - Active

GHANIMA AHMAD AL-GHANIM CENTER FOR PREMATURE AND GENETICS

Contributed By: Eng. Nabeela Al-Mishari, President . Kuwait Technical Consulting Bureau



1.0 Preliminary Alternative Concepts

Two architectural concept alternatives were developed in order to test the site potentials and to select the building configuration, which in the best possible way will respond to functional and spatial requirements of the Center.

2.0 Development of Selected Alternative

2.1 Land use

The new Center is taking place of the existing building for Hospital Administration and part of the existing parking. Most of the site will

be occupied by building itself leaving remaining land for ambulance and services access, and entry plaza with drops-off and pick-up areas. The diagonal orientation of the building optimizes energy conservation and minimizes the effect of the harsh local climate and in the same time giving openness towards the Kuwait Bay. Total land area is – 6,038 m².

2.2 Circulation

(a) Vehicular

The general visitors' access is from the internal double carriage coastal street serving the Hospital's Area. The Genetics patient's access is from Service Street at east side of the building. It is separated from general public providing drop-off and pick up suitable for handicapped. The access for ambulances and services is through



dead-end loop located along the south – west building elevation.

(b) Parking

The parking demand for employees and visitors is exceeding potentials of site. Reduced in size, existing parking located in front of the hospital is capable to provide the Management reserved parking for 85 cars. Parking demand for the Hospital's visitors, patients and employees should be independently studied and location on shore side of the coastal street is suggested.

(c) Pedestrian

The main pedestrian aims will be the entries to the new and existing hospitals. The pedestrians should be well

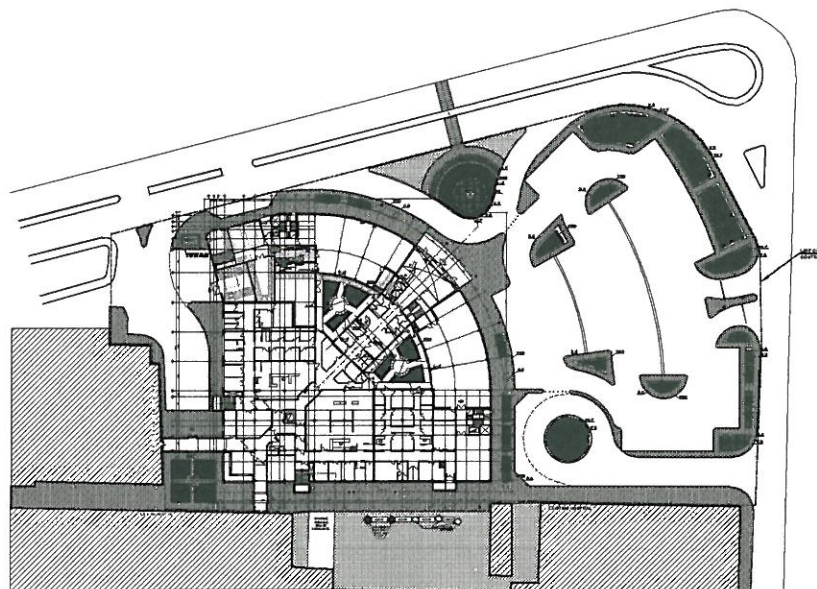
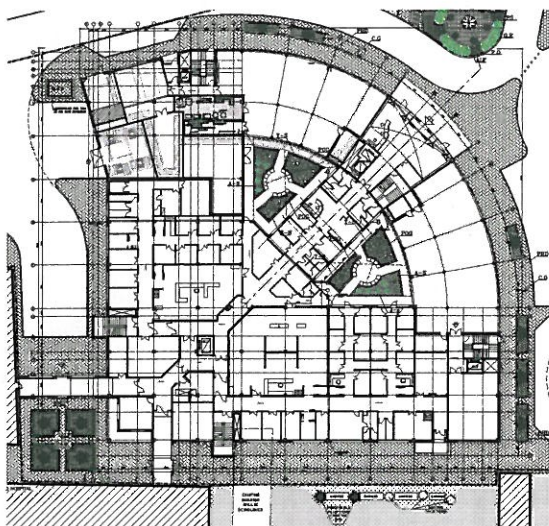
protected walking in and out of parking and crossing the coastal street. Barrier free access to all facilities is provided.

3.0 Architectural Potential and Identity

A strong vocabulary of building elements, character of function, structural modulation and clear circulation system are established. This sets a sound background for rational and attractive architectural development. The detailed vocabulary of the architectural elements will be established in the later phases taking into account sound building technology filtered through regional tradition and climatic conditions. Architectural image of the building is sending clear message that is created by advanced contemporary building techniques housing state of art medical technology which is operated by well trained doctors and nurses and in this way is ensuring parents that their newborn children are in good hands.

3.1 Architectural Approach

The selected concept responds the client's program requirements and to the challenge of the demanding local climatic conditions by forming the architecture, on the basis of rational space planning, environmental protection and energy saving philosophy. The analysis of the local climate in respect to various factors in different seasons in conjunction with defined links to the existing hospital enabled to establish a strong basis for building massing and orientation. This is reinforced by recognition and adoption of adequate measures to ensure a friendly environment for the all of the Center's functions.



The main entry to the Center is from the north side via pedestrian plaza and is emphasized by cantilevered canopy and recessed curvature of front elevation. In the east wing of the building the Genetic Out-patients entrance is located next to the reserved drop off and pick up loop. At the south corner, beside existing link to the hospital the new one is designed to facilitate Ambulance service and connect the new Center with with the Premature Hospital.

3.2 Architectural treatment

All external materials and finishes will be selected taking into consideration the architectural main guidelines.

3.3 Functional arrangement

Efficient and flexible functional spaces similar functions are grouped based on two main factors:

- Similarity in work environment requirement
- Similarity of technical support requirement

This results in forming functional blocks such as:

- "Hard core" heavily armed with services and equipment (Neonatal Intensive Care Units, High Dependency Unit, Laboratories, lecture hall, technical support rooms and vertical circulation elements –lifts & staircases).
- "Soft" functional areas, relatively easy to modify but usually of higher standard of work environment (medical staff rooms, administration offices).

The "hard core" rooms are mostly located in the middle of both wings of the building, surrounded by the "soft" area rooms. Both functional components are linked by system of corridors leading into vertical circulation towers (elevators and staircases). The vertical circulation towers as well as the "hard core" rooms are difficult to modify, while the "soft" area rooms are prepared for easy changes during building live time.

Donator	Ghanima Ahmed Al-Ghanim
Owner	Ministry of Health
Contractor	Al-Ghanim Trading & Contracting Company
Project Value	3 Million KWD
Built-up Area	12,000 m ²
Year	2004 - Active

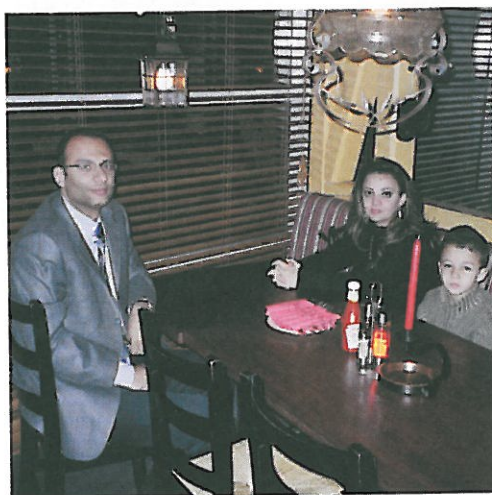
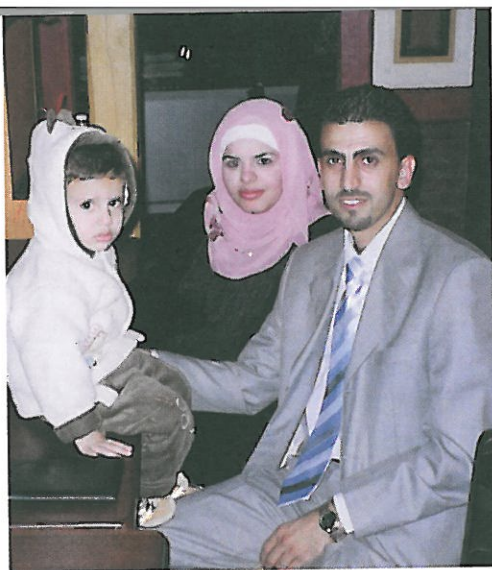
دار الكويت
للإستشارات الفنية
kuwait technical
consulting bureau

The Social Committee invited the ACI-KC members with their families to a dinner party at Peppes Pizza, Thursday the 05th of November 06:30 evening time.

The party witnessed the presence of many children accompanying their parents, where they all enjoyed playing in the children's playground and painting pictures.

The party ended at around 08:30 PM and all the present thanked the committee responsible for arranging a great time.

Eng. Mohamed Harb



SOCIAL COMMITTEE

AWARD OF EXCELLENCE

Every year an Award of Excellence is presented by ACI-KC to a local project. This award aims to:

- Recognize outstanding work in concrete construction and practices in the State of Kuwait
- Draw public attention to recent developments and state-of-the-art applications of concrete in both design and construction.
- Increase public awareness of the importance of quality in construction work.

Any member of ACI-KC can send one nomination for a project in the State of Kuwait that was completed or substantially completed during previous year.

The Board of Directors and representatives of Organizational Members of the Chapter will evaluate nominations and select the recipient of the award. The criteria for evaluation are:

- Originality of design
- Implementation of quality improvement measures
- Application of advanced materials practices to better serve the project needs.
- Uniqueness of application
- Owner's Satisfaction

If you are a member of ACI Kuwait Chapter and would like to nominate a project, please use the attached form.



AWARD OF EXCELLENCE

Project Award of Excellence Nomination form

Nominations are limited to projects that were completed or substantially completed during 2005 and that are located in the State of Kuwait.

On separate sheets please provide the following:

- Project Description Fact sheet: Name, Type, Size, and Location with photographs.
- Concise narrative of why the project is nominated: This shall not be more than one page in length and shall address the objectives for which the award is given.
- List of those to be credited for the project, include Name, Address and Phone Number of:

- a. Owner
- b. Architect
- c. Engineer
- d. General Contractor
- e. Major Subcontractor (if applicable)
- f. Material Suppliers (if applicable)
- g. Others

Nomination by:

Name:

Title:

Affiliation:

Address:

Phone: Business: Home:

Date of nomination:

After selection of the Award Recipient, the winner is expected to provide six 35-mm slides for the projects.

AWARD OF ACHIEVEMENT

Invitation to Nominate for Annual Award

Every year an Award of Achievement is presented by ACI-KC to an individual to recognize outstanding contribution to the Engineering Community in Kuwait, and an Award of Excellence will be presented to a local project.

Award of Achievement

Any member of ACI-KC can send one nomination for an individual, who does not have to be a member of ACI but his or her contribution shall be in the State of Kuwait. The Board of Directors and representatives of Organizational Members of the Chapter will evaluate nominations and select an individual for the award. Any individual, who has made significant contribution in one or more of the criteria listed below, qualifies for the nomination.

1. Contributions to the Engineering Profession and Community

- a. Leadership and Pioneering
- b. Exemplary character
- c. Promoting integrity
- d. Respect of peers
- e. Active participation in professional organizations.
- f. Length of time in the field.

2. Advancement of Technology:

- a. Development of innovative uses and handling of concrete.
- b. Improvements in the quality of concrete.
- c. Innovation in the design and/or handling of concrete.
- d. Increased awareness of modern uses of concrete.
- e. Innovations in the acceptance and uses of concrete.

3. Technology Transfer:

- a. Teaching and training in the field of concrete.
- b. Valuable technical publications
- c. Development of training courses and workshops.
- d. Active participation in organizing conferences and seminars with local and national organizations.

If you are a member of ACI Kuwait Chapter and would like to nominate an individual, please fill out the attached form.

AWARD OF ACHIEVEMENT

Achievement Award Nomination form

Please provide the following for the nominee:

Name:

Title:

Affiliation:

Educational Background:

Address:

Phone: Business: Home:

On a separate page(s), please address, in narrative form, why should this person be given the award following the guidelines set for nomination.

Letters of endorsement for the nominee may be included with the nomination.

Nomination by:

Name:

Title:

Affiliation:

Address:

Phone: Business: Home:

Date of nomination:

Design of Thin Reinforced Concrete Membrane Elements

Part I: A Critical Review of the ACI Provisions

Dr. Khaldoun N. Rahal
Director and Past President,
ACI Kuwait Chapter
Associate Professor, Civil Engineering
Department, Kuwait University
e-mail: rahal@civil.kuniv.edu.kw

Abstract: Thin-walled structures can be analyzed as assemblages of thin membrane elements subjected to in-plane shearing and normal stresses. The provisions of Chapter 11 of the ACI code are commonly used in the design of such elements. This article provides a critical review of these provisions for the case of shear. It is shown that the provisions include some inconsistencies, and can be unconservative when the concrete contribution is accounted for. Suggestions to avoid this inconsistency and un-conservatism are provided. Future articles will provide details of the case of shear combined with in-plane normal stresses, and a proposed alternative simplified method that is partially similar to the plasticity theory commonly used in Europe.

Introduction: Numerous structural elements such as domes, box and I-bridge girders, shear walls, silos and other thin shell and plate structures can be modeled as thin membrane elements subjected to in-plane shearing and biaxial normal stresses. Figure 1 shows two examples. The analysis of such structures is typically based on elastic models such as the Finite Elements Method or more conventional structural analysis methods, while their design is based on the non-linear behavior of the structural elements. Orthogonal reinforcement is typically provided as shown in the membrane element in Figure 1.

Design codes such as the ACI Building code¹ give shear design

equations. These equations were developed over the past century from tests on reinforced and prestressed concrete beams subjected to shear and bending moments, and not for thin membrane elements. Now, how adequate are these provisions for membrane elements?

ACI Provisions: The ACI code equations are based on the 45° truss model, modified with a concrete contribution. For membrane elements, the concrete contribution stress V_c can be based on the web cracking as given in ACI 11.4, where V_{cw} at which web diagonal cracking takes place can be calculated using a shear stress of $0.33 \sqrt{f'_c}$. For membrane elements, the steel contribution V_s (as a stress) is calculated as $f_y f_y$ where f_y and f_y are the ratio of reinforcement and its yield stress respectively. Using the yield stress requires that the section is under-reinforced, i.e. the steel yield before crushing of the concrete. This is ensured by limiting that the steel V_s to $0.66 \sqrt{f'_c}$ as per ACI 11.5.7.9. The total shear strength is hence limited to $(0.33+0.66) \sqrt{f'_c} = 0.99 \sqrt{f'_c}$:

$$v = 0.3 \sqrt{f'_c} + \rho_y f_y \leq 0.9 \sqrt{f'_c}$$

Eq. (1)

The ACI Clause 11.1.2 requires to limit the term $\sqrt{f'_c}$ to 8.3 MPa, which is equivalent to limiting the usable compressive strength to 69 MPa. This limit is not applicable if an ample amount of transverse reinforcement

given in ACI clause 11.5.6 is provided. In any case, this strength is not usually reached in Kuwait.

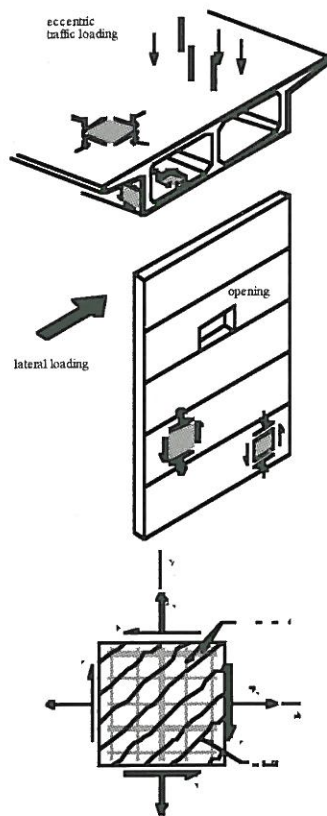


Figure 1: Examples of membrane elements in structures, and a membrane element subjected to in-plane stresses

Which one is the "Transverse" Reinforcement?

Consider a membrane element with unequal x and y direction reinforcement ($f_x = 0.4\%$, $f_y = 0.8\%$ and $f_y = 400$ MPa, $f'_c = 25$ MPa). The ACI code equation (Eq. 1) relates the strength of the membrane to the transverse reinforcement. Now which one is the transverse reinforcement? If it is taken as the y-reinforcement, the ultimate shear strength is $0.33 \sqrt{25} + 0.004 \times 400 = 1.65 + 1.6 = 3.25$ MPa. If the membrane element is rotated by 90° , the strength is calculated as is $0.33 \sqrt{25} + 0.008 \times 400 = 1.65 + 3.2 = 4.95$ MPa. This inconsistency is caused by the fact that the shear provisions were based on test results of reinforced concrete beams where the amount of longitudinal reinforcement was selected to be relatively large to avoid flexural failure. This ensured that the transverse steel yielded before the longitudinal steel, and caused it to be critical in design. This situation is not always true in membrane elements, and can lead to un-conservative results if the x-reinforcement is considerably weaker than the y-reinforcement. The concern with the ACI provisions is that it has not mention of the longitudinal reinforcement.

Recommendation: Using the minimum of the x and y steel in Equation 1 leads to conservative, but more expensive design. If the difference between f_x and f_y is significant, use the provisions of the AAAHTO-LRFD bridge specifications², or the equation which will be proposed in a future article. This equation is partially similar to the plasticity theory, which is widely used in European design codes.

Is there a Concrete Contribution in Membrane Elements?

Figure 2 shows a shear stress-shear strain response of an "under-reinforced" membrane element, where both longitudinal and transverse reinforcement exceed the yield limit before ultimate capacity is reached. The results are obtained from the Modified Compression Field Theory³ (MCFT). The graph also shows the concrete contribution V_c at different stages of the loading. It can be seen that the v_c deteriorates as the strains increase, because the cracks widen and the aggregate interlock decreases. Meanwhile, the steel contribution increases because of the larger stirrups and longitudinal steel strains. When both steel yield, the aggregate interlock at the crack location is exhausted because the crack opens up, the concrete contribution drops to zero, and the strength comes only from steel. The maximum shear is equal to the steel contribution, and adding an ACI concrete contribution is inadequate. Hence, for such elements, considering an active concrete contribution at the same time as fully-yielded steel is un-conservative.

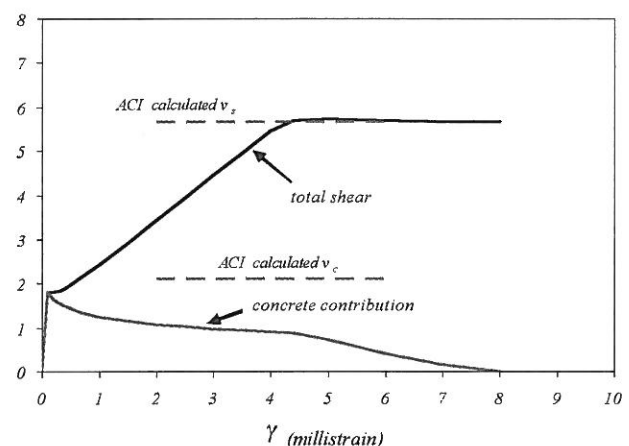


Figure 2: Shear stress-strain response of under-reinforced membrane element

Panel specimen PV3 tested in pure shear by Vecchio and Collins³ was 89 x 89 cm, and 7 cm thick. Its concrete strength was 26.6 MPa and it was reinforced with equal orthogonal layer of steel, with $f_x = f_y = 0.48\%$ and $f_y = 662$ MPa. The concrete contribution is calculated as 1.7 MPa and steel contribution is calculated as 3.18 MPa, totaling 4.88 MPa (3.72 MPa if the yield stress used is limited to 420 MPa as required by the ACI code). The experimentally observed ultimate shear strength was 3.07 MPa, which is nearly equal to the steel contribution. This confirms the discussion of the results of Figure 2, and shows that in under-reinforced membrane elements, the addition of the ACI concrete contribution can be un-conservative.

The graph in Figure 3 is similar to that in Figure 2 except that the membrane had a relatively large amount of longitudinal reinforcement that did not yield when the ultimate capacity was reached (the transverse steel did). This is partially similar to the case of beams with relatively strong longitudinal reinforcement. The figure shows that a considerable concrete contribution v_c was available at ultimate conditions. This is due to the ability of the below yield longitudinal steel to limit the opening of the cracks, maintaining aggregate interlock.

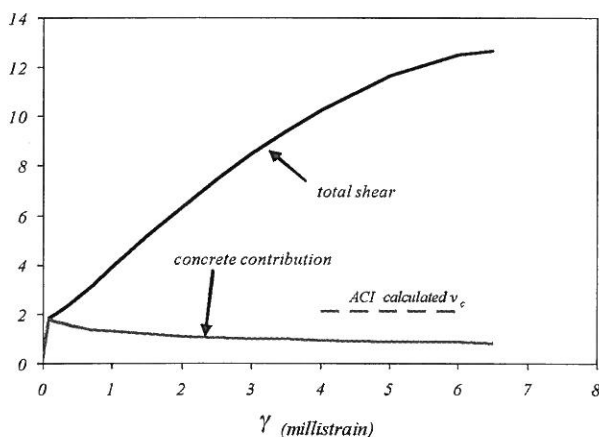


Figure 3: Shear stress-strain response of partially over-reinforced membrane element

Recommendation: If the amount of reinforcement is not relatively large, do not rely on the concrete contribution in membrane elements. Again, use the provisions of the AAAHTO-LRFD bridge specifications², (equation which will be proposed in a future article.)

Maximum Allowable Shearing Stresses.

The ACI allows a maximum shear stress related to $\sqrt{f'_c}$ as shown in Equation (1). This limit was based on test results on conventional concrete with strength smaller than 35 MPa. In addition, this limit was originally developed to ensure that the crack widths at service loads are not excessive. Later, this limit was considered also adequate to avoid over-reinforcement. Meanwhile, the AASHTO LRFD2 Bridge design specifications allow an upper limit which is a function of the concrete strength:

$$V \leq 0.25 f'_c$$

Eq. (2)

Note that the material reduction factors are not shown in the equation.

The maximum shear stress in the ACI code and the LRFD are significantly different especially at higher concrete strengths. Figure 4 shows a summary of the experimental results from 77 membrane elements subjected to pure shear. The amounts of reinforcement in these elements were variable, but it is shown that shear strengths significantly larger than the ACI limits can be achieved. These shear levels are not commonly encountered in design, but if they are, and the project allows it, consider using the bridge LRFD specifications. The provisions do not

have the concerns usually encountered in the ACI provisions. However, I suggests to limit the shear stress to $0.2f'_c$ for concrete strengths larger than 65 MPa.

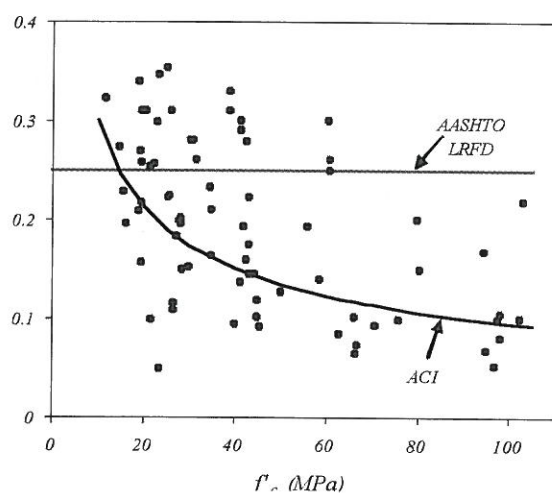


Figure 4: Maximum shearing stresses (normalized to f'_c)

Recommendation: If the maximum allowable shear stress is reached, use the provisions of the AASHTO-LRFD bridge specifications², { or the equation which will be proposed in the future article. }

References

1. ACI Committee 318, "Building Code Requirements for Reinforced Concrete and Commentary ACI 318M-05," American Conc. Institute, Detroit, 2005, 436 pp.
2. AASHTO LRFD, "Bridge Design Specifications and Commentary," 3rd Edition, American Association of State Highway and Transportation Officials, Washington D.C., 2004, 1264 pp.
3. Vecchio, F.J. and Collins, M.P., "Modified Compression Field Theory for Reinforced Concrete Elements Subjected to Shear," ACI Journal, Vol. 83, No. 2, Mar.-Apr. 1986, pp. 219-231.

Upgrading the shear strength of frame connections using FRP overlay systems

**Dr. Mohamed J. Terro,
Dr. Moetaz El-Hawary
and
Dr. S. Hamoush**

This

investigation presents the use of FRP composite systems in upgrading existing reinforced concrete frames to meet strength and ductility requirements laid out in recent ACI building codes. Analytical calculations are presented for the shear behavior of frames strengthened with layers of FRP and an experimental study is carried out to verify the mechanical properties of the proposed FRP systems with various fiber architecture designs. Carbon and fiber glass FRP systems have been analyzed. Flat layers and corrugated shapes with rectangular and circular configurations are employed in the retrofitting systems in addition to various orientations of the fibers which are taken into consideration. The ductility requirement is ensured by controlling the out of plane flexural rigidity of the FRP systems. The desired out of plane rigidity is obtained by increasing the thickness of the FRP systems or by corrugating the applied FRP overlays. In conclusion, this study has shown that the use of FRP systems is an efficient and viable repair method for upgrading concrete frame connections with shear deficiency.

A frame connection is considered in the design of equivalent FRP retrofitting systems for upgrading connections with deficiency in shear. The cross section of the beam is 300x600 mm with 2 Ø 28 bottom steel and 4 Ø 28 for the top steel. The column has a cross section of 600x600 mm with 8 Ø 25 re-bars. The compressive strength of concrete (f'_c) is 27.6 MPa, and the steel yield stress (f_y) 413.7 MPa.

The calculated ultimate moment capacity of the beam forming the joint is 514 kN.m .

The nominal shear strength of the connection is given as:

$$V_n = Y (f'_c)^{1/2} b_l h$$

Following the code s_x was calculated and found that it should not be less than 100 mm.

$A_{sh} = 100 \times 3.16 = 316 \text{ mm}^2$, use Ø 12 hoops with three legs in each direction ($A_{sh} = 339 \text{ mm}^2$) .

Shear connections reinforced with frp systems

In this section, the design is based on the strength requirements as specified by the hoop steel area provided by the ACI 318-02 Code and the ductility requirements as specified by the hoop steel spacing. The ductility requirement was achieved by the out of the plane rigidity of the FRP retrofitting systems. The out of plane rigidity is required to confine the concrete of the connection core. The ACI 381-02 guidelines were used to provide the required rigidity. The equivalent rigidity was evaluated based on the assumption that, under the same lateral stress, the out of plane deflection of the hoop steel is the same as the deflection of the retrofitting systems.

Proposed strengthening overlays

Type II joints

The following two systems were considered for Type II joints:

1. Multi-layered FRP system with two fiber layouts 0° , 90° and $\pm 45^\circ$. The thickness of the system can be evaluated based on the ductility requirements. For this system, the confinements requirements (stirrup spacing and cross sectional areas) as outlined in the ACI -318-02 must be used to find the thickness of the FRP overlays.
2. Multi-layered corrugated FRP system with two fiber layouts 1° , 90° and $\pm 45^\circ$. The thickness of the system will be evaluated based on the required equivalents strength (area of the stirrups) and depth coupled with the configuration of the corrugation will be established based on the confinement requirements (stirrup spacing).

It is anticipated that the second system will results in a more efficient design. The ACI 318-02 Code requires the concrete of the joint core area to carry the applied shear force. Therefore, an attempt can be made to increase the core area by wrapping the connection beams to a new dimension that ensures sufficient core area to withstand the applied shear force.

Type I joints

Type I joints also proposed to have three configurations.

1. Joints with insufficient confining spandrel beams and sufficient hoop steel. In this type of joints, FRP wrap will be constructed around the spandrel beams to satisfy the code requirements for considering the confinements due to the spandrel beams. The requirement is specified as the $\frac{3}{4}$ of the connection face is covered by the cross-section of the spandrel beams.
2. Joints with sufficient confining spandrel beams and insufficient hoop steel. In this type of joints, strips or rods are inserted through the spandrel beams after drilling holes as required to satisfy the transverse steel confinements. The rods or strips are epoxy injected and connected at the ends by wraps around the joint beams.
3. Joints with insufficient confining spandrel beams and insufficient hoop steel. A combination of the above two systems will be investigated to upgrade the deficiencies of the connection.

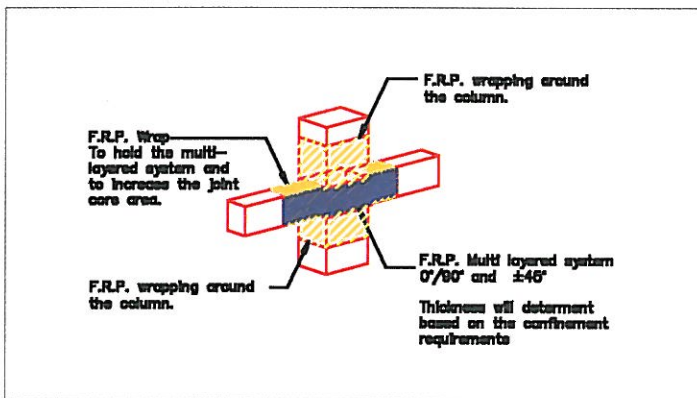
The beams connecting the joints must be also investigated in terms of the core concrete area needed to provide the shear strength of the joints. In the case of any deficiency, beams wrapping may be required for increasing the core area.

In all of the above-recommended upgrades, both ends of the FRP systems must be rigidly fixed to beams to satisfy the fixed support conditions assumed in the analysis. The end of the FRP system support conditions can be ensured by either FRP-wrapping, mechanical fasteners or both.

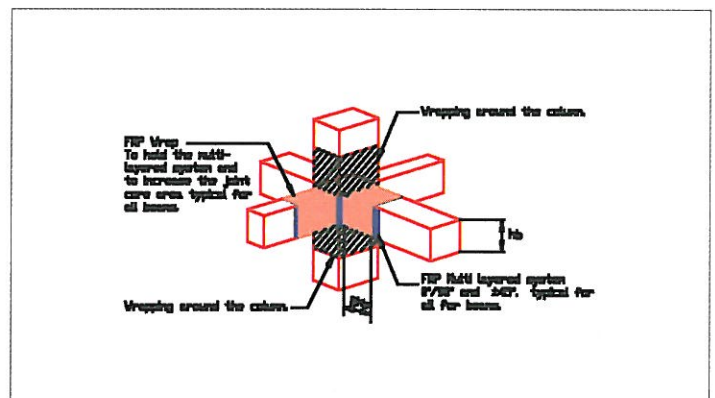
conclusions and recommendations

Based on the performed research investigation, the following recommendations can be concluded:

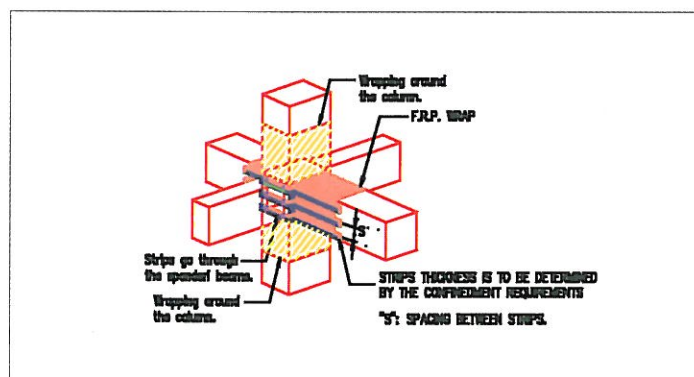
1. The use of FRP systems is an effective method for upgrading deficient concrete connections to enhance the shear strength and ductility performance.
2. Architecturally corrugated FRP retrofitting systems are an efficient option to provide out of plane rigidity for confining the concrete in the core of the connection. Corrugating of the overlays results in a reasonable thickness of the used systems.
3. The use of combinations of $0/90^\circ$ and $\pm 45^\circ$ for the orientations of carbon fibers results in the least thickness of the FRP system. This combination can be implemented in the case where the option of architecturally corrugated FRP systems is obsolete.
4. To ensure the ductility requirements, the ends of the FRP systems should be fixed to the beams forming the connection. This can be accomplished by wrapping of FRP materials around the FRP retrofitting systems.
5. The developed work in this project is to be implemented in actual field applications. Therefore, more analytical analysis is needed to evaluate the elastic modulus of the laminated systems taking in consideration the fiber volumetric ratios and the lamina thickness.



Multi-layered system for upgrading type II joints.



The multi-layered system for upgrading of type I joints with sufficient hoop steel.



The multi-layered system for upgrading of type I joints with sufficient hoop steel.



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AND

**ACI REGIONAL ROUNDTABLE
MARCH 12-14, 2007**

KUWAIT

The ACI-Kuwait Chapter announces its Second International Conference that will be held in SAS hotel, Kuwait, from 12 -14 March 2007. The theme of the conference this year is "Design and Sustainability of Structural Concrete in the Middle East; with emphasis on High Rise Buildings". More than 40 scientific abstracts from all over the world, were accepted so far. Although the deadline for submitting abstracts has passed, if you have a contribution, please submit the full paper to Dr. Naji Al-Mutairi or Dr. Moetaz El-Hawary, directly through the contacts given below or through the ACI-KC office in KSE. The official language of the conference will be English. Papers, however, may be also submitted and presented in Arabic.

KEYNOTE SPEAKERS

Two international keynote speakers have agreed to participate in the Second ACI-KC Conference and share their experience with us. The speakers are Dr. Issam Harik and Dr. Antoine Naaman. Dr. Harik is the Raymond -Blythe Professor of Civil Engineering at the University of Kentucky and the Program Manager, Structures and Coatings Section, Kentucky Transportation Center. The title of his presentation will be "High Performance Material Applications in Civil Engineering". Dr. Namman is Professor of Civil Engineering, Department of Civil and Environmental Engineering, University of Michigan and his presentation is entitled "High Performance Fiber Reinforced Cement Composites".

All members and interested individuals are encouraged to participate in this conference and benefit from the experience of those renowned scientists along with other presented papers.

ANNUAL AWARDS

The ACI-KC International Conference will be accompanied this year by the ACI-KC Annual Awards. As a tradition of the ACI-KC, we honor every year an individual who contributed significantly to the building industry in Kuwait along with an outstanding project the has been completed

recently. If you would like to nominate an individual or a project for this prestigious award, please fill the nomination form that will be mailed to you or pick one up from our office.

REGIONAL ROUNDTABLE

The conference will be also accompanied by the Regional Roundtable Meeting that will be attended by representatives from the ACI Chapters of Saudi Arabia, UAE, India, Lebanon, Iran along with Kuwait. The roundtable is an ACI tradition that is held in different countries to discuss, arrange and promote matters of interest for ACI members in the whole region.

IMPORTANT DATES

Draft Manuscript: December 27, 2006

Final Manuscript: January 30, 2007

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ACI INTERNATIONAL CERTIFICATION

Quality Control and Related Field Testing Practices, was the first ACI certification course organized by the ACI-KC. The course was held in the Kuwait Institute for Scientific Research between 11-13 November 2006 and was attended by 12 participants; one from Aramco Saudi Arabia, three from the ministry of defense, three from Gulf Consult, two from M. A. Al Kharafi, two from KBRC and one from Mushrif. The participants will be given a certificate for attendance from ACI-KC and ACTS. In addition, those who passed the examination will be given the prestigious ACI International Certificate and their names will be published in the ACI site as internationally certified personnel.

The ACI-Kuwait Chapter will soon offer another certification courses. In late March a certification course entitled "Concrete Special Construction Inspector" that will allow the participants, after passing the

examination to become ACI Certified Concrete Construction Inspectors. Another course entitled Concrete Lab Testing Technician Practices, will be offered and will allow participants to become ACI Certified Lab Testing Technicians. If you are interested in any of these courses, please sign up in our office in KSE, as this will help us plan and serve you better. The ACI-KC will also offer certification for the ready mix concrete companies by the National Ready Mix Concrete Association (USA), if your company is interested, please let us know.





KUWAIT CHAPTER

ACI INTERNATIONAL

The American Concrete Institute, (ACI), is a nonprofit international organization that promotes improved technology, technical competence, design, and construction related to concrete for the benefit of society.

PURPOSE OF THE ACI KUWAIT CHAPTER

The purpose of the chapter is to further the chartered objective for which the American Concrete Institute was organized i.e., 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.

HOW THE CHAPTER FUNCTIONS

The ACI Kuwait Chapter is approved and authorized by the Board of Directors of ACI International to provide the means of furthering the chartered objectives of the Institute in the State of Kuwait. The Chapter is managed by a local Board of Directors whose members constitute the Chapter officers. Chapter membership is open to all individuals and organizations with an interest in any aspect of concrete technology. The Chapter is operated through its committees which are made up of volunteers from the membership. Programs are developed by the committees to meet the needs of the Chapter members. The Chapter may hold several meetings each year and engage in activities that may include:

- Sponsoring educational seminars, short courses or workshops.
- Holding or sponsoring certification training courses and examinations.
- Publishing technical information and newsletters.
- Conducting awards, programs for local concrete structures.
- Special social events.

BENEFITS TO CHAPTER MEMBERS

- Attend seminars, short courses and workshops organized by the Chapter at reduced fees.
- Free use of ACI publications, which are supplied to the Chapter by ACI International and are, kept in the Chapter library.
- A forum for members to interact with colleagues and identify potential sources for cooperation in addressing specific technical problems.

HOW TO JOIN THE ACI KUWAIT CHAPTER

To become a member of the Kuwait Chapter please complete the attached membership application form. Different categories of membership are available. You will receive a copy of the Chapter Bylaws upon becoming a member. The work of the ACI Kuwait Chapter is a mutual interest effort and success depends upon your active participation.



KUWAIT CHAPTER

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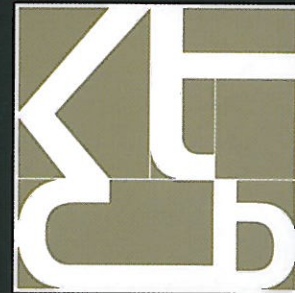


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