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Princess Nora Bint AbdulRahman University: Al Musharabiah/The Central Library ASRS/ E-Campus//

Disi-Dubaydib// DarPune

editor's note

This third issue of DarMagazine is placed under the theme of 'exploring new possibilities'. It has been little over a year since Dar Al-Handasah opened its fourth design center in India's cultural capital; the article 'DarPune' is a retrospective on a year long venture that is now a thriving 400-strong full-service principal design center. 'A Consultant's Concern' is an article from Dubai on Dar's leading efforts for site health and safety and 'Cultured Pearls' brings us up-to-date on Abu Dhabi's ever-evolving green community requirements. In keeping with our exploratory theme, Dar has embarked on an integration of BIM (Building Information Management) project design and planning environment; 'At Cruising Altitude' documents a shift in project perception that has given our architects and engineers new insight into project design and management, pushing the boundaries of control over a project's ingredients to levels never achieved before. In our follow-up article on APC's jetty design, we are presented with a structural perspective of crafted design perfection of the Arab Potash Company third generation pumps' offshore platform and jetty. This issue's main feature is our latest flagship project the Princess Nora Bint AbdulRahman University (PNU) in Al-Riyadh, KSA, a multifaceted large scale project that has been a true test of exploration and collaboration. In this issue we will focus on presenting PNU's architectural design paradigm in 'Al Musharabiah', 'E-Campus' will address PNU's converged network telecommunication design and 'The Central Library Automated Storage and Retrieval System' will present an innovative look at a retrieval system designed specifically for PNU's extensive on-site library collection. 'The American University of Iraq at Sulaimani' documents an earlier Dargroup members (Dar Al-Handasah and Perkins+Will) collaboration on another university project that has paved the way for succesful higher education collaboration. 'Disi-Dubaydib' is an exciting article about Amman's water conveyance strategy and 'Travel Light' documents the Amman-Zarqa proposed light-rail train (LRT) now that the virtues of public transport are slowly infiltrating urban life in the Middle-East. 'Reflective Cracking Potential' relays the findings of a new method developed by Dar geotechnical engineers to evaluate aging airport pavements. Finally, 'Knowledge Economic City, Madinah' takes us through the development process of Knowledge City, Madinah's public realm designed to complement the Kingdom's Third Economic City's mission as a religious, social and cultural think-tank for research and policy.

contents

"DarPune has allowed Dar Al-Handasah to re-think a new focus for the future by hiring exceptional talent, sealing solid partnerships and making full use of technology to fill in communication gaps"

DarPune

When the choice fell on Pune, India as the city where Dar Al-Handasah would set up its fourth design office, it was no arbitrary decision; as it were, DarPune spawned following a well thought out and carefully structured strategic move to choose a location that would complement the already existing three principal design centers. The decision to set up a fourth center was not one that demanded much discussion, "Our practice was naturally expanding," says Youssef Matar DarPune's Partner-in-Charge and the Director of the Electrical Department. "The kinds of projects we were commissioned to design or manage took on a completely new dimension starting in the mid-nineties." The second consensus (apart from the need for a new office) was that it would be in Asia, and will have an easterly outlook. While the 70's and 80's were times where Dar expanded towards the West establishing DarLondon and founding DarGroup, a global network of consulting firms, now was the time to look for new opportunities in the East. Matar and a number of other seniors made exploratory trips to eye potential locations, but while many were great spots, none possessed what Pune had to offer.

A stone's throw from Mumbai, Pune has carved a reputation of being India's cultural capital, boasting nine universities affiliated with the University of Pune and with over a hundred educational and research institutes scattered around the city, it is India's innovation hub and a nation-wide magnet for talent. Its Engineering School (Asia's second oldest) graduates a legion of qualified engineers each year, and with a budding software and IT industry it promises to be the next focus for information technology services. Many of India's prestigious IIT (Indian Institutes of Technology) graduates flock to Pune because of its vibrant job market and the opportunity to work for a 'local' IT multi-national. A city within a city, Magarpatta IT Park where Dar offices are located is a state-of-the-art city built around a Software Technology Park (STP). Managed by Software Technology Parks of India (STPI), a government agency established in 1991 under the Ministry of Communication and Information Technology, STPs claim credit as a basic component of India's economic reforms. Focusing on dismantling tangled bureaucratic regulations that were crippling the economy and opening India's tightly closed markets to imports and foreign investments, the successful, almost two decade old reforms have earned India its current reputation as a global information technology power player. STPs are essentially export oriented schemes for international IT and IT-enabled industries providing freedom for 100 percent foreign equity investment and tax incentives. More than 6,000 businesses are registered under STPI, Pune attracts 20 percent of the total industrial investment in the country and accounts for $2 billion in IT exports — one of the highest for a single city.

It is a win-win situation. DarPune has clearly provided much needed relief to handle the design load but it also offers young Indian engineers the chance to work for a global powerhouse without setting a foot outside their country. But that would be only telling half the story, Pune happened because what Dar was looking for is not only opening a new design hub in a desirable location as much as it was providing new opportunities for our staff and better services to our clients.

"We always like to remind ourselves", Matar says. "That we are not only about opening up to new markets, we also want to be about providing our clients with a wide scope of specialized service"

"You have to understand," he goes on to explain. "Risk is the flip side of resources and in our opinion one way to manage risk is to be clear on what it is we want, this is our own interpretation of risk aversion." On August 1st 2008, the office hit the ground running, we were clear about our goals and that led us to nail the big target we set out for," said Justin Pinto, DarPune's Project and Management Contract Department Head, "to achieve a fully integrated design office within one year." The second phase of the Hajj Terminal Load Center at King Abdul Aziz Airport in Jeddah was the first project designed from start to finish in Pune with no assistance from other offices and submitted within three months of opening day. Locally-recruited engineers went through a training period in either DarBeirut or DarCairo. What also helped is the willingness of many of our seniors to relocate. Pune's laid back atmosphere is a long way from Mumbai's fast rhythm and an ideal place where the whole family could move to — a rare commodity in our business.

In just one year, DarPune has quadrupled in size; the office is now an integral part of Dar's operation handling varying loads of seven big ongoing projects completely coordinated with Beirut, Cairo and London. "We can now definitely talk about a successful end and those who were there for the first couple of months have a lot to do with the outcome. They survived the initial upheaval of setting up a new office, running the day to day operation and ensuring that project deliverables roll out on-time and according to Dar standards," says Matar.

"In retrospect, we took a chance and it paid off because our objectives were clear, and many consultants and contractors we work with are following suit setting up offices in Magarpatta," he continues. DarPune has allowed Dar Al-Handasah to re-think a new focus for the future by hiring exceptional talent, sealing solid partnerships and making full use of technology to fill in communication gaps. We are now working on strengthening cross-office collaboration, empowering our staff to make the right decisions knowing that we have the resources to back them up. There is still a lot to be done, "We are like a talented young student," Justin Pinto likens DarPune, "who needs the mentoring and guidance of their older more experienced counterparts to fully develop and this is how we are proceeding." Dar's established design centers were set up in the 70's the latest (DarLondon) more than thirty years ago, and while we have opened more than 40 area offices all around the world, Pune is our first design venture since London in 1975.

Many lessons have been learned this past year, but the best part is that most are applicable company-wide which has energized the overall design operation something that could only be achieved when you are working with a clean slate. Exactly what DarPune was intended to do.

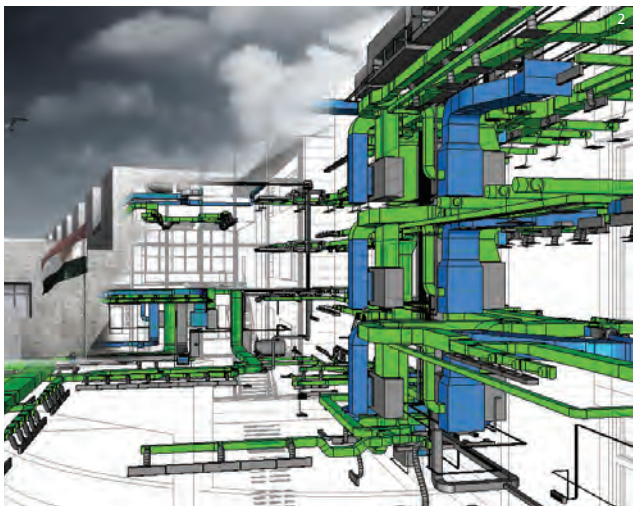
At Cruising Altitude

Project modeling has gained unprecedented popularity in the design-building industry now that the stakes to tighten the grip on a project's components have never been higher. Cost cutting exercises, environmental constraints, and project performance are now staples which is enough reason why Building Information Modeling (BIM) softwares are infiltrating the design process.

Consultants who have jumped on the BIM-bandwagon can deliver a digital model from the project's onset until completion providing the client a better understanding of the design and development strategy, the project's performance (MEP system, environmental impact, project maintenance and management), real-time value engineering exercise, and detailed construction model replicating site condition. Revit® from Autodesk , the choice BIM software adopted at Dar, has hit the 2-year double-target to create more accurate models and to reconcile the project's overall shape with all that goes on inside it and ultimately with the site.

Software development engineers in close coordination with architects and engineers from the different departments worked closely together over the two years to bridge the divide between the different trades. The results have been most satisfactory, BIM teams were able to take full advantage of what the software has to offer and make a significant change in Dar's design protocols. Customized templates with Dar-particular symbols and families, automation of most of the more tedious design tasks, incorporation of external application and exploration of green building requirements are now design contingencies for a more potent tool to keep costs down and evaluate building requirements.

Starting in April 2009, the Information Technology Department embarked on a voluntary pre-emptive exercise to test the limits of BIM and take a closer look at design dynamics changes – and there were some –, BIM altered the way designers, clients and contractors look at the project. The change was not forced; it has slowly and persuasively infiltrated the work-process because of an increasingly demanding and savvy client-base, a general preference for design-build projects and evermore complex and highly innovative projects of unprecedented scale. The successful BIM phasing into an already effectively-running operation to reach comfortable cruising level depended on Dar's robust infrastructure and a top-down commitment upon which to introduce the necessary changes.



1 Revit ® 3-D architectural model for the Kurdistan Regional Government Department of Foreign Relations Headquarters Project
2 The project's Revit ® 3-D mechanical model

Al-Musharabiah

|ˈəl•mu•ʃə•ra•bi:•ə|, **[noun; Origin: Arabic]** A type of ornamental window screen characteristic of Islamic architecture used as a cooling element to move air masses from a zone of high to that of low pressure and naturally ventilate inner spaces and courtyards.

Princess Nora Bint AbdulRahman University is a 2.8 million m^2 built-up area being constructed over an 800 ha wedge-shaped site east of Al-Riyadh, KSA. The unique design concept defined the spatial program of a university campus by determining the requirements of this exclusively women's campus and engaged design in a cultural deference transpiring from a close understanding of the Kingdom's social fabric and way of life.

The design concept and the basic rules guiding it sketch a pervasive duality in what PNU represents for the determined resilience of the women who will grace its hallways, classrooms, laboratories, libraries, and courtyards. The facades inspired by Islamic geometrical pattern are the unifying element weaving an ethereal cover between what is seen and what is unseen to modestly protect a world of possibilities. The airy lightness of the patterns never heavy, or stifling, never restrictive or neutralizing, creates a delicate shield, thinly fashioned and infinitely engaging the duality of universal truths.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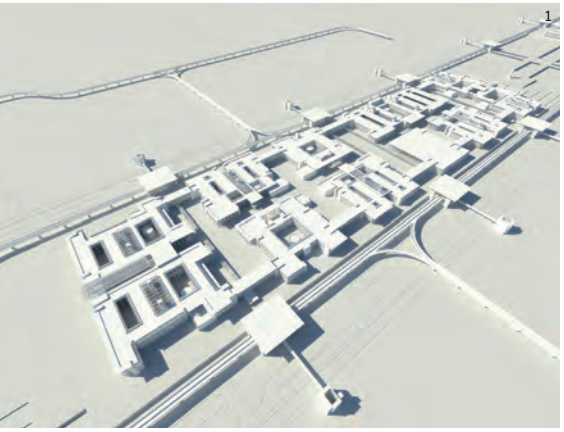
Princess Nora Bint AbdulRahman University, Al-Riyadh, KSA



At conception and spilling into the successive design stages, this universal duality is transformed into a play on textures, perspectives and materials to define gates, walkways, screens and shades, and diffuse a relaxed atmosphere of privacy conducive to learning away from distractions without creating a feeling of seclusion. What must be concealed is carefully kept from what can be revealed in a triumphant use of ornamental facades, screen canopies, glazing profiles and a vernacular palette of textures and colors.

The Academic and Health Sciences campuses are integrated in a rectangular space forming the university's central spine. The two campuses are axially opposed but joined by a central quadrangle of green gardens, water features, and seating areas around a central clock-tower. Elevated on a 6-m high plinth, the 3.7 km long academic platform is serviced from below by a network of tunnels and basements containing all systems infrastructure; maintenance personnel access through separate entrances entirely detached from the instructional elements.

The Colleges of Education and Early Childhood Education, Fine Arts & Design, Arts & Sciences, Business & Management, Human Ecology, Computer Science & Information, Social Work, Language & Translation and the Student Union form the interconnected Academic Campus (the campus also has provision for a continuing education program). The buildings, ranging in height from 4 to 5 stories, are linked north to south by walkways at the Plaza level and level two.

1 Academic Campus design development white aerial
2 The Campus' central spine and southwestern connecting walkway and APM Station
3 Academic Campus canopy-covered inner courtyard and connecting Plaza
4 College of Education entrance Atrium facade elevation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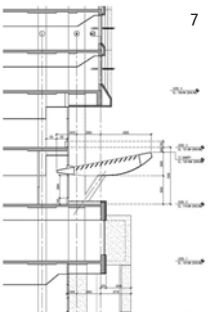
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5 Medical Center southern view. In the foreground, the covered walkway to the APM Station connecting the Medical Center to the Health Sciences Campus and the Emergency Room access ramp visible under the atrium podium
6 Medical Center northern shot
7,8,9 Medical Center shade modeling detail
10 Medical Center light mapping section view

The central linear Plaza is a progression of landscaped spaces varying in space and functionality and bringing identity to each entrance atrium. The buildings are paired under ornamental canopies to form shaded courtyards. Each Faculty includes standardized and reconfigurable classrooms, a grand lecture hall and smaller lecture halls equipped with distant learning capabilities, open computer and language labs, a faculty library, and specialized labs depending on the curriculum demands. One distinguishing aspect of PNU is the accurate reflection of the faculty requirements in space design; this is because the academic curriculum was being developed in tandem with architectural detailing.

The Health Sciences Campus' 200,000 m^2 buit-up area includes the Schools of Medical Sciences, Nursing, Dentistry, Pharmacy, Physiotherapy, Clinical Skill Development, Basic Sciences and Clinical Skills Development in the same unified yet identified architectural paradigm of slightly varied musharabiah-inspired envelopes and screens. Flanked to the south, between the Health Sciences campus and PNU's teaching Hospital and Medical Center, stands the Research Laboratory – a facilitator of interactivity between research and active learning for the benefit of students, patients and the advancement of scientific research. The multi-discipline Research Lab is designed with adaptable planning modules, shared support functions and a vibration-control structural grid.

The entire double campus perimeter is laced by an Automated People Mover System (APM) lifted 10 m high and stopping at 10 different drop-off stations along the campus loop. The APM, based on peak flow modeling, transportation congestion and entrance queuing analysis for 40,000 students, branches to all vital areas of campus to include a total of 14 stops. These stops are PNU's primary entries points designed for maximum security and access control.

The Medical Center spearing the Health Sciences Campus at the university's southernmost tip is a 312-bed (designed for 600 for a later phase) 107,000 m^2 built-up area teaching hospital. This Tertiary & Quaternary Care facility provides outpatient and inpatient care including Non-Invasive Diagnostics Medicine, Dialysis, IVF, Interventional Surgery, Comprehensive Obstetrics and Gynecology Care including Neonatal ICU, Pediatric Care and ICU, Cancer Treatment Center, Musculo-Skeletal Clinic, Cardiology, Respiratory Therapy and Adult Care. The Medical Center arrow-shaped design around a rectangular glass-top atrium is clad in a combination of local stone, architectural precast concrete with concentrations of Low-E high performance glazed areas. A careful study of the community's healthcare needs and the university's teaching requirements led to a space program arranged to maximize the Center's operational performance. Garnering every aspect of health and serving the community at large, PNU's Hospital and Medical Center is also part of the network of quality care hospitals Kingdom-wide.

Completing the LEED registered campus are the iconic Central Library and Administrative Buildings and the PNU Convention and Exhibition Center striving for LEED® Gold. The Administration Building is the first seen after crossing the Ceremonial Gate Entrance.

1 Academic Campus view
2 Illuminated atrium facade

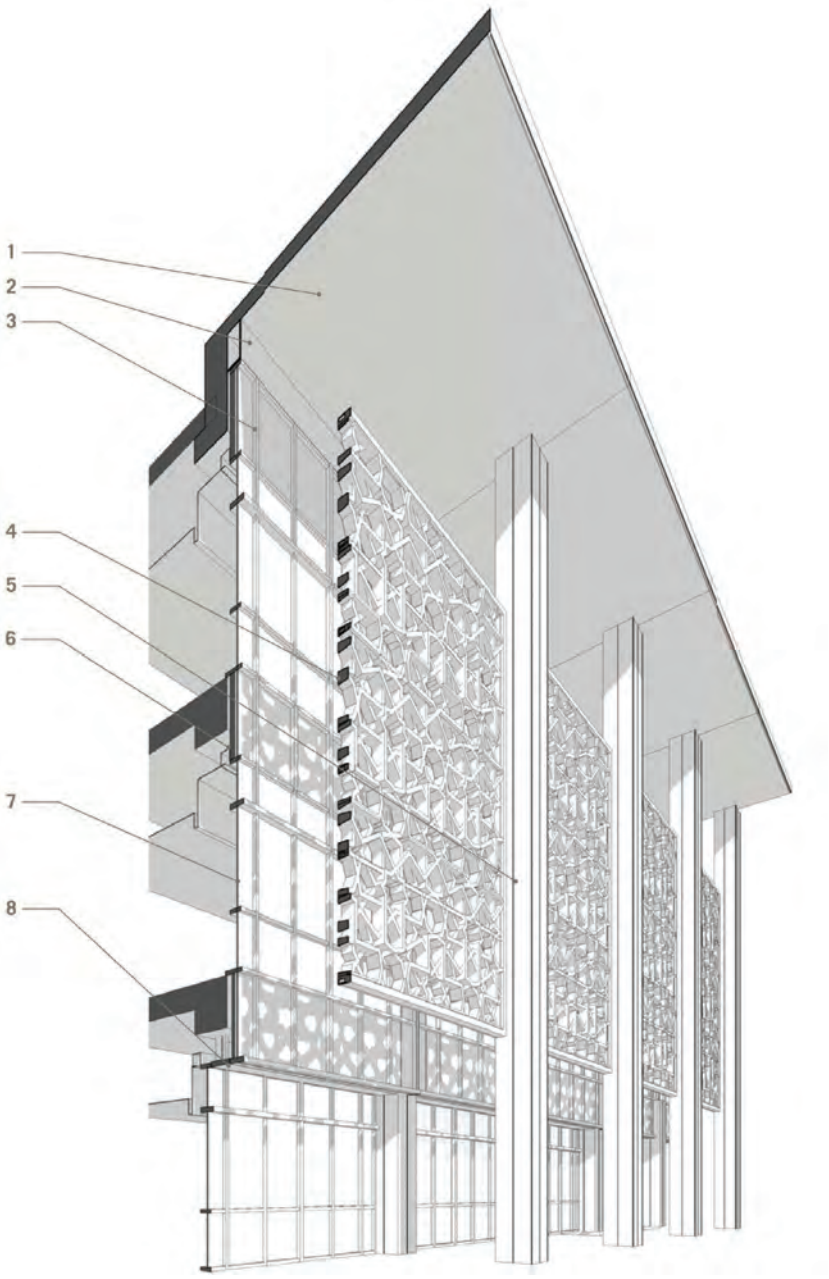
The imposing three-story plus ground floor structure is ringed with window arches running first circular then turning two 90-degree angles to form double extending wings on both sides of a squared corner-towered central entrance. Drawing inspiration from Islamic Architecture and the majestic Arabian Desert, the Administration Building's inner court is the site of PNU's Central Library, inspired by some of Islamic architecture's oldest surviving examples. The exterior grandeur of the Administration building holds 62,000 m² (male and female quarters) of efficient, functional and sumptuous, modular inner space design. It houses the Royal Quarters, four Deputy and six Vice-Presidential Suites, in addition to the Offices of the Deans of Post Graduate Studies, Admissions and Registration, Students, Continuing Education, E-Learning, Faculty Affairs, and Libraries.

A self-sustained community, PNU will be home to senior staff members residing in 400 villas, junior staff will occupy 1,000 apartments in addition to housing for students and medical staff. Staff children will be able to attend the on-campus boy and girl K-12 schools, enjoy the staff's Community Center and Sports Facility located on the eastern side of campus (there is a mirror facility for students) and the many retail pavilions and restaurants.

3 Health Sciences Campus and Research Laboratory headed by PNU's Medical Center

The facades

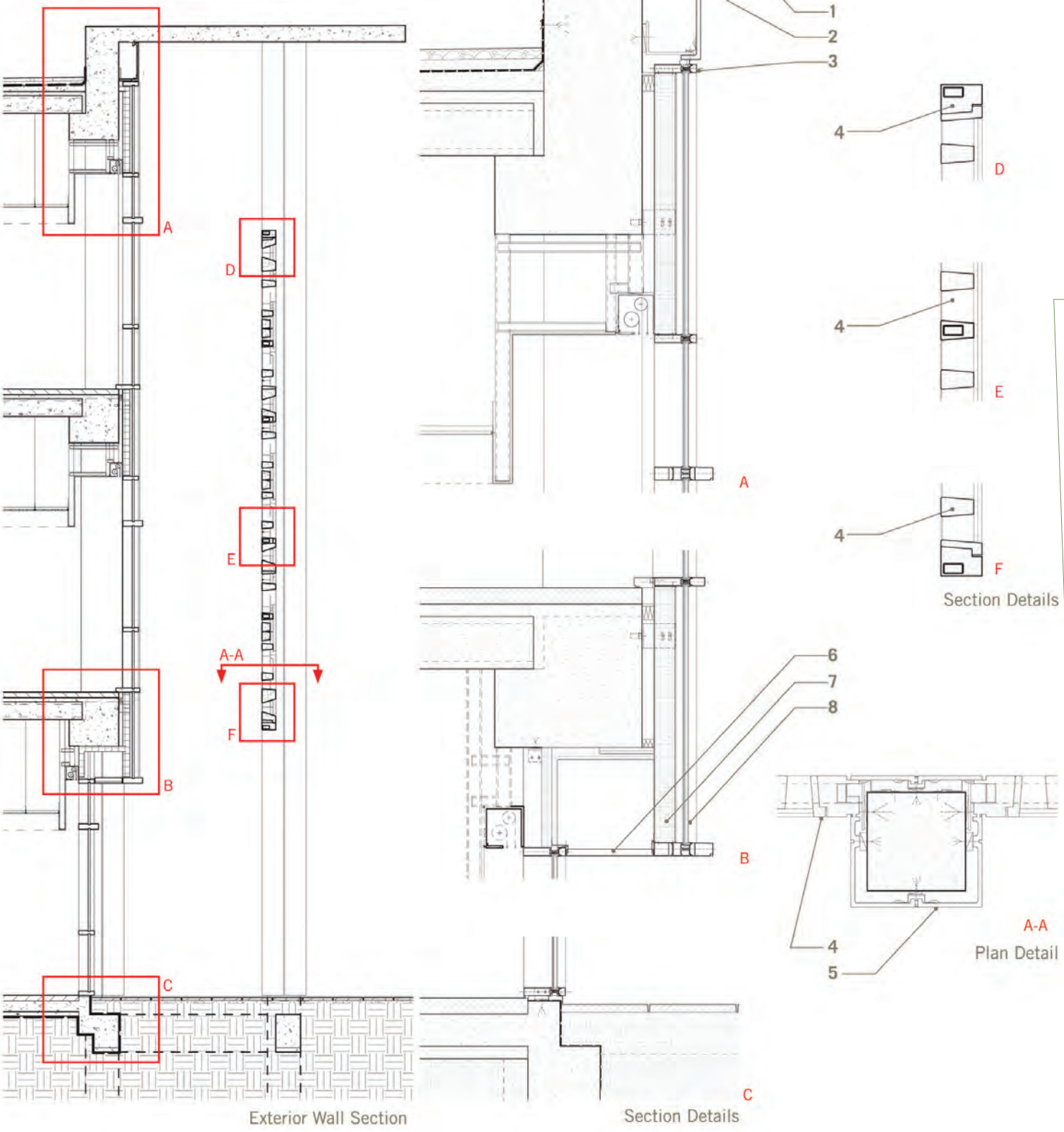
The language of the ornamental facades is the campus' unifying vocabulary found in Islamic art and destined to join the functional to the artful. The lacing is achieved with GFRC cladding layered over contemporary building forms stone-clad with locally quarried Riyadh Hurymullah and Taif Najd stones. There was a desire to create ornamental textures that continue from one material to another and exploit innovative techniques as a single architectural language. Precast screens panels based on solar orientation and the sun shading requirements of interior spaces are created of patterns, textures, relief effects and ornamentation by means of formwork. The wall assembly is comprised of an aluminum curtain wall system, architectural cast-in-place concrete canopies and columns, and glass-fiber reinforced concrete shading screens. The building envelope is designed to be an energy efficient response to a harsh and challenging climate. The curtain wall system includes high-performance vision glazing and insulated shadow-box construction at column and spandrel zones. The system helps the buildings achieve energy reductions of 19% over baseline conditions. The GFRC shading screens are designed to do three things; shade the building from direct solar gain, provide visual privacy for building occupants, and create a culturally relevant architectural expression for the campus. The Academic Colleges will utilize approximately 80,000 m^2 of the shading screens and they will account for an overall reduction in building energy consumption of 3.5% (13% reduction in heat gain on the exterior envelope).



Construction in progress

1 Cast in place architectural concrete
2 Glass Fiber Reinforced Concrete (GFRC) panel
3 Aluminum curtain wall system
4 Panelized GFRC screen
5 CIP concrete column w/ GFRC column covers
6 Shadow-Box construction
7 High Performance Low-E Insulating Glass
8 Formed aluminum panel soffit

Screen detail



1 CIP architectural concrete, integral white color
2 Glass Fiber Reinforced Concrete (GFRC) panel
3 Aluminum curtain wall system
4 Panelized GFRC screen
5 CIP concrete column with GFRC column covers
6 Formed aluminum panel soffit
7 Insulated shadow-box construction
8 High performance low-E insulating glass

LEED® Gold Administration Building and Central Library

The Central Library ASRS

by Layal Saadeh, Industrial

The Automated Storage and Retrieval System (ASRS) has only recently been adopted from industrial type high density automated storage technology into library space design. Libraries holding large on-site collections and rare fragile items requiring a controlled environment for safekeeping, and a quick and efficient storage and retrieval method will benefit most from the system. The ASRS solution designed for PNU's 4.5 million volumes (reducing storage required space by 10 folds) stores 4.5 million volumes in a total of 12 double-deep storage racks (30 m in length X 17.5 m in height) for bin storage. The racks will include 90,000 storage bins with an average capacity of 50 books each in a mini-load configuration extending from the first up to the fourth floor of the library. Each mini-load has 5 double-faced racks and 2 peripheral single-storage racks with aisles between these racks constituting the path of the automated storage/retrieval cranes (SRC) used for bin storage and retrieval – a total of 12 SRCs were used, 6 on each storage side.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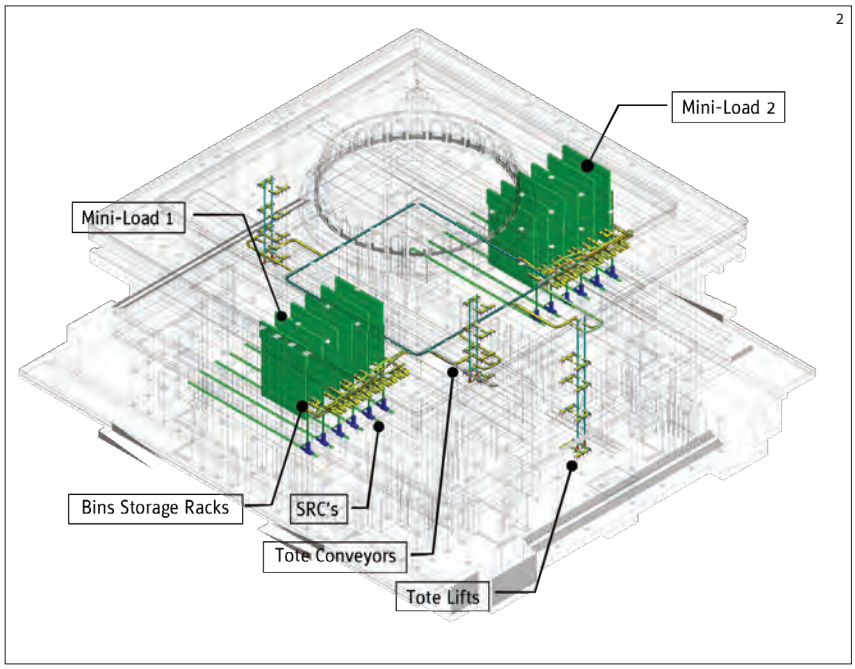
Operation design and performance

Books arriving to the basement get de-palletized, sorted, tagged with a barcode, entered to the library archiving software, and then transported via the AS/RS service lifts to the third floor working area. There, operators store books in bins where bins in turn will be stored by cranes in the available locations on the racks assembly. A PLC (Programmer Logic Controller) computer controlled single-mast crane running on floor-mounted and overhead rails in the space between racks move into and out of the rack assembly removing and replacing bins. When a book or item is requested through the library archiving software uploaded on a laptop/PC, a command is sent to the appropriate AS/RS crane to reclaim the book by travelling to the location of the corresponding bin from the storage racks. The AS/RS crane will then carry and place the bin in a system of bin conveyors towards the available working station. The PLC/PC-based working station is guided by a visual display to help the working-station operator retrieve the book from the bin, check it out from the system with the use of the barcode reader, and place it in a tote on a tote conveyor system. Single totes running on the totes conveyors transport the books from the workstations area onto a loop connecting the two sides of the ASRS.

From the tote conveyors' loop, single mast lifts vertically transport the books to the different reading areas of the library. These lifts deliver books in totes to book pick-up/drop-off stations spread on all floors. At the drop-off stations, operators can retrieve the book from the tote and hand it to students or return books from students to the storage system via the lifts (after checking the book 'in' using the barcode reader again). These book stations are equipped with PC's and barcode readers to enable workers to update the library archiving system upon returning of books.



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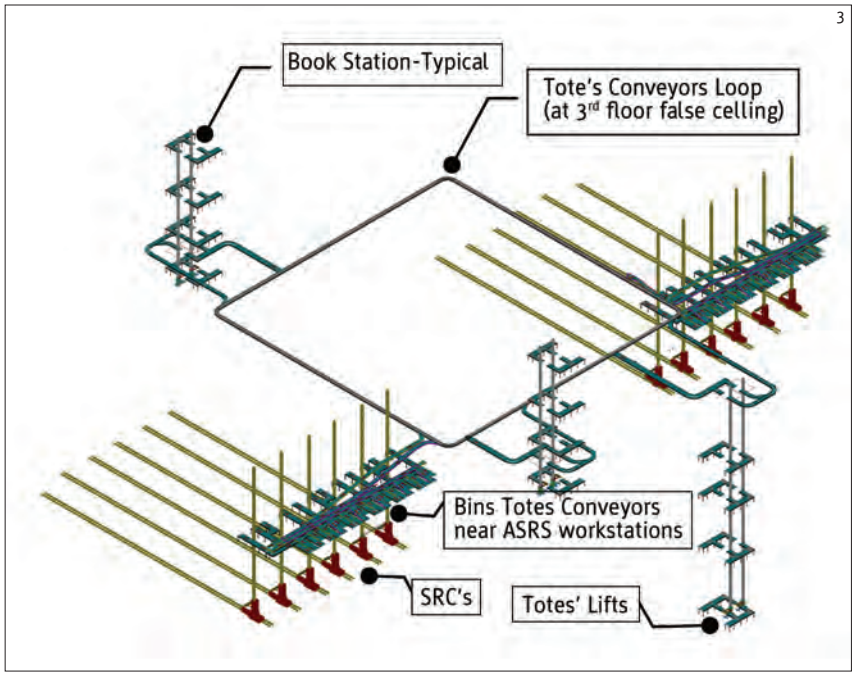

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1 Central Library 3-D view
2 ASRS Bentley 3-D Model featuring the system's equipements: mini-load racks occupying the volume extending from 1st to 4th floor for bins storage; 12 SRC's for bins storage/retrieval; tote conveyors for transportations of books placed in totes; tote lifts for transportation of book totes to/from book stations spread across the reading areas on all floors
3 ASRS equipment in a Bentley isometric view showing SRC, bins and tote conveyors and lifts

It is the control system that ensures the arrival of the book to the desired book station at the same floor where the book order was placed. Empty totes as well as full totes awaiting retrieval from operators at book station are stored in vertical racks installed next to some of the tote lifts. This 4.5 million-volume designed-system will have around 12 working stations at the bins handling level, and 6 totes lifts for totes transportation to the different library areas.

The throughput of this system is around 1,500 book/peak hour. Time needed for delivering a book to a student waiting for it at a book station will not exceed 15 minutes time interval between the electronic placement of the book order, and the arrival of the book to the destined book retrieval station.

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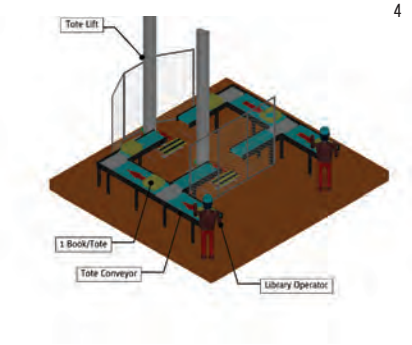

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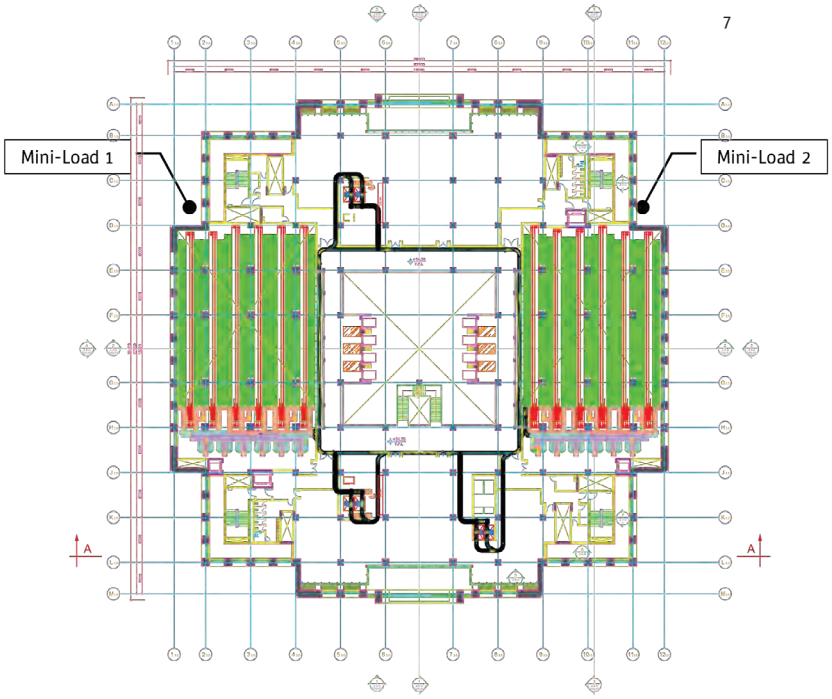

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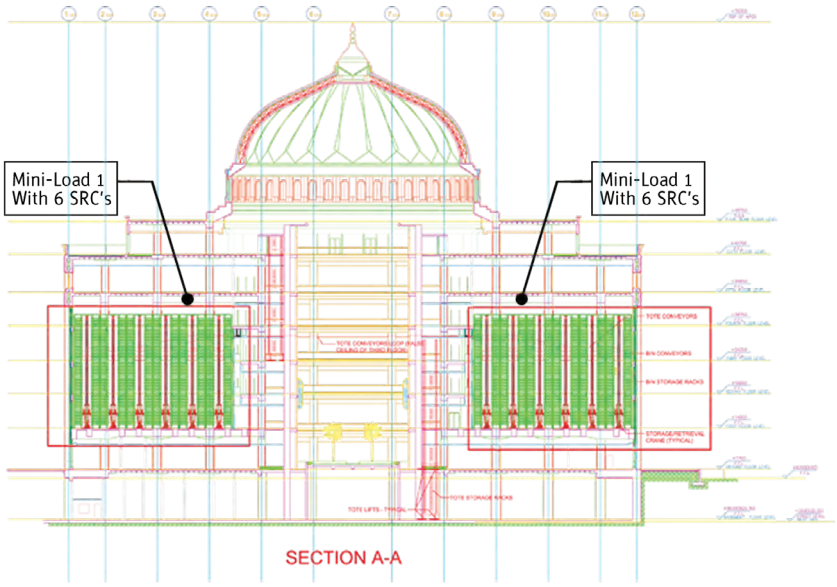


4, 6 ASRS supply and return activities. The library operator retrieves book from tote coming via tote lift, scans it out of system, and hands it to student. For the return activity the library operator places returned books into totes onto tote lift to send back to the ASRS worker for automated storage in the mini-load via SRC
5 ASRS workstation pick and store activities. The ASRS worker picks up ordered book from bin, places it into a tote, and sends it via the tote conveyors to the tote lifts reaching the book station. For the store activity the worker removes the returned book from the tote, places it in the bin, and sends the bin via the in's conveyors to the SRC storing it back in the mini-load racks
7,8 Section and plan drawings showing the ASRS solution within the library architecture

E-Campus

by Bernard Zablit & Souhaib Ibrahim, Telecommunication

PNU's telecommunication architecture is designed for a digital classroom, virtual Teaching Medical and Research Centers, a high degree of campus connectivity and IT services, the latest in presentation and audiovisual systems, and a campus monitoring and control security system via a single network.

The converged network is built to integrate voice, video and data applications across one transport system. It is often likened to a road network (as opposed to a rail system for dedicated networks) where information fashions itself towards its destination rather than be restricted by design specifics. The dominant Internet-based protocol improves communication within the campus and with the outside world with the right protocol stacks, routing algorithms, gateways and switches.

The network infrastructure supporting web and application servers and the operating systems to run them will be housed in two Data Centers, one covering the campus and the second dedicated for the Medical Center that has the infrastructure to be linked via a private network to all other medical centers within the Kingdom. They are precisely controlled facilities ranking III on Uptime Institute's IV Tier availability level classifications system incorporating core, distribution and access layers in a continuously monitored environment. PNU's main Data Center is physically located inside the easily-accessed service and utility band along the campus' westernmost boarder, and will house all computing hardware, communication servers, and storage systems with all associated cabling, FM200 automatic extinguishers and very early smoke aspirating detection systems. It is a design recognizing the short lifecycle of computing devices, anticipating future space needs and extensive electrical and mechanical systems needed to maintain it. Heat loads and heat-induced system shutdowns are not only guarded against with enough cooling capacity, but with uninterrupted cooling and electrical supply to deliver the right cooling to the devices that need it most. With a comprehensive maintenance program, the maximum annually expected downtime is 1.6 hours and will be human or machine-induced with complete proofing against system shutdowns or deficiencies.

By its own definition, a converged network is one that supports an infinite number of communication technologies designed to be a fault-tolerant logical mapping of the physical infrastructure whenever possible. Physically redundant elements and logical resilience of the campus' converged network system set the configuration parameters for IP's addressing choices and VLAN design. Conventional in many of its components, the quality of a converged network is ultimately the product of decisions about its flexibility, perpetuity, expenditure and expectations. The telecom network should also be designed to match the overall lifespan of the campus in relation to a relatively

short-term lifespan of the technology – this is telecom's main challenge. The one designed for PNU supports a campus-wide enterprise grade VoIP telephony solution, Wireless LAN solution for voice, data and video services, external and internal site-wide GSM coverage throughout the campus, high-speed internet access and high availability back up connectivity network storage. Within these defined boundaries, PNU's converged single-network system integrator is an intelligent, structured and integrated connectivity network with redundant bandwidth capacity and system modularity to support the distribution of IT wired and wireless services backbone. The fiber and copper infrastructure supports a multiple-speed communication and highly rated copper end-user connections capable of carrying signals up to 10 gigabits over a 100 m distance.

All internal technology systems are integrated at a project and design level for interoperability and centrality: a single technology space for all systems requiring distribution to a floor or a building, a single physical cable infrastructure between the technology spaces, and an IP single logical network for the transmission of converged system.

The campus domain single technology space convergence is achieved through increasing bandwidths, a number of refinements in network transmission techniques allowing many information types to be transported by Ethernet interfaces and IP-based technology. The system is accessible anywhere, being carried by the same physical and cable infrastructure, and shared network core, distribution and edge switching logically segmented into VLANs for security (traffic and management concerns with resiliency achieved through redundancy). The best part of converged systems is that if properly managed and maintained, they do not impose any additional security concerns on the system, but a sealed security policy should be developed and maintained as for any enterprise network.

With over 1,000 classrooms; 200 lecture halls; 10 libraries in addition to the main central library; 200 meeting rooms; 150 science labs; 300 computer and 120 language lab; 100 audio-visual rooms it is a digital campus. PNU will be retrofitted with video (DVD recorders, robotic cameras, distributed TV systems), audio (sound reinforcement, radio, microphones, live interpretation, surround sound system and display systems (projectors, screens, flat panel displays medical imaging) in multiple configuration for typical classrooms, multi-purpose rooms, lecture halls, gathering areas and science and language labs. Typical classrooms, for instance, intended for daily lecturing will be fitted with a projector, a screen, portable document camera and DVDs, lecture hall will have additional annotation boards and e-learning technology. The Medical Center's teaching clinical simulation lab AV technology involve informatic displays, cameras, test subjects or simulated human devices, and image acquisition components.

PNU's AV system will be monitored and controlled by a central management system which will perform such actions as cover room usage and help requests, trigger alarms when devices are disconnected, as well as track and notify emails in cases of major failure or unplugging of an unauthorized device.

The American University of Iraq, Sulaimani

by Youssef Azzam, Dar Erbil

Project overview:

- The site: 180 ha, located 10 km east of the city of Sulaimani along the Kirkuk Highway, adjacent to the Sulaimani Airport
- The University is planned over five phases of academic expansion and building construction
- At completion of Phase III, 52,000 m² will be dedicated to the university campus buildings
- Future developments around the site include commercial, office and warehouse space
- The campus will be self-sustaining with all infrastructure utilities developed on site including power, domestic water, waste-water treatment, fire protection, and storm-water control

Site design concept

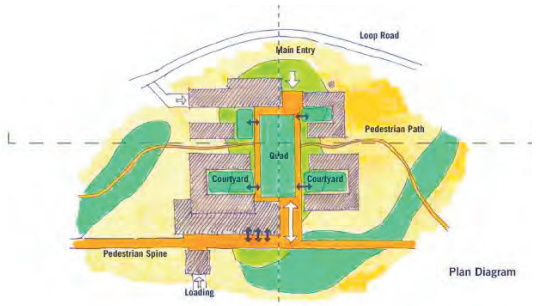
A converging river symbolizes AUIS's ideals. A university is a source, a conduit – multi-sourced and convergent – coming together to form a common body more powerful than any of its individual parts. A university experience is the distance travelled to reach and benefit a larger body.

River confluence guides the campus design and special organization to create a secure, visually cohesive and welcoming campus that preserves the natural landscape of a pedestrian-oriented core campus.

New on old

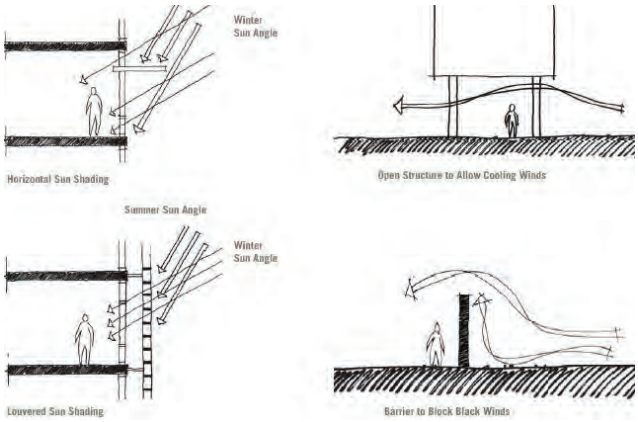
A modern beacon of knowledge and leadership rooted in the wisdom of the past, the architectural concept is based on an open design atop a solid stone base. The open buildings emblematic of a new liberal educational institution inspired by the surrounding hilltop traditional stone villages – the latest addition to the unbroken progress of culture and history in Iraq. The 'New' leaning on the 'Old'.

AUIS site map. Inset, Sulaimani, part of northeastern Iraq's Kurdistan Region



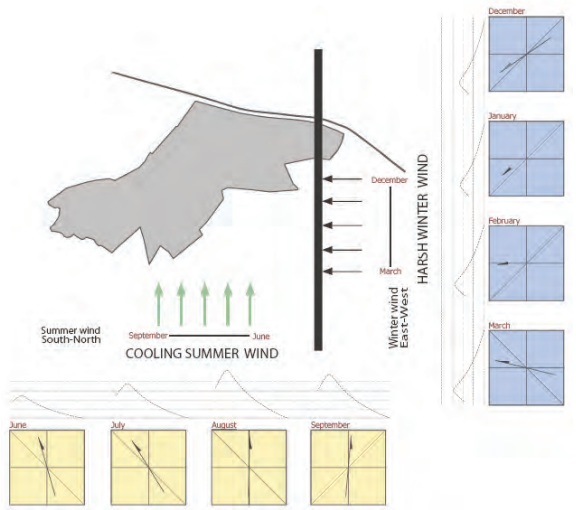
Quadrangle design concept

The arrangement of campus buildings reflects AUIS's ideals: support community identity; promote interaction and knowledge-sharing; and provide a secure learning environment. Traditional quadrangles are strong campus identity builders reflecting a secure setting and fostering an atmosphere for learning. Each college is an academic village around a quadrangle connected to the larger university community. The Presidency Building will be the first collegiate building to be constructed on the 180-ha AUIS campus. Located at a higher elevation perpendicular to the naturally sloping terrain, it will be the campus' most prominent edifice.



Sunshading and wind control analysis diagram

The prevailing summer wind in Sulaimani is from the south, in the winter months a seasonal wind called 'Reshe Ba' (or 'Black Wind') blowing from the east causes temperature drops and carries dust and pollutants that create inhospitable outdoor conditions. Reshe Ba can also occur in the summer months, causing local temperature to rise. Design planning shielded outdoor areas from the Reshe Ba phenomenon and maintained a comfortable pedestrian environment year round.



Wind analysis diagram

Sulaimani's high mountain desert climate has four distinct seasons with very hot summers and cold winters. Horizontal sun shading devices on the south face of the buildings will dramatically reduce heat gain in the summer months when the sun's angle is high, and absorb heat from the winter sun when the sun is low.

1 The campus central quadrangle
2 School of Arts and Sciences facade elevation

Disi-Dubaydib

A water Conveyance Scheme for Amman

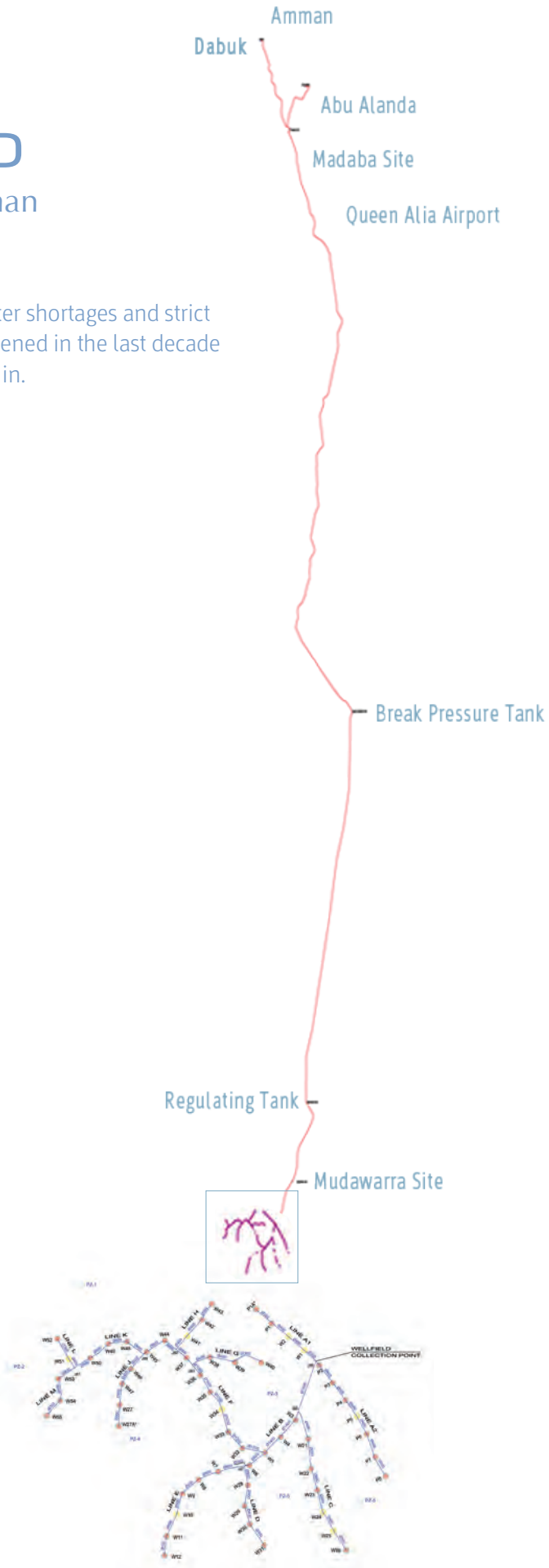
by Sirine Maalouf, R&E

Greater metropolitan Amman has been plagued with water shortages and strict rationing for over twenty years, the situation having worsened in the last decade with the city's latest wave of regional immigrants settling in.

The Government of Jordan and the Ministry of Water and Irrigation (MWI) have joined forces with DIWACO, a Jordan-registered subsidiary of GAMA –a Turkish company with extensive experience in BOT infrastructure projects –, to solve Amman's water needs and alleviate over-extraction of existing wells.

The project first envisioned by MWI and WAJ (Water Authority of Jordan) will convey 100 MCM (million cubic meters) of water annually from the Disi-Dubaydib wellfield (325 km south of the city) and provide emergency supply to four communities along the route. In a region where water is a scarce commodity, the Government of Jordan's decision to move ahead with the project will answer a vital need for a number of deprived communities. The 3.5 years design and construction period is the first phase of a 25-year BOT project, an initiative into partial privatization of large infrastructure schemes. The $1.0 billion financing is mostly funded by MWI, with additional loans from EIB, AFD, PROPARCO and OPIC. Contracted by GAMA EPC, Dar Al-Handasah is carrying out the project's detailed design from an existing initial concept and developing an Environmental and Social Management Plan. Construction works are now underway.

Starting at the Disi wellfields (55 wells), the water conveyance scheme includes in addition to the initial well collection pipelines, about 350 km of conveyance pipes with associated pump stations, tanks, chlorination stations, surge vessels, cathodic protection, conveyance monitor and control system and all necessary ancillaries. The system is designed to meet MWI's 100 MCM Amman water needs with a 7 MCM (7% redundancy) additional system capacity to compensate for any interruptions or repair and maintenance downtime. Residents of Amman will receive a potable quality of water superior to what they currently have because of the initial good quality of the water at the source and the system's overall disinfection strategy.



The Disi-Dubaydib water conveyance scheme and wellfield layout at Disi

The conveyance system

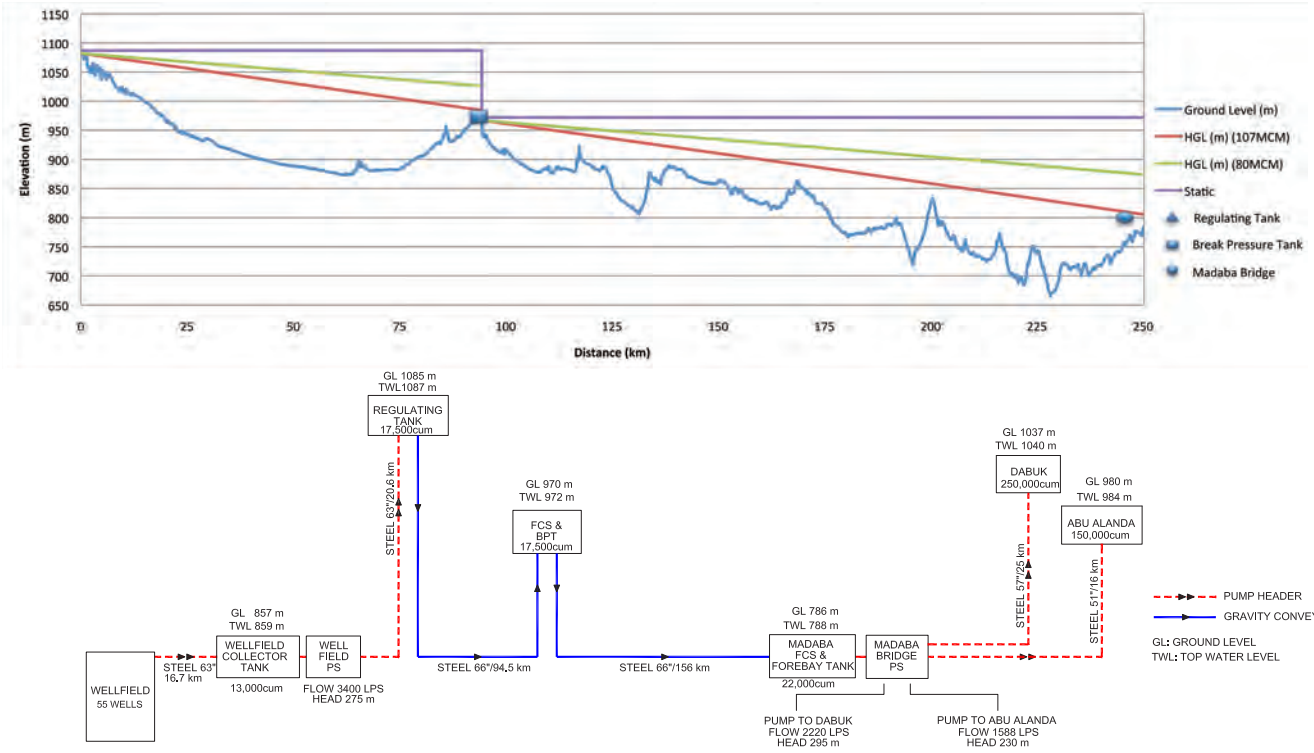
Forty-six monitored wells with 9 additional stand-by wells (open hole or screen completion method depending on ground conditions) at 70 l/s capacity within the Disi-Dubaydib aquifer will supplement Amman with an uninterrupted 100 MCM potable water. The location of these wells was determined by MWI based on SWK regional study of Disi-Rum aquifer based on a 100 MCM supply over 50 years of project operation. Depending on each well's characteristics (location, water level at the well and expected drawdown), different pumphead types will be used for the 55 pumps with a maximum discharge lift of 250 m. The wellfield includes about 80 km of collection piping with diameters between 300 and 1600 mm (ductile iron and steel).

A collector tank is positioned 17 km north (downstream) of the wellfield. The location of the tank was optimized to allow the conveyance of water further north with no additional pump head or pipeline pressure rating increase. Four 850 l/s @ 275 m head pumpsets (plus one stand-by) will lift the water from the collector tank to the regulating tank through a 63" steel header.

An alignment adjustment was introduced to lower the regulating tank's elevation from 1120 m (proposed in the initial concept design) to 1085 m which reduced the maximum working pressure along the 95 km conveyance route between the regulating and the break pressure tanks by 4 bars and made possible the use of lower class pressure pipe, reducing cost and decreasing pumping head at the wellfield pump station.

The break pressure tank along the gravity conveyor (between the regulating tank and Madaba Pump Station) 95 km north of the regulating tank lies at a 970 m elevation. This particular location conformed with flow requirements at the same time reducing the regulating tank's static head over the 156 km to the Madaba Bridge which allowed a reduction of the pipe class along this stretch. The conveyance pipes (66" diameter steel pipes) running downstream of the regulating tank allow a gravity flow to Madaba Bridge at which point pump heads fulfill the lifting of water to the new 1037 m Dabuk and 980 m Abu Alanda reservoirs feeding Amman. A forebay tank is proposed at Madaba Bridge, upstream of the pump station to Dabuk and Abu Alanda. A flow control station is also proposed upstream of the forebay tank to reduce residual pressure resulting from low flows in the systems. These stations consist of three flow control valves 750 mm diameter each with an additional stand-by valve with isolation valves upstream and downstream of each flow control valve. A similar flow control station is designed upstream of the break pressure tank.

Four 555 l/s @295 m head pumpsets and four 397 l/s @ 230 m head pumpsets will lift the water from Madaba Bridge to Dabuk and Abu Alanda respectively (a 5th stand-by pump is provided for both pumping sets) through steel headers 57" and 51" diameter. Dabuk and Abu Alanda's reservoirs will receive a 60%-40% share of Disi's water flow (with additional 10 MCM capacity each to meet MWI's flexibility requirements). Two new reservoirs proposed in Abu Alanda (total capacity of 150,000 m³) would be constructed adjacent to the existing 12,000 m³ reservoir that is now insufficiently feeding Amman's distribution network.



Conveyance scheme design and hydraulic gradeline from the regulating tank to Madaba

The recommended surge protection strategy was determined following a segmental surge analysis providing flow to the system and at the same time cushioning any positive wave after a closure within the system. A surge vessel (isolated from the system during normal operation) is envisaged to perform the necessary surge maintenance. As part of best options exploration for the entire project, MWI requested Dar investigate the possibility of locating the pump station at Muntazah instead of Madaba Bridge and combining flows from Zara's main 1200-mm diameter conveyor with a capacity of 40 MCM/year with the Disi water from Muntazah to Abu Alanda.

The study concluded that such a scheme would require an increase in the gravity pipe section. Furthermore, since the 1200-mm pipe between Muntazah and Abu Alanda is already under construction, combining the two flows will require the installation of a parallel line suitable to convey the total 80 MCM/year; the single pipeline and the provision of additional pumping sets at the congested Muntazah site were not a good option. The surveillance strategy adapted for the conveyance system centralizes monitoring of all mechanical and electrical systems in Madaba Command Central with peripheral control panels along the scheme's critical points. It uses the Supervisory Control and Data Acquisition System (SCADA) to manage the entire system based on a four-level architecture with automatic and manual control and backups. Field devices are linked by fiber-optic cables to SCADA's logic controllers and it is where instructions for the automation of the field devices, such as pump control logic are located. Operator Workstations and Network Peripherals will be LAN-connected.

Disi-Amman water conveyance scheme ushers a new management approach for Amman's precious water resources that is poised to tap into a vast resource of clean, economical and sustainable hydro-plan.

Unloading first pipe shipment

Airfield Pavement Overlays

evaluation of reflective cracking potential for airfield pavement overlays by finite element method

by Nadim Haddad, GHCE

The evaluation of reflective cracking failure potential of asphaltic concrete overlays at the location of existing joints (or cracks) in the concrete pavement underneath is a complex issue that is still not adequately covered in design manuals and technical literature. This prompted Dar's GHCE pavement design team, led by Nadim Haddad, to carry out a comprehensive study and develop a means to understand and evaluate this important factor by utilizing the latest techniques and numerical methods. This article summarizes the findings presented to the 2nd European Pavement Workshop 2009, for the Information and Technology Center for Transport and Infrastructure (CROW) held in Amsterdam. CROW is an organization for engineers and industry experts concerned with the development of pavement technology and its application to airports.

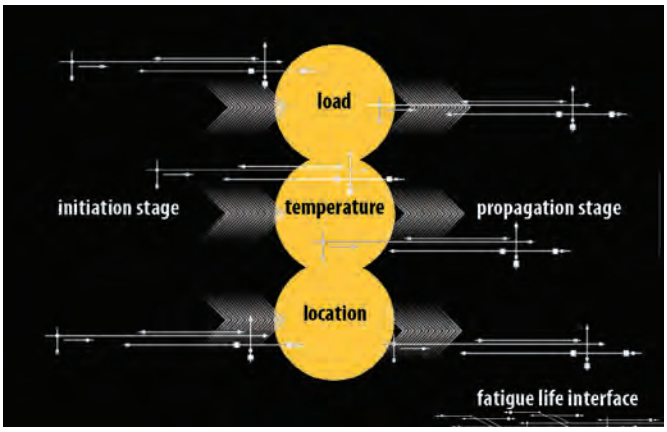
Airfield pavement rehabilitation is a substantial field of work for a generation of aging runways and taxiways around the world. Most pavement design techniques provide procedures for obtaining the thickness of Asphalt Concrete (AC) overlays over existing concrete pavements based on measured residual fatigue strength of existing pavement and the required strengthening an overlay can provide to withstand future traffic. The potential for reflective cracking in the asphalt overlay at the location of concrete joints is generally overlooked or at best simplified by providing a 'safe' overlay thickness that can withstand the reflection of cracks for a certain period of time. Additionally, most computer programs for pavement mechanistic design are more suited to flexible pavement design than composite pavements. This paper is an attempt to evaluate the behavior of overlays and reflective cracking at location joints through FEM (Finite Element Method) techniques using the ABAQUS™ software.

In airfield overlaid pavements at locations of transverse joints, the occurrence of reflective cracking is due to a combination of Modes I and II Cracks. Crack propagation starts when the initiated crack travels through the asphalt layer up to the top surface. This phenomenon is temperature and load-dependent and can be estimated according to the forces applied on the pavement structure. Reflective cracking can therefore be evaluated by constructing a 3-D finite element model to simulate the material properties of AC overlay over the existing rigid pavement and all possible wheel loading positions. The 3-D model various interface conditions, joint horizontal and vertical movement, loading positions, load configurations, climatic conditions, asphalt thickness are all considered to study their impact on the design of the AC overlay system.

The results

The crack initiation stage of perfectly bonded overlays, as revealed by the results of the sensitivity analysis with different interface condition, almost immediate as the crack in the overlay is induced straight above the existing joint because of the high tensile stress generated at the interface at this location–an important finding of the study confirming the theoretical behavior of reflective cracking and its relationship with the interface conditions. For pavement designers, the evaluation of the interface and its effect on the crack behavior is important to optimize the thickness of the asphalt overlay.

The results of the model with different loading positions quantify the difference in strains between corner loading and edge loading conditions (the ratio between the two is about 1.06)–a finding that corroborates design is adequate for all loading conditions.



Fatigue life interface

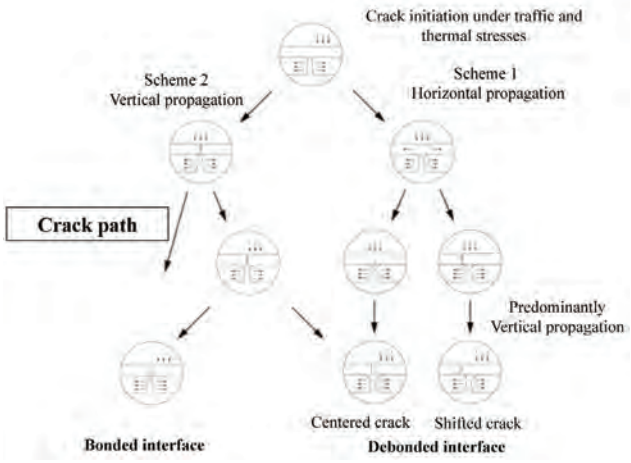
The fatigue life of asphalt can be divided into two stages: Initiation Stage and Propagation Stage. Reflective cracking is caused by the fatigue of asphalt pavement due to stresses induced through cyclic, thermal, and traffic loading. Crack propagation starts when the initiated crack travels through the asphalt layer up to the top surface.

The single wheel configurations, resulting from different loading configuration testing, proved to be more damaging for pavement layers over a joint, but dual wheel configuration should not be ignored for the estimation of the interface tension force. Quantification of the interface tension force is essential for the design of the Stress Absorbing Membrane Interlayer (SAMI), which is usually placed between the existing concrete pavement and the new AC overlay to enhance its performance.

When considering different AC thicknesses, strains in AC overlay are nearly constant over an AC thickness between 6 and 20 cm but decrease at a non-linear rate when the AC thickness exceeds 20 cm. Stresses in PCC (Portland Cement Concrete) are nearly constant over AC thicknesses between 6 and 15 cm, but decrease at a nearly linear rate when the AC thickness exceeds 15 cm. The results in Cement-Treated Base layer show that stresses are nearly constant over AC thicknesses between 6 and 20 cm, but decrease at a non-linear rate when the AC thickness exceeds 20 cm. At the surface of interface between AC and PCC layers, the tension forces increase with greater AC thickness up to 35 cm, at which point the force variation follows a mild slope with thicker and stiffer AC layer, as predicted. As the interface between PCC and CTB layers is assumed to be nearly smooth, the resulting tension forces are very small (in the range of 0.80 to 1.0 kN).

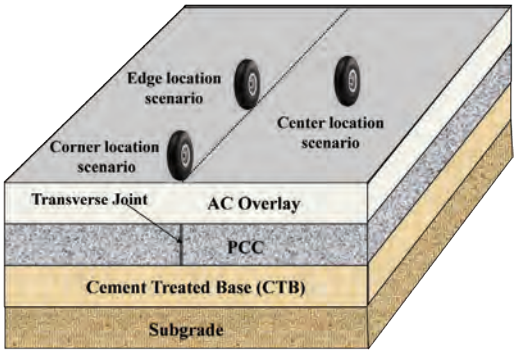
The purpose of this paper was to propose a specific FEM model that pavement designers can use as an effective tool to model the actual behavior of asphalt overlays over existing concrete pavements; and to evaluate the impact of the various climatic, loading, and interface conditions on the overlay system, thereby optimizing the overlay thickness and the type and quality of the required stress absorbing interlayer.

For additional information the technical paper and presentation are available at http://www.crow.nl/engels/_t0_p0_m7_i6538.htm.



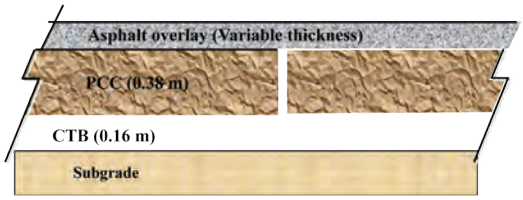
Crack initiation under traffic and thermal stresses

The location of stress is an important factor in the initiation stage while the interface conditions play a more important role in the propagation stage.



FEM 3-D model description

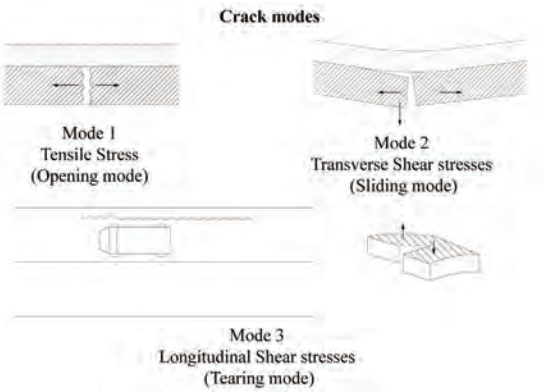
The Finite Element 3-D model usuing ABAQUS™ to evaluate the stresses and strains at the bottom of the asphalt concrete overlay under specific geometry, interface, load and climatic conditions.



Gap-adjusted to model the actual load transfer efficiency 'LTE' factor (~40%)

A significant factor in the model is the actual load transfer efficiency between the existing joints of the concrete pavement. Such a factor can be measured on site by testing but cannot be modeled because 3D models either consider a continuous structure (i.e. Load Transfer efficiency LTE of 100%) or a discontinuous structure (i.e. LTE of 0%): they cannot allow an intermediate LTE Value (between 0 and 100), which is what is encountered on site.

This software limitation was overcome by creating a special model with a virtual gap between the slabs then adjusting the width of the gap to mimic the actual load transfer efficiency (as measured on site), allowing evaluations of the critical strains at the bottom of the asphalt layer over the joint at the actual Load Transfer Efficiency provided between the concrete slabs.



Crack mode failure

Reflective cracking can follow one or a combination of the following three modes of failure

- Mode I Crack – Opening mode tensile stress normal to the plane of the crack
- Mode II Crack – Sliding mode shear stress acting parallel to the plane of the crack and perpendicular to the crack front
- Mode III Crack – Tearing mode shear stress acting parallel to the plane of the crack and parallel to the crack front

Load Configuration	Results					
	AC Layer		PCC	CTB	Subgrade	Interface AC/PCC
	E hz. bott (*10^{-6})	E pr. bott (*10^{-6})	pr (kPA)	pr (kpaPA	E vert. top(*10^{-6})	Tension (kN/m)
Config. 1	305	350	1582	469	405	11.65
Config. 2	280	357	1516	527	451	12.85
Config. 3	210	255	1312	521	450	14
Config. 4	207	225	819	461	401	12.5

Results for models with different load configurations

The results show that for AC layer, Config.1 gives maximum horizontal strain whereas Config.2 gives maximum principle strain. In addition, Config.1 gives maximum principle stress in PCC layer whereas Config.2 gives maximum principle stress in CTB layer.

Config.3 gives the maximum tension force at the surface of interface between AC and PCC layers. This means that single wheel configurations can be more damaging for the pavement layers over a joint but the dual wheel configuration should not be ignored for the estimation of the interface tension force.

Variation	AC Overlay (cm)	Wheel Load (kN)	Loading Position
Interface Cond.	16	274	Middle of the Edge
Loading Config.	16	210	Variable (2 cases)
Loading	20	274	On the Edge
Climatic Condtions	Variable	274	Middle of the Edge
Asphalt Concrete	Variable	274	Middle of the Edge

Results summary

The 3-D FEM tool was found useful to quantify certain parameters that affect the design AC Overlay over the existing jointed concrete pavements. Results clearly show the effect of transverse joints with low Load Transfer Efficiency on the fatigue life of AC overlay. The boundary conditions and material properties play an important role in the resulting strains.To get realistic results, attention should be paid for such boundaries, among these are the interface conditions between different layers, material properties, in situ thicknesses of different layers, load configurations, etc.

The results from the available linear elastic computer programs indicate that failure due to traffic loading is mainly anticipated in the PCC layer, while this study indicates that failure can well be in the AC layer due to the consideration of the reflective cracking potential and the possible vertical and horizontal movements at the existing joints. This is because linear elastic computer programs assume full bonded layer conditions, thus resulting in compressive strains in the AC overlay which does not represent the actual potential of failure in the AC Overlay. These programs assume no movement at location of joint which is also another unrealistic assumption. These two obstacles are reasonably overcome by the FEM Method of analysis.

In the examples given, the results of the 3-D Finite Element Model confirm the critical tensile strains in the AC Overlay while the resulting stresses in the PCC and CTB layers do not seem to cause any concern of failure in these layers. The vertical strains in the subgrade are also not critical.

The importance of applying the 3-D Finite Element Method lies in the accurate assumptions that are plugged in the model and should be based on a reliable and accurate pavement evaluation survey. This is specifically emphasized in the input of the Load Transfer Efficiency at the joint and the interface conditions.

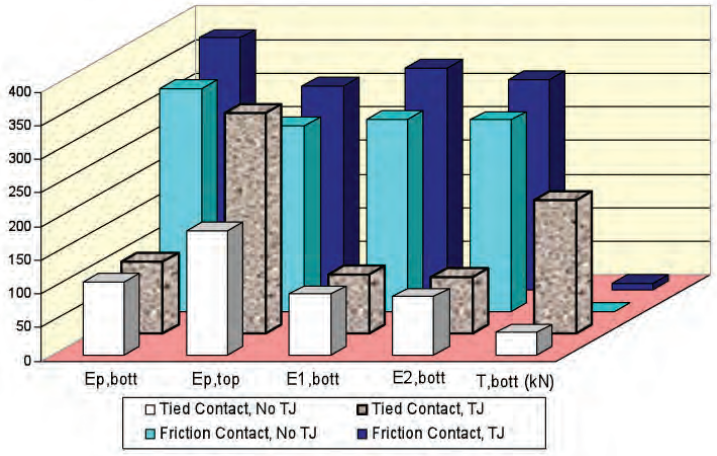
The success of applying the proposed approach is also function of closely respecting the construction specifications and quality control measures during execution. It is not good to quantify the tensile stress at the interface and place the overlay directly over the concrete without providing the required interlayer system (SAMI) that can take the computed stresses adequately and safely. Similarly, assumptions on bonding conditions between the overlay and the existing concrete need to be verified during execution, through testing, to confirm the validity of the assumptions that were taken in the FEM Model at the design stage.

Strain in AC Layer	Corner Loading	Middle Loading
Hz. E1 (*10-6)	227	215
Hz. E2 (*10-6)	196	187
Max. Epr. (*10-6)	242	228

Results for models with different load positions

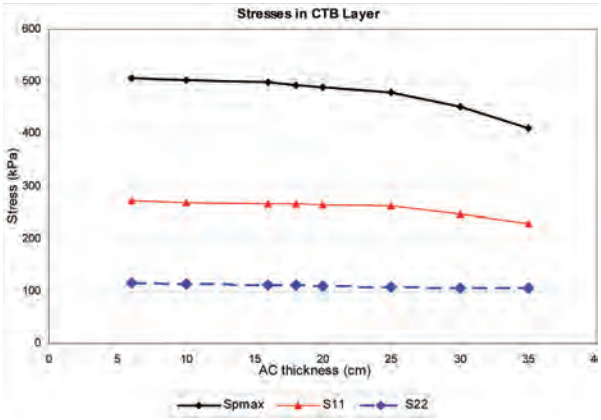
The results are for an AC overlay of 16 cm thickness with two different load cases; wheel load of 210.0 kN is applied first on area over the corner and second on area over the middle of the edge.

Interface AC/PCC layers is frictional contact with coefficient of friction (F) =1.0 and interface PCC/CTB has a coefficient of friction =0.10 to simulate smooth interface conditions. The results of strains in AC layer show that strains resulting from corner loading are greater than those due to edge loadings. The ratio between both is 1.06.



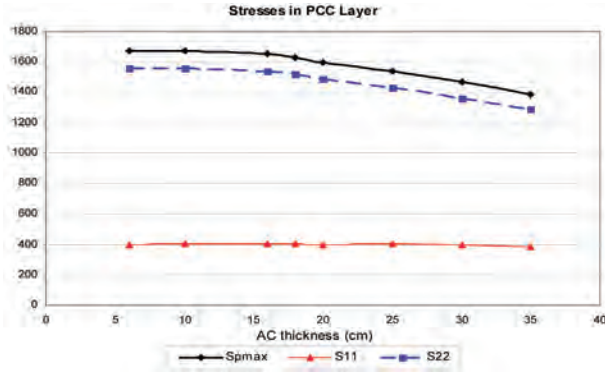
Strains in AC layer and tension force at AC/PCC interface, model with different boundary conditions

The results of strains in AC layer; 'Ep,top' principle maximum strain on the top, 'Ep,bott' principle maximum strain at the bottom, 'E1' horizontal strain parallel to the direction of travel, 'E2' horizontal strain perpendicular to the direction of travel, and the tangential contact force 'T,bott' between AC and PCC layers. The results illustrate that the models without transversal joints (models 1 and 3) have lower strains than those with TJ (models 2 and 4), due to continuity. Models with full bond (tied) contact (models 1 and 2) have a much greater tension force at the surface of interface between AC and PCC, than models with frictional contact (models 3 and 4). This probably explains why the crack initiation stage of perfectly bonded overlays is almost immediate as the crack in the overlay is induced straight above the existing joint because of the high tensile stress generated at the interface at this point.



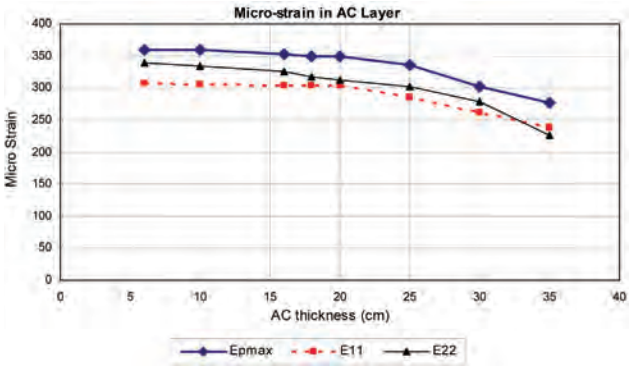
Stresses in CTB against AC thickness, dry season

Stresses are nearly constant over AC thicknesses between 6 and 20 cm, decreasing at a non-linear rate when the AC thickness exceeds 20cm.



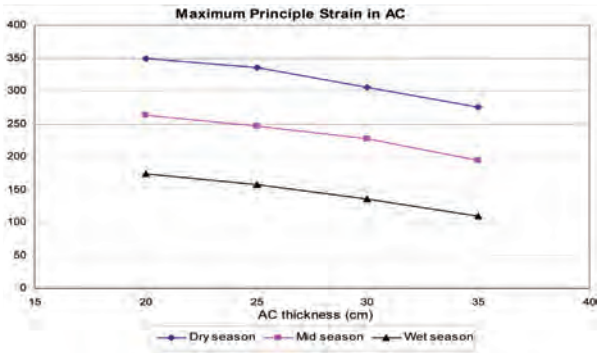
Stresses in PCC against AC thickness, dry season

Stresses are nearly constant over AC thicknesses between 6 and 15 cm, decreasing linearly when AC thickness surpasses 15 cm.



Strains in AC against AC thickness, dry season

Strains in AC overlay are nearly constant over AC thicknesses between 6 and 20 cm. However, the strains decrease at a non-linear rate when the AC thickness exceeds 20 cm.



Strains against AC thickness for 3-D model with different climatic conditions

A wheel load of 274.0 kN is applied on AC layer with different configurations regarding the position of TJ in PCC.

Site Safety: A Consultant's Concern

How Dar is part of the effort for improved site conditions

As construction in Dubai is pressing on at a more regular pulse after the frantic 'boom' years, local authorities and the construction industry are taking a serious look at safe and efficient site conditions. Site safety is not only good business, but also good for the environment.

Save the global economic downturn and the deliberate local authorities' direction to revisit some of the more ambitious projects, Dubai still boasts around 20 percent of the world's cranes and the largest number of workers, engineers, specialists and supervisors actively populating construction sites. Dubai's famed Palm Trilogy project and the newly renamed Burj Khalifa, the world's tallest structure for the next 5 to 10 years, are but two of the most talked about projects having set-off a revolution in architecture and engineering design. Such projects made what could once only be dreamt up on the drawing boards suddenly become achievable.

The initial thrust and excitement that accompanied the early developments and the desire to have projects lift-off the ground at astronomical speed led contractors to hire scores of unskilled labourers or follow unorthodox construction practices. Meeting design revisions and developers' soaring expectations put an enormous strain on site safety conditions. But according to one watchgroup connected to Health, Safety and Sustainability issues, "Despite the unusual conditions, Dubai standards improved at a faster rate than the West improved their safety standards from, say, the 1950s through to the 1990s." Implementation of site safety guidelines makes financial sense for Dubai, according to a recent study on the costs of site accidents in the Emirate a single site fatality could suspend construction for up to 2 days and run a tab for investigation, potential litigation, and workman compensation that can go as high as AED3.7 ($1M) and that is for just one worker.

A lot of energy and resources at Dar (design and site) go to promote site safety conditions in our projects. Set against lengthy site safety infraction reports on some of Dubai's biggest construction sites, there is the satisfaction that our diligence is not wasted. Our site engineers implement Dar's project management and supervision manuals, review all contractors' safety plans and follow up on their compliance. All our specifications and contract documents require contractors to follow international standards and codes and Dubai's local laws and labour regulations in addition to submitting conservative and detailed safety plans, risk assessment and mitigation measures. In fact, we have gone as far as literally stopping works – project clock ticking – in instances of observed unsafe practices. It all started as part of our long-term involvement in the Dubai International Airport when DarDubai developed a safety manual specific for the Airport project that has been adopted in our other Dubai projects including the Marina Tower and the Ibn Battuta site supervision projects.

The imperative for site safety conditions was combined with a decree by Dubai's ruler Sheikh Mohammed bin Rashed Al Maktoum (effective January 2008) that all projects comply with sustainability rating standards. EGBC is the UAE council on green building practices equivalent to its American counterpart USGBC, the independent body regulating the voluntary LEED rating system for construction environmental compliance. EGBC's green buildings are designed, constructed and operated over their lifecycle to boost environmental, economic, health, and productivity performance over that of conventionally designed and constructed buildings. The lag in seeing directives translated on-site is partly due to perceptions in the GCC's construction sector that stiffer safety measures will jack up construction costs and since it is "how we used to do it [then] it is still okay". But change is happening as the community is taking notice of what is safe and eco-friendly and what is not. Competitors once vying for sizable projects with undercutting bids are now coming together for a common stake: they are on a mission to swap lessons, set best practice guidelines and work methods in terms of building site safety and environmental site concerns. One such initiative is BuildSafe UAE, a non-profit watch group of local and international developers, contractors, consultants, project managers and service organizations working together for safer construction and working methods across the UAE.

As design and engineering consultants in Dubai for over three decades, our close relation with the region's contractors and suppliers allow us to deliver design strategies that will cut the number of site workers needed by easing the construction process and bringing down cost, all the while reducing construction carbon emission. Tailoring our specifications to allow material ordering to correct standard size from local suppliers has curbed in-situ construction especially in the warmer months and reduced crane-lifts use and construction hazards. Designing insulation systems based on our performance energy models has capped-off construction carbon use and projects' overall energy demands. On the ground, our project management and supervision teams place great emphasis on the health, safety and welfare of the construction team.

A total of 1 million man-hours completed without any reportable accidents were just surpassed on project supervision services for Dar-designed Nakheel's Marina Towers project.

When it comes to budget revisions or timeline adjustments, it is often too easy to overlook site health and a safety issue which makes it our responsibility (with all other stakeholders) to promote and maintain a culture of improved site conditions.

Made in China

by Sari Kalakesh, PMC

With increased construction demands to meet modern living standards and a dire need to curb energy consumption (95% buildings in China are counted as high energy-consuming), the construction industry in China has suffered from severe over-consumption, over-pollution and over-sourcing. Corrective measures by a resourceful construction industry seeking practical solutions to achieve the dual purpose of improved building performance and simplified constructability were soon put in motion

Prefabricated buildings, also known as assembly-type housing technology, are one such solution: a building made out of several factory-built or pre-engineered components or units that are assembled on-site. Introduced in 1994, they now surpass conventional construction methods in time-saving, cost-cutting, energy and pollution-reducing. Shrinking both schedules and resources and standardizing residential construction and operation, this new industrialized construction method relies heavily on coordination between all relevant trades. And, while conventional building projects suffer from subcontractor delays, scheduling conflicts and inclement weather the major advantage of pre-fab buildings is that design and production take place within the same facility.

Standardized pre-fab construction is designed to be highly efficient assembly-line production delivering elements in multiples. Manufacturers purchase material in bulk and units are factory-produced in typical controlled production-line environment. All elements including concrete samples are then inspected and tested as they roll off the assembly line. During the building process, raw materials are not exposed to the elements and theft has been virtually eliminated. With the added-value of enhanced design flexibility and sturdiness, modules and certain components are built and reinforced to withstand high speeds, bumpy roads and crane-lifting stress.

Composite materials are for the most part used to produce pre-engineered components for residential (single housing or building), factory, bridge and other infrastructure modules, either wholly or partly. Composite materials can be used with conventional construction materials in exterior cladding panels, roofing, ceiling, balconies, door and window frames, cabinets and storage tanks; structural elements (columns and beams) end up to be essentially the only elements cast in situ. Attachment between the structural elements and the prefabricated components is via anchoring steel bars embedded in the pre-fab element to form a cohesive unit once concrete is poured. To prevent the embedded anchoring steel bars from forming an obstruction for the column's steel bar and to simplify the hoisting process, a coupler is embedded in the column for the lapped joint.

Market growing demand

Prefabrication finds readiness in low-cost housing and other projects where price is a major consideration with most cost-reduction achieved in foundation, scaffolding, shuttering and undoubtedly in labor. The myriad of pre-fab elements on the market today are a clear indication of the umbrella of new specialized suppliers furnishing the market. SCG (Shanghai Construction Group with its chain of subsidiaries) claims credit for having pioneered the rising spread of prefabricated housing construction in China. In February 2007, it launched Xin Li Cheng Project, completing the first assembly-type structure residential project in Shanghai. The company, crediting itself with being the first to recognize the importance and future of pre-fab projects, considers Xin Li Cheng to be a landmark project setting off a housing industrialization explosion in Shanghai. Following Xin Li Chen, assembly type RC structure projects mushroomed around the city with such projects as Block W6-3 and W6-5 of San Lin Town Project and Xin Lin Cheng Block B04 PC Project adopting the innovative method.

Going green

With growing global environmental concerns, China (like many other nations) is engaged in research to make prefabricated construction more economical and environmentally responsible. Naturally occurring material or natural fiber composites (NFC) like bamboo, flax and jute are being tried out as pallets, boards, sheets and other forms for use as partitions, facades, flooring, roofing and fencing, among other things. Research and advances have made it possible for pre-fab building materials to mimic masonry, timber, marble and a variety of other items used in conventional construction satisfying aesthetic and practical considerations.

All be it too early to think of prefabricated components as completely edging out traditional materials like bricks, concrete, wood, iron and steel, advanced technology and an increased awareness of the advantages and a surprisingly enthusiastic receptiveness across the industry are jacking up demand for pre-engineered products and assembly-type construction.

Sari was part of a team from the Project Managment & Contracts Department to visit construction sites in Shanghai, part of a series of workshops conducted by the Department.

Images part of DarDubai Projects Collection (Palm Jumairah Marina Towers and Dubai International Airport entrances and approaches)

An Offshore Platform

for APC's new generation pumps

by Elie Ghorayeb PE, Structural

Following 'Mining the Dead Sea', a feature article in our last issue about Dar's intake pumping station (PS3) design for the Arab Potash Company's third generation pumps, we were hard-pressed to take a closer look at the PS3's jetty and platform design from a structural perspective. This follow-up article delves in greater detail into PS3's jetty and platform design and construction.

Piles being eased into the water then tugged to their location and crane-lifted into position

PS3 's bigger and more powerful pumps designed to meet APC's ultimate 305 Mm^3 annual brine extraction and their location 269 m inside the Dead Sea at an elevation of minus 44.5 m depth below sea level together with an aggressive earthquake zone (categories D for elastic and E for inelastic analysis –IBC Code) translated into a series of design challenges for the structural team. The 269-m long jetty approach consists of a 10-m wide access road and an adjacent mechanical saddle (spaced 18 m apart) to support twin offshore brine intake pipelines (2 m each in diameter). The jetty is designed to withstand the loads of a 70-ton(installation and maintenance) mobile crane and its 50-ton lowboy trailer. The jetty approach ends with a 65X27 m pump platform housing in addition to the four large pumps, a 350-ton lifting capacity crane, brine pipes, several equipments, a two-level control room and several 12-m high lighting masts.

A structural design

The 65X27 m steel offshore platform consists of main built-up girders in the transverse direction bolted on steel pile caps. Secondary girders running in the longitudinal direction and bolted to the transverse beams hold the 2000-ton steel platform made of high strength steel (50KSI). The platform itself is supported on circular steel piles 1067 mm and 914 mm in diameter filled fully or partially with reinforced concrete to provide stability and prevent overturning. Shear studs inside the piles ensure composite action. The piles driven deep into the soil are designed to withstand all platform and approach loadings.

Piles and decking

The circular piles are made from a high strength steel material [50KSI]; they are spirally welded, 100% tested and then coated with one epoxy coat and two coal tar epoxy coats at the fabrication shop. Strengthening shoes are provided at the bottom to alleviate stresses on the weld due to hammering action.

Environmental loads

- Environmental loads are loads due to wave, current, marine growth, wind, earthquake and sea bed movement.
- Temperature loads (T = 30°C)

Stability of the structure

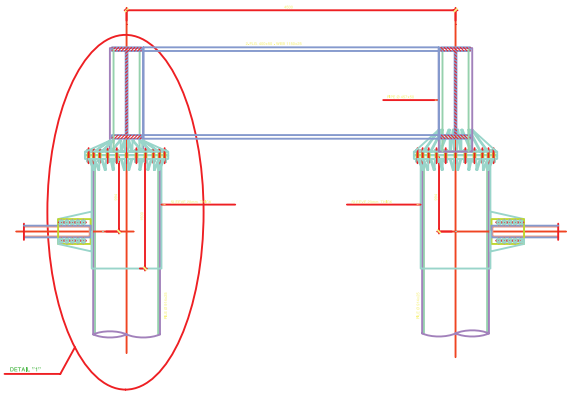
- Raked piles for transverse stability
- Horizontal diaphragm truss resting on racked piles for longitudinal stability of the platform
- Raked piles and horizontal diaphragm trusses for longitudinal stability of the platform area
- Raked piles at main frame and between expansion joints are provided for the jetty approach

Load combinations

- Total number of static load combinations is 396
- Total number of dynamic load combinations is 28

Special considerations

- A specialized finite element software was used to analyze the structure (SAP-offshore module).
- Extensive dynamic analysis was performed to ensure that the natural frequency of the system supporting pumps is outside the applied frequency by a minimum of +/- 20% resulting in the usage of a very stiff framing plan under the pumps. This was needed to avoid resonance and to ensure a life time of smooth operation.

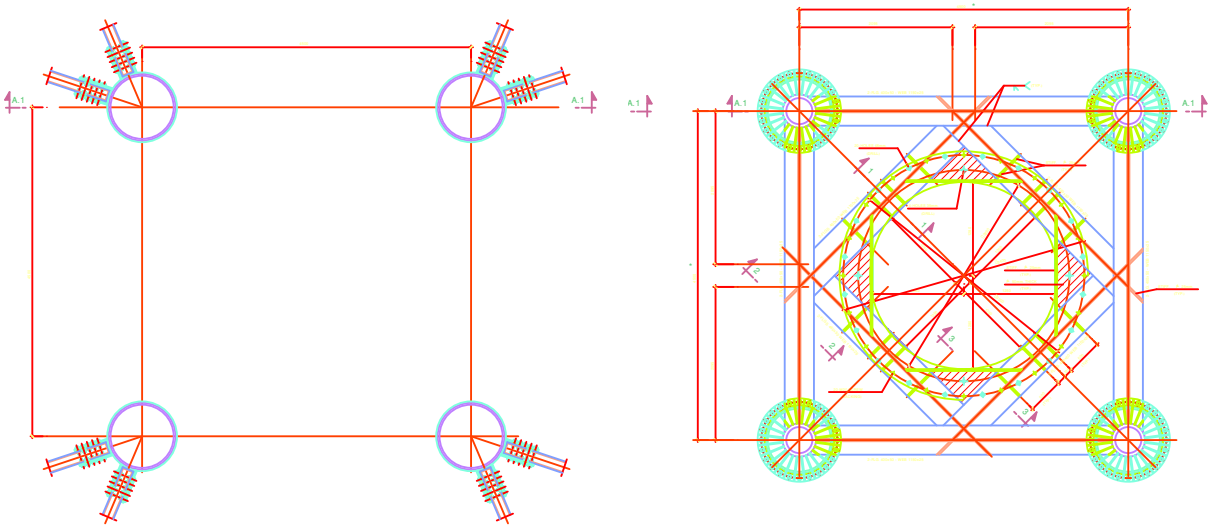


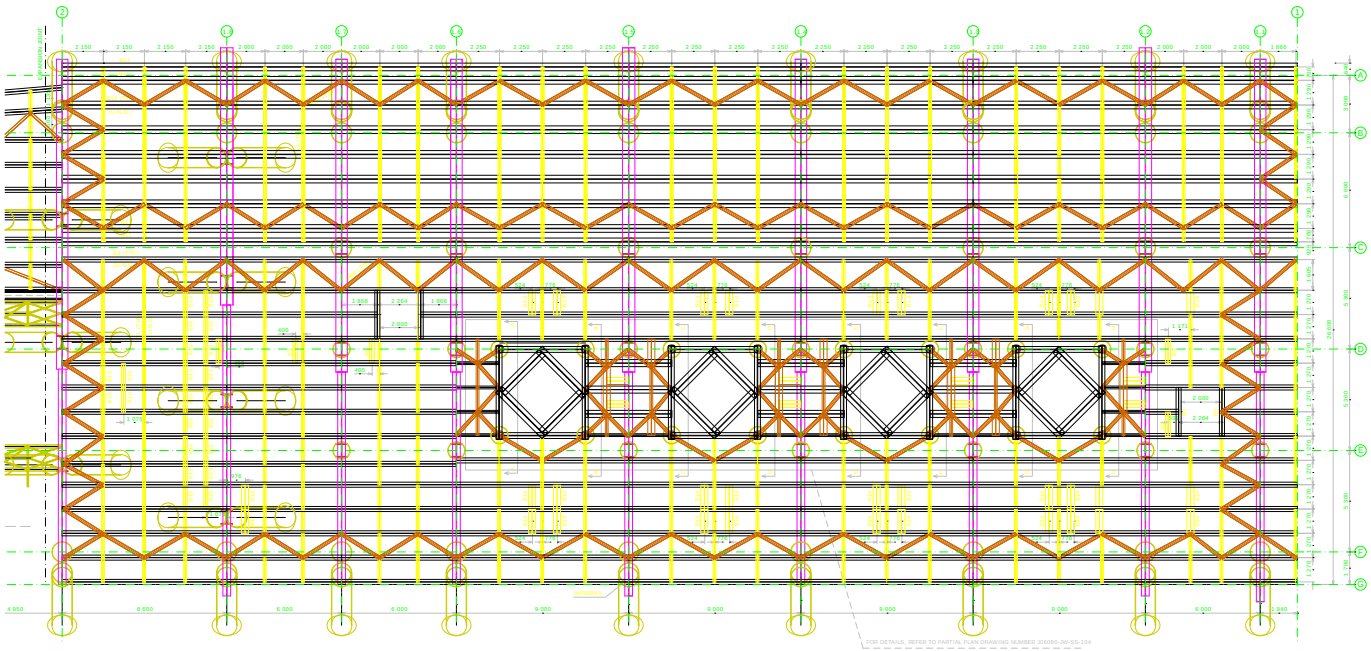
Jetty Approach

- Total number of piles = 109
- 67 Vertical piles (914mmX19mm)
- 42 Raked piles (914mmX25mm)

Platform

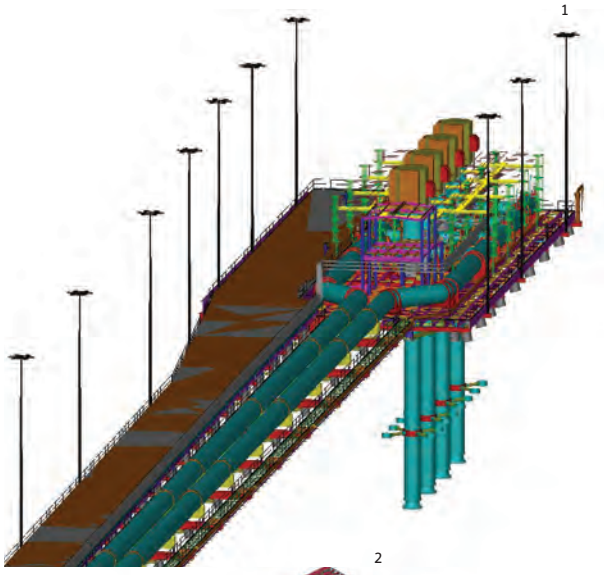
- Total number of piles = 87
- 30 Vertical piles (914mmX25mm)
- 25 Vertical piles (1067mmX25mm)
- 32 Raked piles (1067mmX25mm)





Top Pump framing and pile section detail
Bottom Platform encasing the four pumps base model

1



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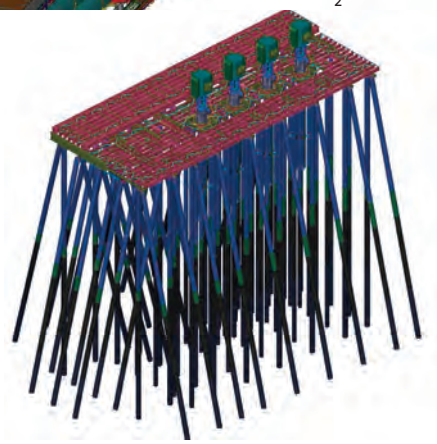

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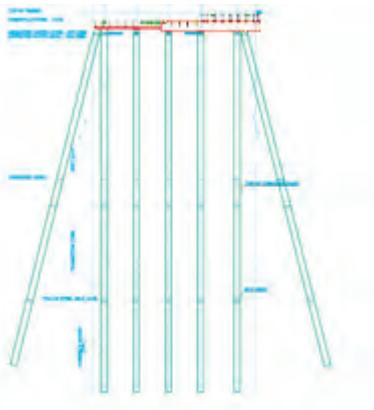


Solid timber decking finish is used for the crane passage and catwalks. The Canadian-imported timber (225 mm thick timber members with a 75 mm wearing course timber on top) treated with inorganic boron (SBX) and re-dried to 15% maximum moisture content will ensure a long maintenance free life. Thick checkered plates (10+2mm) are used around the pumps platform area (both permanent and removable types were used). The removable plates are provided for periodic maintenance work, repair and clean up of the pumps. Lighting requirements necessitated the extension of main steel girders to receive several 12-m high masts. The needed number of piles on the project is 196.

PS3's platform and jetty construction is currently underway with some minor design modifications due to actual soil conditions varying slightly from the assumed design profile at some areas. Structural design was also challenged following the 'out of plumb' final locations of some piles. The soil profile at the Dead Sea Bed is the product of a complex geological process during which various materials were deposited, remolded and consolidated. The multi-layered strata's nature and characteristics at pile location varied with depth (as the platform starts from ground level and extends into the Dead Sea at a depth of -44.5 m). A clay layer of different depth was found in two distinct locations (of 12 m deep at the base of the jetty approach and 3 m deep inside the dredged basin at the platform level). Sandwiched between the clay and the salty rock at some locations the soil profile includes an 18-m deep transitional layer – the bottom salty rock layer mid-transitional sand layer. Piles penetrate the bottom salty rock area 1 m deep affixed to a concrete socket with a length that varied between 5 to 20 m depending on location.

1, 2 Platform and jetty 3-D isometric model
3 Platform and piles section

cultured pearls

Estidama adopts integrated design and extends beyond occupancy

by John Davey, R&E

Abu Dhabi's Urban Planning Council (UPC) has substantially revised its Pearls Design System (PDS) for Estidama with the aim of creating a sustainable approach tailored to the climate, culture, economy and available resources that will inspire good governance and community development in the UAE and beyond.

Building on the aspirations for sustainable development set by Plan Abu Dhabi 2030 and the 2030 Plans for Al Ain and Al Gharbia, the recent review of UPC development and building codes concurrently with permitting procedures allows many sustainable procedures and base level performance criteria to be adopted as regulatory requirements. Hence, from 2010, every new development will be expected to attain a performance level equivalent to 1 Estidama Pearl.

Estidama identifies five elements for the focus of Sustainability: water, energy, living systems, liveable communities/liveable buildings, and stewarding of materials. Two primary PDS Rating Systems are currently available; for New Communities (NC) and New Buildings (NB), with developments having two or more public open spaces, mosques, schools or health care facilities deemed to be communities. The concurrent development of these Systems has afforded the opportunity to logically scale credit opportunities and optimize requirements common to both.

Perhaps the most fundamental change, and perhaps also the most valuable for Sustainable Development, is that all projects have to adopt an Estidama Integrative Design Process (EIDP) from inception to delivery, requiring design charettes, workshops, consultations with the UPC-appointed Estidama Assessor and other design events not only to be undertaken but also documented for submission and approval.

An Estidama Pearl Rating is now granted as follows:

- The Design Rating, awarded at the end of the design phase, concurrently with or subsequent to, but never prior to, UPC planning approval, confirms that the proposed design and technical strategies are consistent with PDS credit requirements; thus potentially offers developers financial advantage with respect to early sales and lease commitments
- The Living Rating is made when a project has reached an established threshold of operation or completion. For New Buildings this is defined as two years full occupation after achieving 80% occupation. For New Communities it is when 25% of the program, measured by number of units, gross floor area, or both, together with corresponding amenities and infrastructure services are complete. Submittal requirements include updated Design Rating credit resubmissions and operational performance data from meter readings, site measurements and occupant/user surveys

On completion of the rating process, scores are converted to an overall percentage and translated to an official Pearls Rating from 1-4 Pearls, 1 being the basic requirement, 2-4 respectively representing 45%, 60% and 75% compliance with credit requirements.

But the revised PDS aspires to do more than simply 'sustain' life. In accordance with the original Arabic context, Estidama, now seeks to help living systems 'thrive'. The 5th Estidama Pearl

is therefore reserved for achievements beyond the commonly accepted standards of sustainability and will only be awarded to those projects that afford a net benefit to human and natural environments. Assessed on the basis of compliance with various key life-cycle performance indicators, including cumulative carbon reduction, the 5th Pearl challenges developers and design teams to create more resources than their projects consumes by adopting strategies such as ecological restoration, life-cycle analysis, carbon footprinting, energy and water generation, and managing the life-cycle impacts of materials. It will not be unusual for a 5-Pearl development to generate more resources than it consumes.

The revised credit requirements not only expand the scope for technical achievement but also provide for addressing important social issues such as equitable development, private outdoor space, indoor and outdoor noise pollution, community benefits in emerging economies and labour practices. Newly introduced technical requirements also highlight longer-term interests such as design for adaptability, design for disassembly and dematerialisation.

The ways in which the world is currently addressing global warming is by slowing down the damaging results of decades of industrialisation. But this is only part of the solution. Greater efficiency may delay the inevitable but will not change the long-term outcome. While cutting carbon emissions and reducing environmental impacts are essential, we must also engage in the restoration and regeneration of living systems and communities to create a healthier planet. The new Pearls Design System for Estidama has great potential to so engage and it to be hoped that all project proponents will embrace it enthusiastically.

Abu Dhabi skyline. Photo credit: © Stefan@ India/flikr.com

Travel Light: The Amman-Zarqa Light Rail System

by Elie Kharrat, Transportation

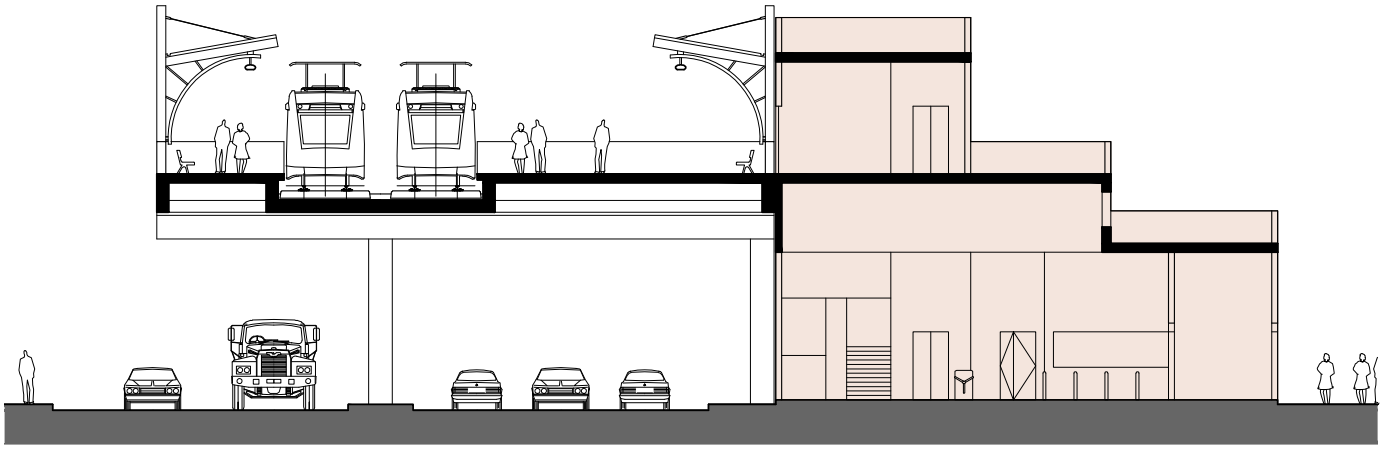
The Hashemite Kingdom's transport policy to reduce road-dependence and create a sustainable long-term transport network, establishing rail routes along busy transport corridors and offering a cheaper and quicker alternative to travel between Jordan's major cities is being translated into a number of vital public transport projects. The Amman-Zarqa light rail is a considerable investment in mass transit with meaningful economic and environmental benefits that Dar has newly signed on to design. The commission includes the design of the infrastructure and rail system components for the Amman Zarqa Light Rail Link up to tender for all civil works, procurement of rail systems and operational equipment supply including rolling stock, for a fully functional Light Rail Transit (LRT) System.

The network under study, based on an existing concept design, provides primary domestic connections from Amman to Zarqa where a depot and workshop are envisaged. With economic development projected along the rail line's station nodes, it is expected that the Amman-Zarqa LRT will bring innovative development, new jobs and significant private investment to the sluggish and arid region separating Jordan's two biggest cities.

The light railway will now be built as a public procurement scheme, after the government abandoned the build-operate-transfer framework it has previously employed. The railway will be Jordan's only passenger rail service.

Railway operation

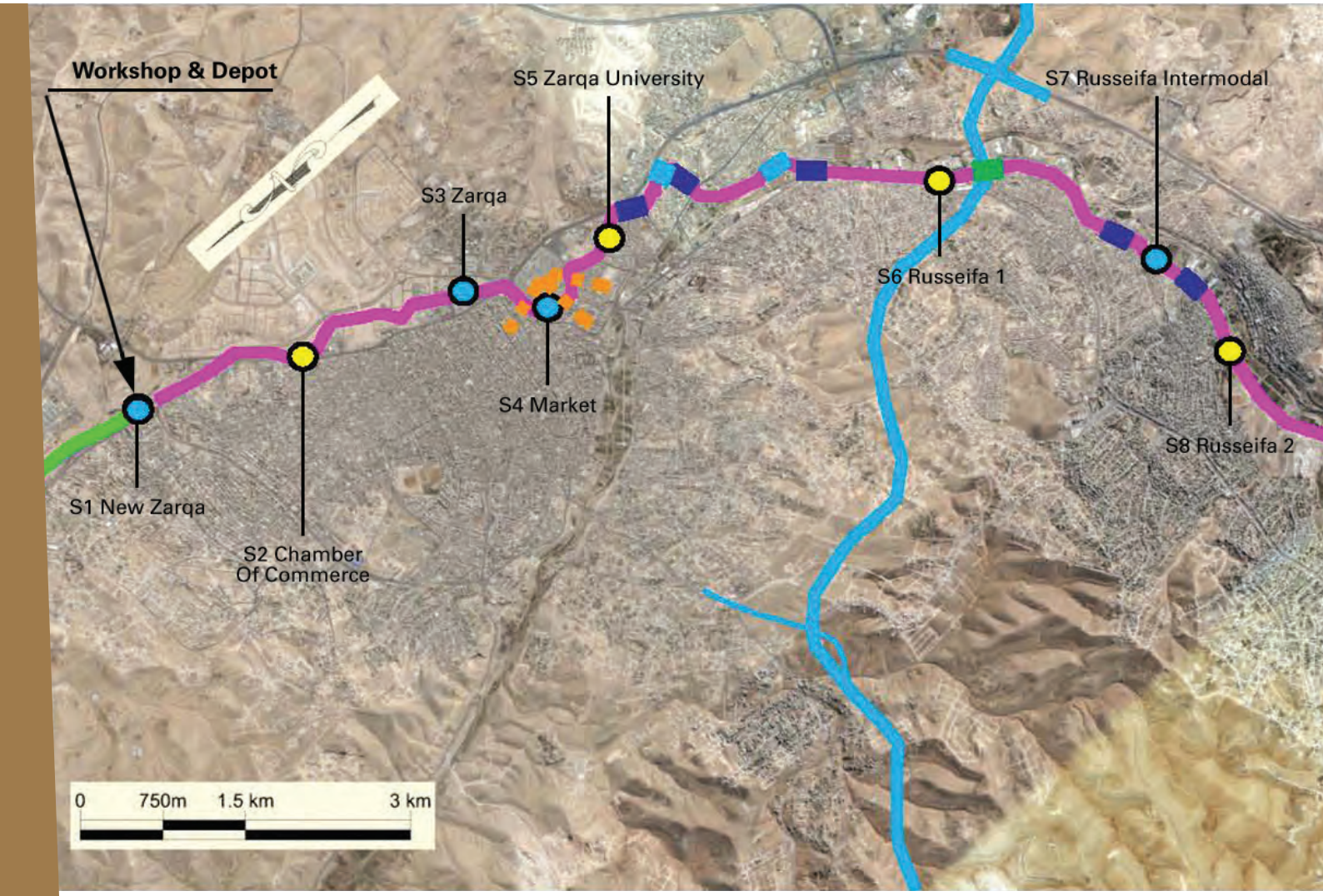
The railway operation will be dual track, electric powered, operating at a maximum speed of 90 km/h. The entire Amman-Zarqa rail network is around 24 km, crossing two different topologies: urban and interurban. With 12 stations as a maximum along the corridor (6 in an initial stage and up to 5 projected depending on demand), 23 km run along the surface on ballast in an existing track corridor while the last kilometer crosses a viaduct and heads to King Abdullah I Street onto the street's reservation. The system stations provide aesthetic and visual integration between the light rail as a transit facility and the



Sample station cross section

surrounding environment where passengers/commuters interact. The system in addition to its attractiveness, will demonstrate reliability, availability, and maintainability (RAM) while ensuring continuous safety and comfort.

Design solutions include a number of structures along the corridor to resolve the crossings of the railroad with the different tracks, roadways and highways. Sixteen grade-separated crossings: two underpasses, seven overpasses, three roadway bridges, the doubling of four existing bridges and the construction of 40 pedestrian crossings will be required.



1 Station interior perspective

With an ultimate capacity greater than 10,000 PPHD (Passengers Per Hour and Per Direction), and a total running time of less than 37 minutes, the Amman-Zarqa LRT system is a step in the right direction towards long overdue efficient transport models in the region.

Jordan's experience demonstrates the importance governments in the region are giving to public transport projects through the investment and resources earmarked for rail projects. The long-term benefits to national business, transport and tourism reaped from launching such projects in a downturn outweigh by a long shot the difficulties and challenges they entail.

2 Station exterior perspective
3 Key Plan (base map courtesy of Google)

Knowledge Economic City, Madinah: A significant new knowledge-based urban development

by David Edwards & Oula Aoun, Town Planning

As part of a meaningful initiative that is being driven by the Saudi Arabian General Investment Authority (SAGIA), under the directorship of King Abdullah bin Abdul Aziz, Custodian of the two Holy Mosques, the 'Knowledge Economic City' will be the third of six 'Economic Cities' that are proposed in KSA. With each city intended to have a unique role and function that is centered on a particular growth sector, KEC has been planned to become the Kingdom's IT and bio-technology hub, harboring such activities as telecommunications, software engineering, renewable energy resources, and bio-science research. Construction is already underway on King Abdullah Economic City (KAEC) in Jeddah, the first of the economic cities, and, it is anticipated that each of the new cities will be operational, at least in part, by 2020.

The objective behind this ambitious plan is the careful creation of an environment that is best suited to support the Kingdom's future growth and push the nation into the 'top ten' of international destinations for investment. The underlying policy to diversify the economy is also based on the over-riding ambition to guarantee an environmentally viable future – a hot topic recently thrust into the very forefront of international affairs and popular discussions. Such forward thinking and national strategic policy-planning can only be seen as a step in the right direction and, through this, it is hoped Saudi Arabia's stimulus will provide as an exemplar for others to follow.

Dar's involvement in KSA's Economic Cities started with successful delivery of a Masterplan for Phase 1 of KAEC, Jeddah – cited by industry followers to be among the largest construction project in the world at this time. In KEC's instance, Dar came into the project as the infrastructure team tasked with making a reduced-scale Masterplan by another consultant into a reality. However, things soon took a different turn when the original site area doubled from 380 ha to 864 ha, leading to the development of a fully integrated Masterplan for the expanded site area.

The new city is designed to include all the necessary services and accommodation that will enable it to become a 'center of excellence' in the fields of information and biotechnology. This is coupled with the provision of new housing and community facilities, schools, shops and restaurants, parks and public transport connections to provide for the growth of a new community of young and dynamic Saudis.

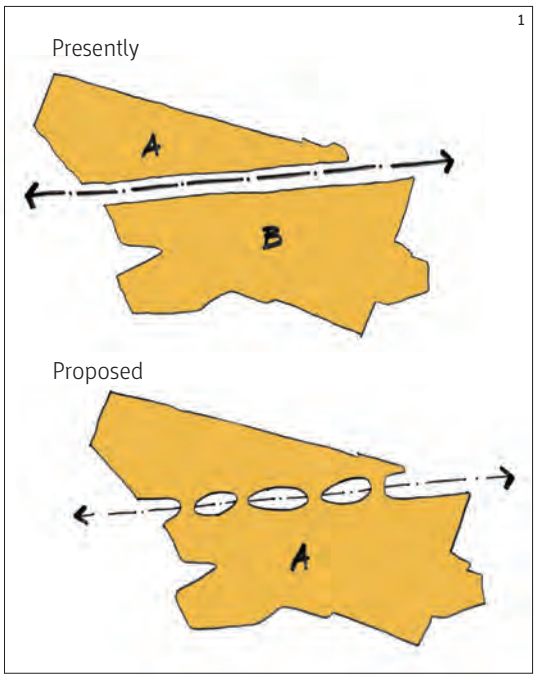
Like the cities of Oxford and Cambridge in the UK, Lund in Southern Sweden, Louvain-la-Neuve in Belgium and Princeton in the USA, KEC represents the potential for a mixed-use, urban center where people will live, work and stay in a place that is born out of a focus on academia and learning. A similar situation occurs at a more micro level in the districts of Hamra and Clemenceau in Beirut, where a concentration of academic and research institutes provide as a generator for a particular demographic and social mix. Overall, the site occupies an area of 865 ha of largely undeveloped land on the eastern edge of Madinah. To the east and the west, the site is bordered by Madinah's second and third ring roads. These are connected by the King Abdul Aziz Highway, which passes directly through the site, almost carving it into two pieces; a significant constraint that we have attempted to overcome in the design of the Masterplan and which is explained in greater detail in the following article with regard to the plaza.

As the birthplace of the Prophet Mohammed (PBUH), Madinah is one of the most holy cities in the Islamic world, second only to the Haram Al-Sharif in Makkah. During the Hajj, Madinah's population swells to an estimated 1.3 million people (almost double the regular population of the city). Owing to excessive demand for accommodation during peak seasons, it is considered to be highly creditable to own a real estate base in the city and there is great demand for the availability of new property. The increased demand for new accommodation is made greater by

Project Factfile:

- 865 ha
- Up to 14,000,000 m² of developable area
- 70,000 new residential units of varying densities
- 230,000 new residents
- 77,000 new jobs
- 20 year completion period, over 6 primary phases
- Core accommodation
- New University with 30 ha campus
- Madinah Al-Haramain Rail Terminal
- 2 light rail stations on the new line between the Airport and the Haram
- Central Business District, with +30 ha of retail area
- +9 ha Cultural Theme Park
- +35 ha for parks and recreational
- A Grand Mosque and up to 12 local mosques

Site location and view



Saudi Arabia's rapidly growing population and presently, the nation has one of the highest birth rates in the world, at 28.55 births per 1,000 people, which is greater than China, (13.1) Kuwait (21.8) and India (23.0) (Source; UN, 2009). From Google Earth images of Madinah, the site for KEC appears as a hole in the fabric of the city. This is a result of two primary reasons; land ownership and site conditions. In the first instance, the land for the new city was bequeathed by King Abdullah's foundation to the Royal Family Estate and, having one sole owner has protected the site from piecemeal new development. In addition, the site is made up of an area of basalt rock, which has made it more difficult to develop than other areas around Madinah. As a result of each of these, the absence of new development on the site has prevented the sporadic growth of Madinah to the east and now, located only 3.5 km of the Holy Haram, the vacant site represents a very unique and exciting scale of opportunity for new development. In addition, Madinah is surrounded by a range of mountains, the Ouhud Mountain range, and, while these serve to define and give the city character they also restrict its future growth and expansion. By its location and undeveloped nature, KEC will open the possibility to develop new homes and facilities within close proximity of the existing city center without the constraints of resettlement or urban regeneration.

The scale of the opportunity for new development at KEC is made greater by the long-term strategic plans for the eastern sector of Madinah and core public transport initiatives, such as the recently completed airport and the proposed Al-Haramain Rail Terminal that will transform the area into a gateway to the city. Within this, existing city center activities will begin to decentralize and gravitate towards the east to form a secondary central district at KEC, with the impact of reducing congestion and alleviating densification in the culturally

1 Concept sketch. Improve connectivity across King Abdul Aziz Road and form one unifying place at KEC
2 Concept Master Plan
3 Final Land Use Plan

sensitive area around the Haram. Overall, KEC has been planned to provide all the necessary living services and facilities for up to 230,000 new residents, including new office, academic, research and institutional activities that will enable the city to become a recognized center of excellence in the field of knowledge-base activities. Core accommodation at the new city includes a University, a Grand Mosque, a mixed-use Central Business District with up to twelve supporting local centers and a 9 ha cultural activity park that is similar in function to Al-Azhar Park in Cairo. The site also includes the Madinah Terminal of the Al-Haramain High Speed Rail between Makkah and Madinah and, up to three light rail stations along the proposed line between the Al-Haram and the airport. Within this, KEC will become the front door to Madinah and a gateway to the Al-Haram.

July, 2009, an Outline Masterplan was submitted to the Municipality in Madinah for planning approval. The submission included a suite of Framework Plans that each outlined a different component of the Masterplan, including land-use, density and massing, building heights, road network and hierarchy, service and utility provision and, open space strategy. In August 2009, Dar successfully gained planning approval and the team quickly moved forward with developing each of the technical aspects of the Masterplan up to a greater level of detail in order to make this vision for a new city into a reality that can be carried through to implementation.


1


2


3

1 Knowledge University
2 View accross villas to the central business district
3 Residential square

Central Plaza at KEC: a fully-integrated approach to design

The Petronas Towers, the Palm Islands, Big Ben and Jorn Utzon's and Ove Arup's cast concrete Opera House – each of these provide the 'signature image' that makes us think of a certain place that is bigger, or greater, than any one of these developments alone.

Owing to the unique nature of their designs, these iconic developments have become widely recognized as landmarks on a global scale. As a result of the international exposure this creates, each also has the great power to bring value to the wider area in which they are located. In the case of the above, the wider area is Kula Lumpa, Dubai, London and Sydney.

At the very heart of the new Knowledge Economic City is the Central Plaza. As with Trafalgar Square in London, Midan Ramses in Cairo or Place de l'Etoile in Downtown Beirut, the plaza has an important function at the new city; it will define the Central Business District and serve as the 'first destination' for visitors. Arranged around the plaza are a mixture of different land-uses, including shops, restaurants, hotels, offices and modern apartments. At the center will be access to a light rail station at sub-level, with quick connections to the Haram, the new Train Station and also, to the Airport. The plaza itself will be a valuable area of public open space, offering a range of recreational activities for both residents and visitors.

In addition, the plaza fulfills a key role in underpinning the Masterplan for KEC. In the earlier article, it is noted the King Abdul Aziz Road, a key district distributor for the city of Madinah, passes directly through the site with the impact of separating it into two parts. In an attempt to overcome this, and tie together both the north and the south part of the site, the plaza acts as a large land bridge with a diameter of up to 110 m from the light rail station at the center. The plaza is the center point along a main pedestrianized route that connects the University in the north area to the Grand Mosque and the Central Park in the south area. To strengthen this connection, each of the axial routes to the Mosque and the University are aligned to the center of the plaza and this provides a visual link for visitors arriving from out of the light rail station.

In comparison, the area of the plaza is almost twice the scale of St. Mark's Square in Venice and 1.5 times the area of St. Peter's Square in Rome. The magnitude of the space is emphasized by the dynamic architectural vision; a continuous colonnade encloses the plaza, with 12 m high columns that are regularly spaced in relation to the treatment of the hard-landscaping. While, at the eastern side, two slender iconic towers of up to 40 stories in height will frame a view to the Haram and, at the same time, activate and illuminate the plaza at night.

From the planning of the traffic movement around the plaza to the feasibility of the structure itself, the creation of the plaza has involved close coordination and collaboration of a number of different departments. This is not to mention, the study of the massing of the surrounding buildings, the arrangement of hard and soft landscaping and also, the sheer task of lighting and servicing the plaza, its buildings and the light-rail station.

In this respect, the Grand Plaza can be seen as a microcosm of the wider project and, like each of the above noted iconic gestures, the effect is a unified and singular element with the potential to be the landmark that puts KEC on the global map.

The Pearl, Qatar

Dar has been part of UDC's Pearl Development from the inception stages providing design, tender, and site management for the entire project as well as designing a number of residential and hospitality projects, the latest, The Four Seasons Hotel at Al-Marsa, signed in 2009.

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