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Qatar 2005-2010: A Five-year Retrospective //
Not Going to Waste: Water Management in Kuwait /
Upward Mobility: Improving the Urban Environment in Taiz

editor's note

It has always been a changing world, but change is happening very fast now, faster than people can adapt to. What was once safe and solid can suddenly and with no prior warning turn into complete disarray. Tight response to new events and circumstances for an enterprise translate into capturing and connecting intellectual capital and seeing the difference between past and new business needs. This issue of Darmagazine is inspired by unexpected waves of change and the take-away value of evolutionary potential in the face of adversity sometimes and healthy change some other times. Dar Al Handasah combines expertise and global presence with real-time reactive measures making us a true global partner and seasoned local expert, dealing with inevitable change by integrating new elements not reactivating old plans. In this our fourth issue, we take a look at what Dar has achieved in just five short years in '2005-2010: A five-year retrospective of Dar projects in Qatar', with projects lined up as Qatar readies to host the FIFA 2022 World Cup, Dar takes on yet another new role after a thirty year presence in the rising GCC state. In 'Testing Intuition' we take a look at how CFD technology has served us through the years to make not just better design decisions, but more targeted response providing our clients with the information they need for more sound environmental decision and better project management control. Riding the wave of change takes us through Kuwait and a innovative water strategy in 'Not Going to Waste' introducing Umm Al Hayman, a wastewater treatment hydro-scheme where water reuse is set to support the burgeoning agricultural sector and decrease exuberant reliability on desalinization. A first for the Middle East is the 'Haramain High Speed Rail' electrified passenger railway joining the Holy cities of Makkah and Madinah. This first of its kind speed rail in the region is set to ease traffic congestion, reduce carbon emission, and cut down on journey time for a much improved passenger experience. 'Upward Mobility' is an article about improving the urban environment in the city of Taiz, Yemen through a novel communication strategy based on open dialogue, participatory research and building trust with the local community. 'Floor Vibration Analysis' presents an occupant comfort study at the Princess Nora Bint Abdul Rahman University Staff & Faculty Community Center.

contents

Not Going to Waste: Water Management in Kuwait

revised by Faten Nazzal, Water Network Engineer

For utilities projects, an economic slowdown can have a positive effect and nowhere was this more apparent than in the GCC region. The halt of commercial and residential projects transformational effect shifted focus to growing power and water demands and the hot topic of energy conservation. In an area where water is a highly valued commodity, water recycling projects are expected to soar in the next two decades.

Inlet works
- Inlet distribution chamber

Preliminary works
- Mechanical screening chambers
- Grit removal chambers
- Oil & grease removal tanks

STP's 5 trains
- Phase I = 3 trains
- Phase II = 2 trains
- @ 130,000 m^3/day/unit

Secondary treatment
- Biological removal (anoxic/ anaerobic/oxic – A2O process) of the carbonaceous, nitrogenous, and phosphorus compounds
- Settling tanks
- Process monitoring

Tertiary treatment
- Disc filtration
- U.V. disinfection
- Chlorination added after disinfection to maintain a residual

SCADA system with the necessary monitoring and control stations at the new STP and connected to the other work stations at Egaila pumping station, Ardiya STP, and Sulabiya STP

De-salinating seawater has accounted for most fresh water needs in the region; but with an increasing population and an expatriate influx still on the rise, local authorities are looking for new alternatives to cope with the water demands of modern life. Most treated sewage effluent (TSE) was being fed back into the sea and potable water was serving household and industry use or irrigating lush green patches introduced into the desert landscape around residential neighborhoods, luxury resorts and golf courses. The prohibitive cost of desalination and the elevated energy costs associated with it are only intensifying the push for new sustainable water sources and local water authorities are working to define new standards for particular water uses and set relevant risk management monitoring programs for water recycling alternative uses that spare potable water. Water recycling is set to play a bigger part in the water management cycle with the growing demand from new residential developments, burgeoning new industries, and a mounting interest towards the agricultural sector.

Gulf states are investing heavily to increase their wastewater treatment capacity with some $15 Bn worth of wastewater treatment capacity slated to be built in the GCC by 2015 (Source: MEED Project Tracker). In the UAE most urban and industrial areas and all new developments are connected to the public sewage system, new privately-ran waste water treatment plants (WWTPs) are being build near industrial parks and urban centers. Dubai's WWTP in Jebel Ali will reach a 300,000 m^3/day effluent capacity, while Ras Al Khaimah's Industrial Park at Al Ghail will benefit from 100 percent TSE from its newly built WWTP. In January 2011, Abu Dhabi hosted the 3rd World Future Energy Summit where water management was a central issue and the city – an exemplar for environmental concerns for the region with such projects as the Foster-designed zero-carbon Al Masdar City and the city's sustainable Plan Abu Dhabi 2030 and Urban Planning Council's (UPC) Estidama rating system - will achieve 70% TSE use for non-drinking purposes in the near future. Bahrain plans to increase the TSE water supply for irrigation to 350,000 m^3/day (up from 200,000 in 2008), while Qatar and KSA who have relied on desalinization in the past and were least affected by the economic downturn with growth and development still on the rise, are looking to ramp up TSE. A similar situation is happening in North Africa with Egypt and Algeria building new wastewater treatment plants and upgrading existing ones to meet growing demand from expanding population, economic diversification and urban development needs.

Umm Al Hayman identified irrigation zones and water demand within each zone will be serviced by the TSE reservoirs and PS at the STP station itself. Irrigation needs totaling to 651, 833 m^3/day are conveyed to seven strategic reservoirs, PSs, and about 55 secondary reservoirs and more than 300 km of secondary irrigation lines

Sludge stabilization process consist of gravity thickening, aerobic digestion, and belt filter presses for sludge dewatering (with emergency drying beds). Treated organic sludge or compost is a natural soil conditioner and nutrient-enriching supplement that has been widely used in Kuwait since the yearly 90s.

The design redundancy of the new STP allows for removal of any biological treatment unit without affecting overall performance

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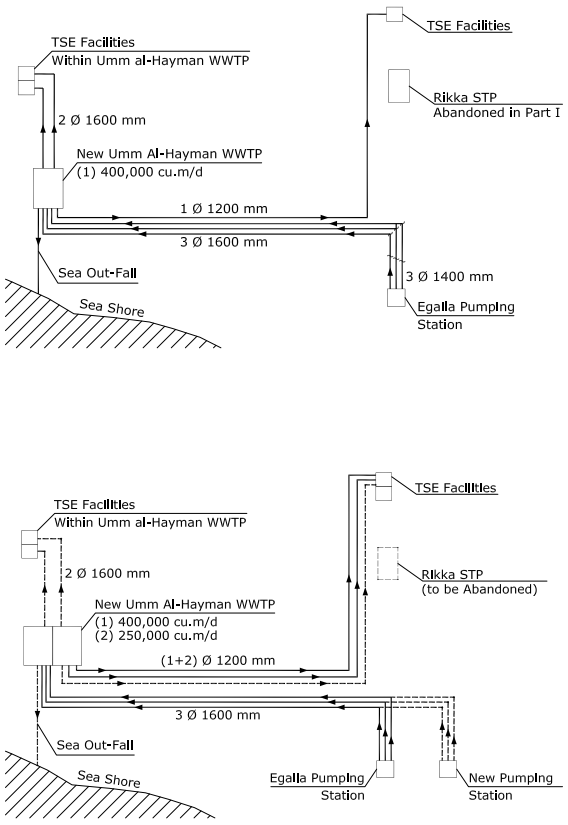


1 Two-phased schematic representation

Projected flow for Al Riqqa totals 315,606m³/day. The existing Al Riqqa STP will be converted to a TSE reservoir and pumping station. Three 1,200-mm diameter lines proposed from Umm Al Hayman to Al Riqqa will supply landscaped areas with 425,137 m³/day (above projected demand) branching into secondary network to cover all irrigation needs

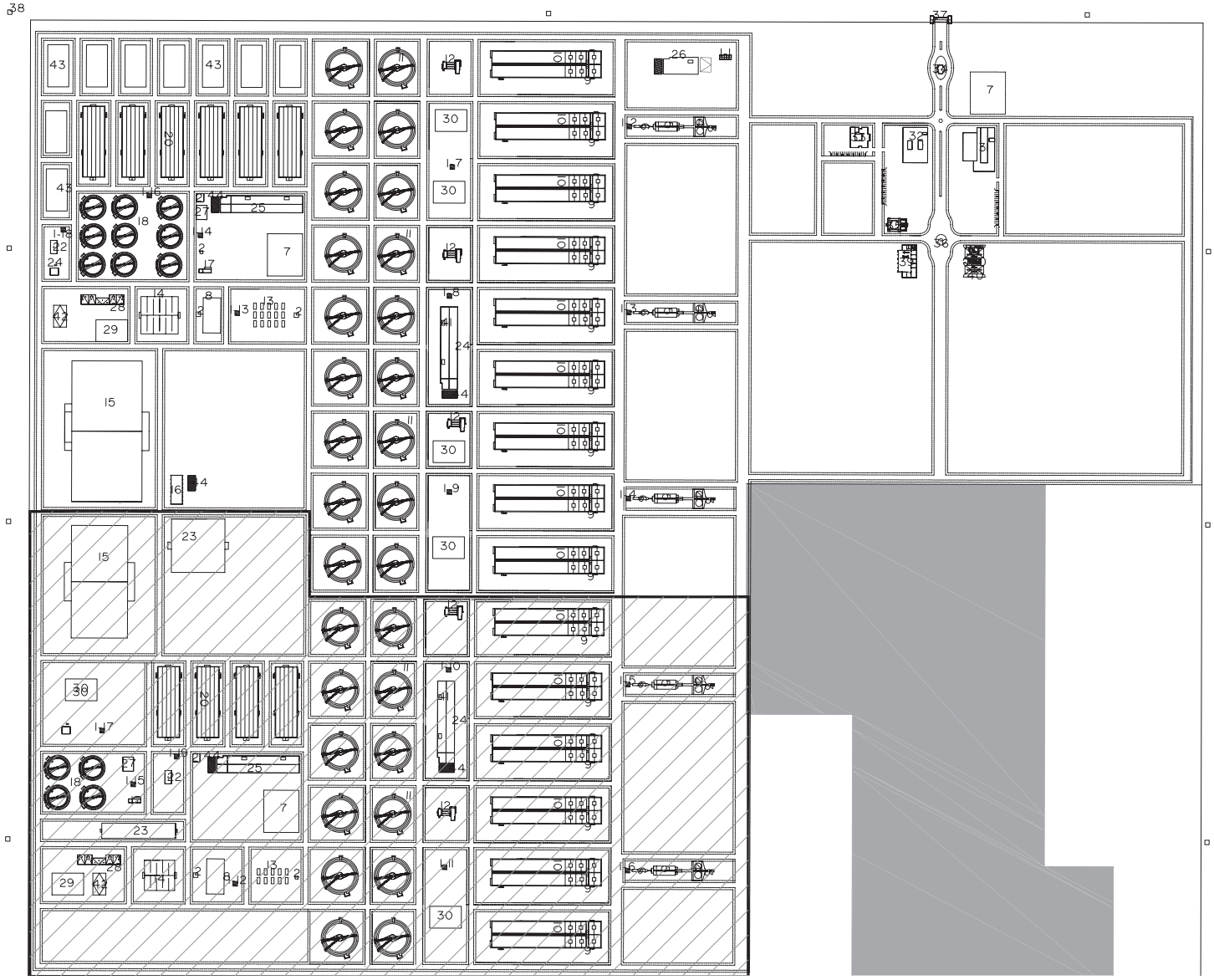
This flat, oil-rich desert with no natural lakes or freshwater reservoirs and a per capita water consumption that has more than doubled in 20 years, (the two freshwater aquifers supplying the country are insufficient to meet rising modern water demands) has been working towards economic diversification branching into small industries, agriculture (successfully producing quality crops in excess of local needs) tourism, and finance.

TSE is the most readily available and cheapest source of additional water especially in water-deprived regions of the world. Nutrient-rich, wastewater treatment and re-use gained popularity for agricultural irrigation enriching the oil and improving crop yields and has been implemented for decades.

A high level of treatability in TSE applications has been used to replenish aquifer for a couple of decades and more recently TSE water in many cases around the world is being diverted back into drinking water networks. Owing to these facts, the government of Kuwait has steadily increased TSE, and national policy calls for gradual replacement of fresh water and brackish water by reclaimed effluent (presently 60 % or 693,000 m³/day) to 100 percent treatment of the country's wastewater for unrestricted irrigation with zero risk to soil and water resources.

Located in the north-west corner of the Arabian Peninsula, Kuwait is one of the smallest countries in the world (Area: 17,818 m²; pop. 2.6 million Kuwaitis, 1.29 million non-Kuwaiti).

2 Overview of the TSE system



1 Distribution chamber
2 Collection chamber
3 Screen chamber
4 Grit removal tanks
5 Grease removal tanks
6 Parshall flume
7 New electrical substation
8 UV building
9 Return liquor pump station
10 Bioreactors tanks
11 Secondary settling tank
12 Return sludge pumping station
13 Disk filter building
14 Chlorine contact tank
15 Treated sewage storage tanks
16 Treated sewage pumping station
17 Waste sludge pumping station
18 Sludge thickening tanks
19 Thickened sludge pumping station
20 Aerobic sludge digestor
21 Digested sludge pumping station
22 Sludge dewatering building
23 Waster liqor holding tanks / Pumping station
24 Air compressed for the biological tanks
25 Air compressor building for the sludge digestion tanks
26 Odor control building for the inlet works
27 Odor control chamber for the sludge thickening

Umm Al Hayman WWTP general layout plan

Irrigation reservoirs, mains and control systems fully coordinated with the MPW and the Public Authority for Agriculture and Fish Resources (PAAF) will cover all irrigation requirements for mostly residential Umm Al Hayman and industrial Al Riqqa

The biological process ensures that the phosphorous concentration in the effluent is in accordance with landscape irrigation limits, but in instances of sea discharge effluent water will be chemically treated for further reduction in effluent phosphorous concentrations to safeguard the quality of the receiving Gulf water from any excess phosphorous discharges

Fact File	
Per capita water consumption	500 m^3/day
Per capita waste production	275 l/c/day
Phase I Total Capacity	400,000 m^3/day
Phase II Total Capacity	250,000 m^3/day
Al Riqqa projected population (2035)	1,544,086
Umm Al Hayman projected population (2035)	245,175
Total estimated design flow	495,000 m^3/day
Disinfection train capacity	130,000 m^3/day/unit
Total cost estimates (STP + TSE system)	KD 425 Million

A sewage treatment plant at Umm Al Hayman

In September 2007, H.E. Dr. Fadel Fasar Ali Safar, Minister of Public Works and Minister of Municipal Affairs for the State of Kuwait, announced that Dar Al Handasah was selected for consultancy services of the expansion works for the Umm Al Hayman Waste Water Treatment Plant – the region's largest to be built. On January 18th, 2009 Dar signed an agreement with the Sanitary Engineering Sector (SES) of the Ministry of Public Works to design the new Sewage Treatment Plant at Umm Al Hayman. Based on numerical standards for discharge into public sewers, discharge into the environment, and for the reuse of the TSE set by SES's 2002 Sanitary Master Plan, the design will divert water from the catchment areas of Umm Al Hayman and Al Riqqa back into non-drinking use.

The catchment area of Umm Al Hayman is a new urban area south of Kuwait City sparsely populated (around 5,500) and forecasted to grow to approximately 240,000 inhabitants in the year 2035. Further to the north within Kuwait City's urban sprawl, the Al Riqqa catchment area links Kuwait City metro area to the south-westerly Khiran and Sabah Al Ahmed new residential developments. Highly industrial - Al Riqqa's Mina Ahmadi and Mina Shuaiba are Kuwait's main sea ports – also holding the oil extracting operations of Al Ahmadi. Based on a per capita wastewater generation rate of 275 l/c/day, the new Umm Al Hayman STP will receive wastewater conveyed from the Al Riqqa (current capacity 173,000 m^3/day but set to be decommissioned) and Umm Al Hayman (current capacity 27,000 m^3/day).

Decommissioning, upgrading, treating, disinfecting, irrigating

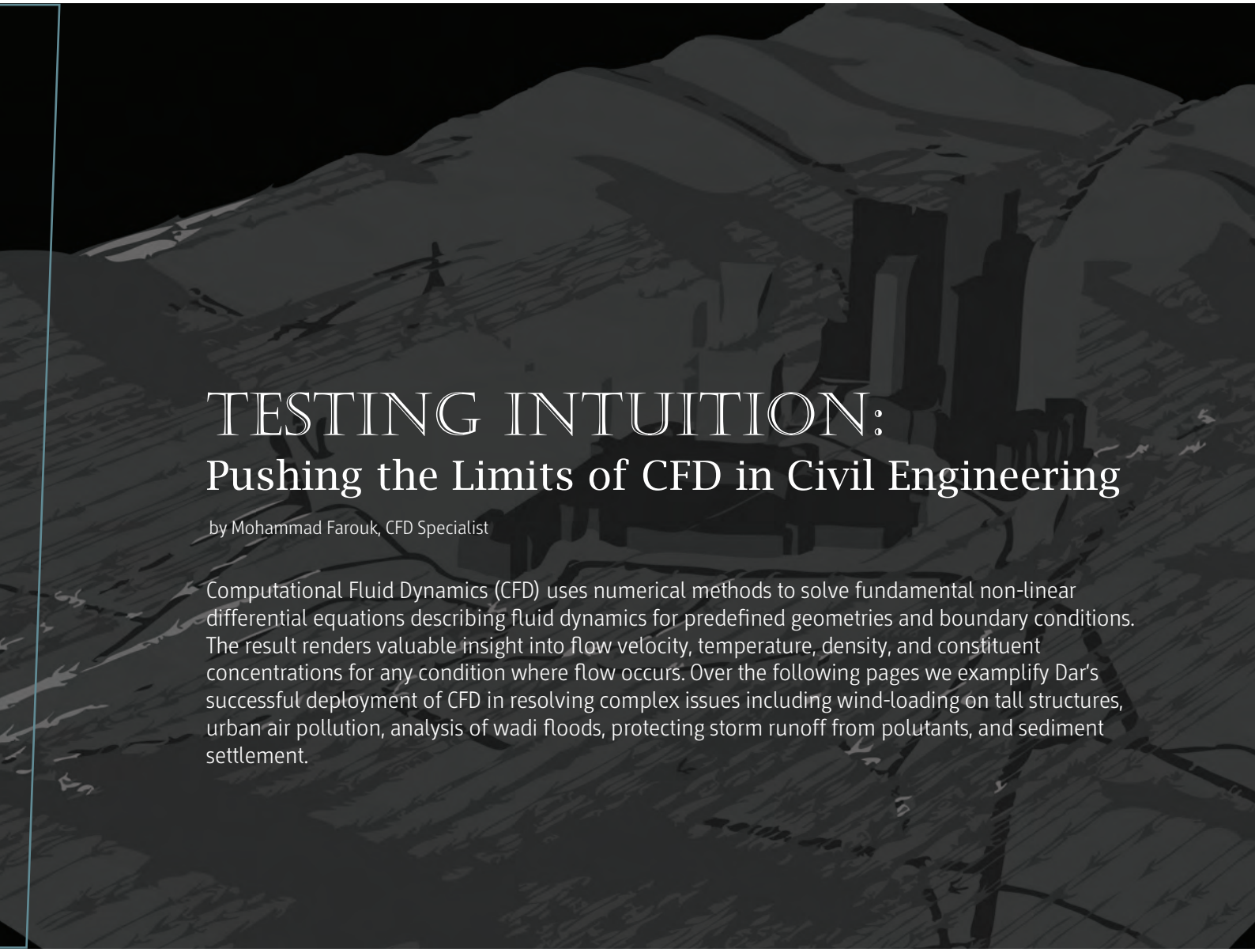
The plan calls for the decommissioning of the Al Riqqa WWTP and the diversion of the Egaila Pumping Station (PS) flow (3.6 km from Al Riqqa) to the new Umm Al Hayman WWTP 45 km south. The existing Egaila PS runs at total 4.2 l/s @ 70 m head pumpsets, with flow estimated to be increased to 7.4 l/s. Based on the new flow estimates, physical testing, mathematical and CDF modeling, design favored the construction of a new PS and maintaining the Egaila PS in its initial condition. The rising mains between the Egaila PS and Umm Al-Hayman new STP are sized to maintain the heads of the existing transfer pumps (70 m) within the 45-km new transmission mains.

The conveyance scheme leads to a pressure rising main from Egaila PS to a pressure break chamber 23.4 km downstream at a 87 m above sea level elevation via existing 1400 mm pipes (for new pipes diameter will be increased to 1600 mm). From the pressure break chamber a gravity line will complete the scheme to Umm Al Hayman's inlet works traveling a total distance of 45 km over 18 hours travel time (with provision for oxygen replenishment due to travel duration).

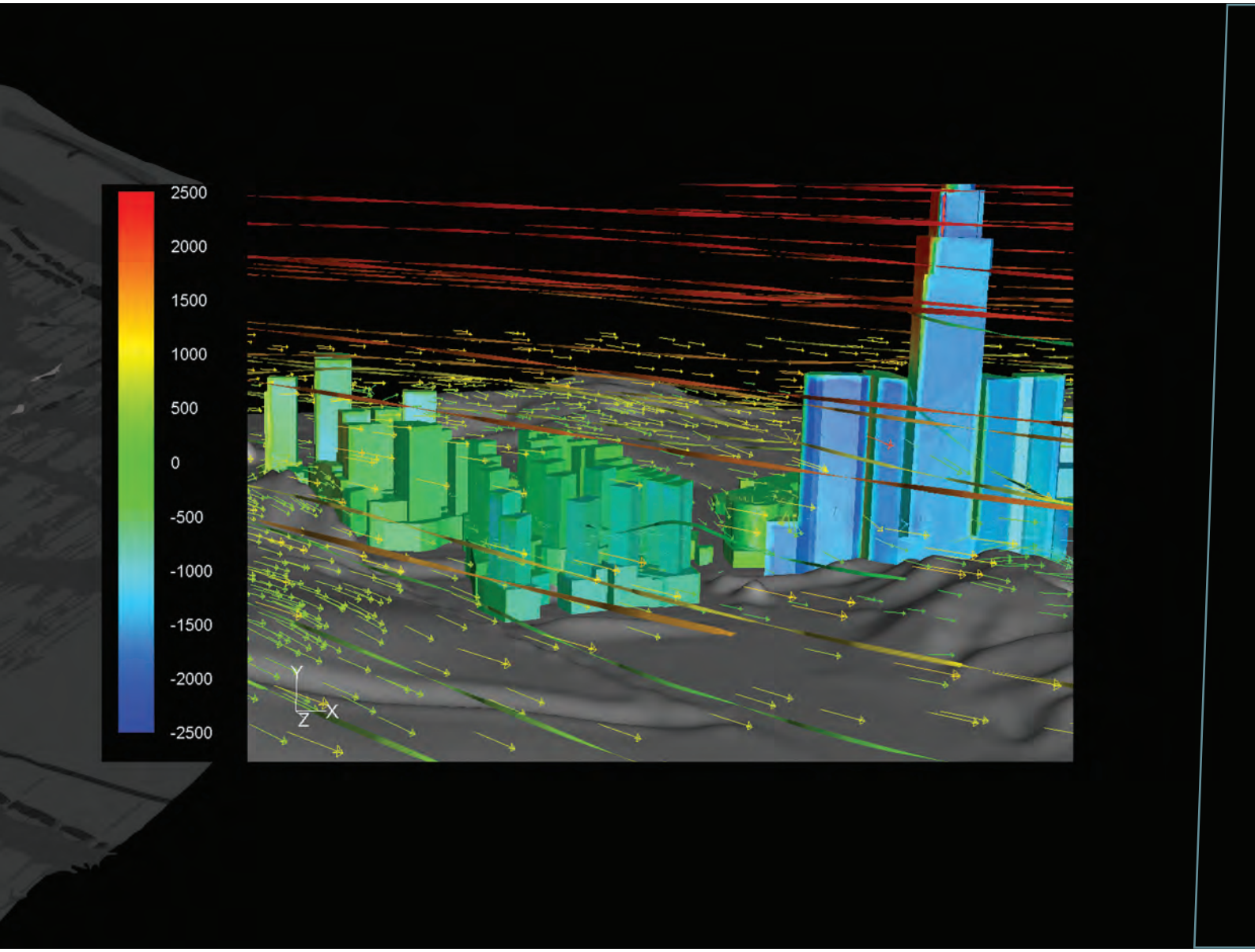
TESTING INTUITION:
Pushing the Limits of CFD in Civil Engineering

by Mohammad Farouk, CFD Specialist

Computational Fluid Dynamics (CFD) uses numerical methods to solve fundamental non-linear differential equations describing fluid dynamics for predefined geometries and boundary conditions. The result renders valuable insight into flow velocity, temperature, density, and constituent concentrations for any condition where flow occurs. Over the following pages we examplify Dar's successful deployment of CFD in resolving complex issues including wind-loading on tall structures, urban air pollution, analysis of wadi floods, protecting storm runoff from polutants, and sediment settlement.



Pollutant flow diffusion study for the Holy Haram Precints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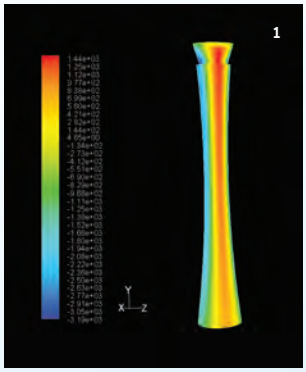
By its non-intrusive, virtual modeling technique with powerful visualization capabilities allowing engineers to model performance in a wide range of design applications, CFD has become a valuable evaluation for large scale projects. Environmental management and occupant comfort have added a new dimension to what CFD can do for project design delivery and it is safe to say that no project can take off without a thorough assessment of what the engineering scheme, the project development process and the environmental burden pulled on the project's site and the health and comfort of its occupants.

CFD technology has in effect aided intuition by eliminating doubt in any kind of application that can be described using algebraic or differential equations.

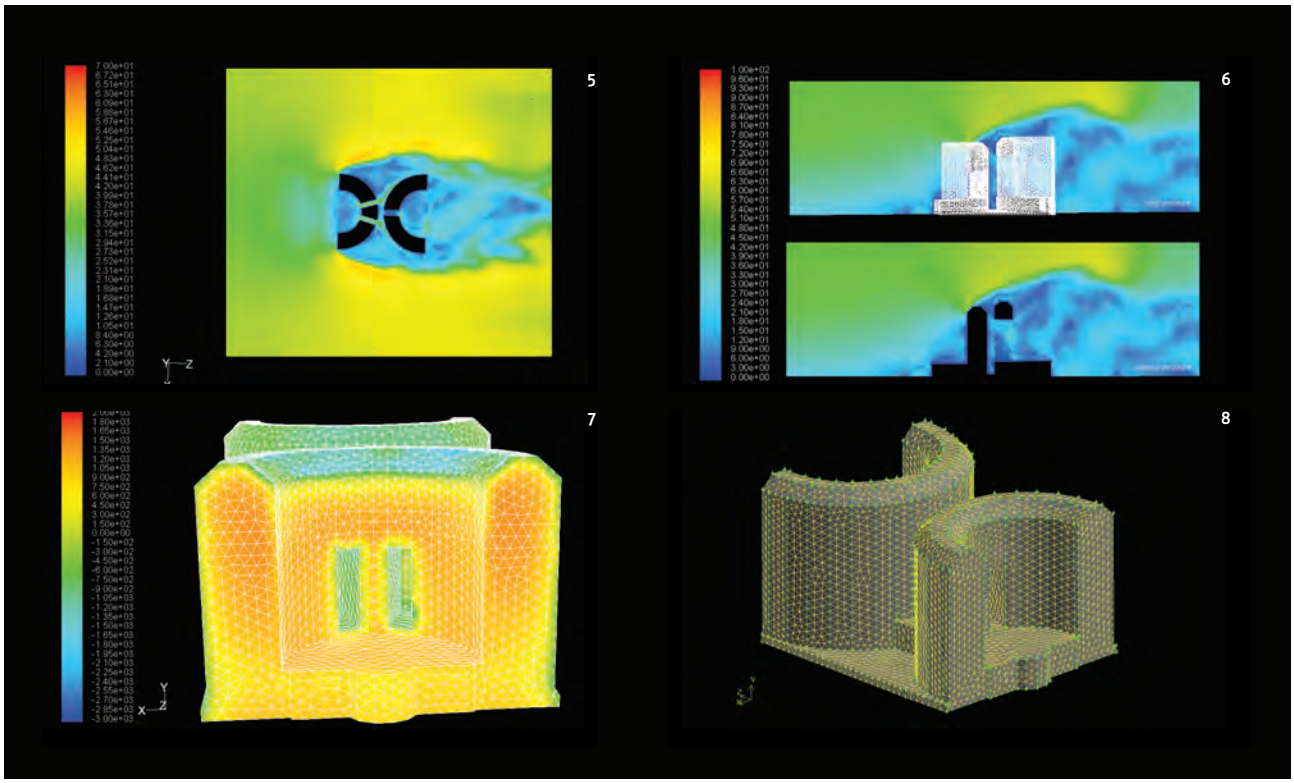
But despite rapid advances in numerical schemes and methods, the reliability of the CFD prediction still depends on experienced users to define the simulation, identify the best numerical method for the physical model and interpret the model's results. CFD is a complex discipline and it takes many years of experience to be confident of the accuracy and quality of the simulations.



1 Cairo International Airport air traffic control tower wind stress model
2 Tower during construction
3 Completed tower

Dar was the first firm in the Middle East to use CFD in civil engineering in 2002 applying calculation of bending moments, torsion moments, axial forces, maximum pressure and maximum suction acting on the San Stefano complex building in Alexandria and the air traffic control tower at Cairo International Airport.

The numerical model for San Stephano comprised an eastern tower with a large central opening and a western tower with two smaller openings extending to about two thirds of the buildings' 110m height. The model includes more than 820,000 tetrahedral cells to simulate the complex shape of the building and its surrounding area accurately. More than 30,000 cells are attached to the surface of the buildings to measure accurately the stresses, forces, bending moments and torsion moments. The actual wind exposures have been considered in all different directions. The numerical model and the physical model measured results were in agreement (with maximum difference of ± 20%).



4 The San Stephano, Alexandria, Egypt
5 Velocity contours at 68 m measured from the ground surface
6 Velocity contour on a vertical plan mid-structure
7 Wind stresses determining cladding design
8 Numerical model

Wind Effect Modeling in Holy Makkah

Kind Abdul Aziz Endowment, courtesy of skyscrapercity.com

Kind Abdul Aziz Endowment

Dar embarked on the architectural design for Jabal Al Qala'a in 2001 as part of King Abdullah Bin Abdulaziz Al Saud Endowment for the Two Holy Mosques. It is a unique structure offering world-class accommodations for visitors and residents of the Holy City. The now almost completed Kind Abdul Aziz Endowment (sometimes referred to as Makkah's Royal Clock Tower because of the famed clock atop its highest tower) majestically stands on a 23-ha prime site south of the of the Holy Haram within walking distance from the Haram extending Sahaat (outdoor plazas). The iconic 2.8 million m^2 built up area mixed residential and hotel superstructure (the world's largest built-up area) spreads over seven towers above podiums totaling up to almost a third of the total space program designed for a total occupant load of 136,000. The Makkah Clock adorns the structure's highest tower some 600-m above ground level.

The size and stature of Kind Abdul Aziz Endowment makes it prone to the Arabian Desert's sandstorms that hit the Holy City and can rage for days. The effect of the engulfing massive cloud of dust accompanied by strong wind gusts that are known to hit the Holy Precinct were tested with a CFD numerical model. The model studied the effect of wind and tested the induced forces for different scenarios including cases of strong winds and was verified against external numerical and experimental models conducted in parallel. All surrounding structures having any impact on wind effects (existing and future developments) were included in the model to create the closest site duplication possible. One model was developed with accurate representation of wind flow velocity and direction and tested the wind effects on the concrete superstructure, the top steel clock tower, the spiral, and the crescent.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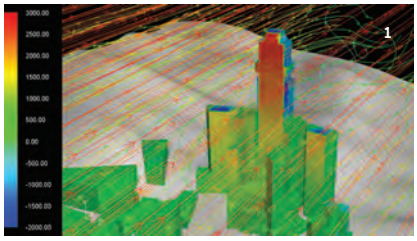
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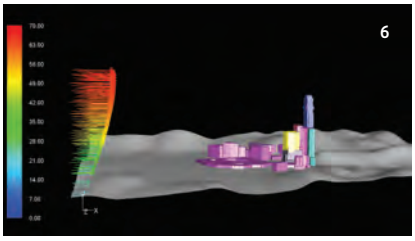
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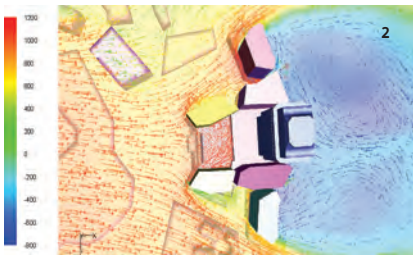
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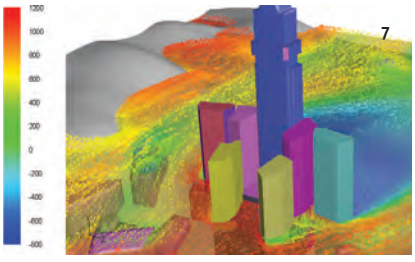
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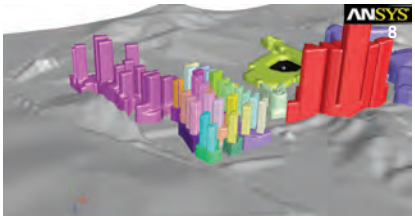
1,2 Wind pressure distribution results determined the exact locations and values of maximum pressure and suction needed to check the safety of the cladding design
3 The clock's cresent minor details part of the 3-D model
4 Physical scale model of the steel structure holding the clock, the spiral, and the crescent
5 Wind pressure distribution on the top of the tower
6 Actual wind velocity profile and actual terrain around Kind Abdul Aziz Endowment; all surrounding structures with potential wind-inducing effect are inserted into the numerical model
7 Velocity contour vectors and ribbons around the structure

Jabal Omar

The Jabal Omar Development Project, a 23-ha land west of Holy Haram, is a Omar Development Company (JODC) project projected to provide first class accommodations and services for visitors and residents of the Holy City. Once completed, the development will significantly enhance the experience of an ever increasing number of pilgrims and seasonal visitors to the Haram. The project includes 24 towers counting ten luxury hotels, seven seasonal residences, and seven permanent residences. The podiums at the towers' bases comprise places of worship, retail and commercial venues, restaurants, food court, car parking, and serviced high-end villas. Within Dar's full design services of the south parcel, a CFD model was constructed to interpret wind induced velocities on the towers and their occupants.



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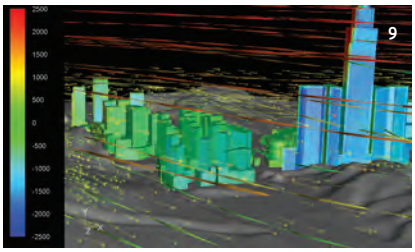
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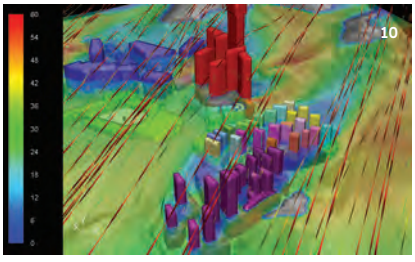
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Top Jabal Omar perspective
8 Geometry
9 Pressure distrbution on the structures
10 Wind eddies 50 m from ground surface

Al-Shamiyah Air Quality Study

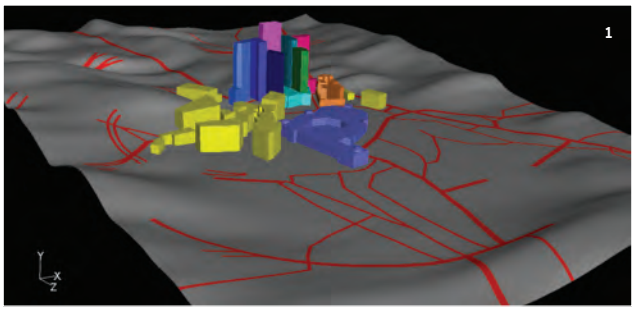
The northern Haram sector, part of the larger Al-Shamiyah, is one of the last remaining undeveloped region with direct proximity to the Holy Haram walls. This area adjacent to the northern outer limit of the Holy Precincts is now largely occupied by informal settlements and plans for an integrative and flexible masterplan to redevelop it have been secured by the Makkah region governor and the High Committee for the development of the Makkah region. The 180-ha area under study will expand the Sahaat (outdoor plazas) by providing an additional prayer capacity to about 200,000 worshipers. At its most basic concern is the safety, security and well being of the worshipers as well as the sanctity and the preservation of the Holy Place. Connectivity is at the core of this massive undertaking, the safe passage of thousands of worshipers transcribes into developing an integrated network for pedestrians and vehicles. An extensive 3-leveled road network is being conceived with main roads, local roads and arteries roads integrating into the already existing transport infrastructure in place.

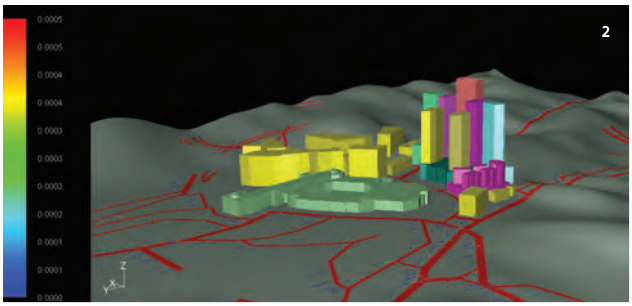
In this instance, our mission was an air quality study of Al-Shamiyah's north Haram sector expansion. The model measures the existing air quality around the Haram and the Sahaat and is designed to measure future air quality after the construction of new developments and the full deployment of the Al-Shamyiah expansion. The results of the air movement and pollutant dispersion study investigate the environmental impact of any proposed structure on air quality for all stages of development (pre-construction and post-construction). The significance of the study at this early stage touches all aspects of design within expected growth and potentially years of construction ahead.

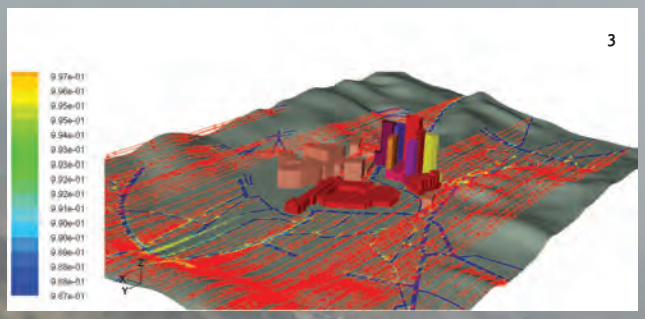
The 3-D numerical model covers a 5-km^2 area around the Holy Haram comprising more than 2.6 million tetrahedral cells. Thirty-six roads within the studied area constitute the model's main source of pollutant with the model considering the worst case scenario for wind speed and maximum peak traffic hours as main road modeling parameters. A simple CFD air quality model was measured against a comparable analytical model developed at King Abdul-Aziz University to verify its accuracy. Dar followed suit with a real-life numerical model comprising the following parameters:

- Real terrain
- Real geometry of the surrounding buildings
- Real wind velocity profile
- Real road network plan
- Real road profile
- Real tunnel location
- Vehicle fuel type
- Vehicle year of manufacturing
- Vehicle type
- Peak hourly and daily traffic

Main image Northern Haram sector aerial view



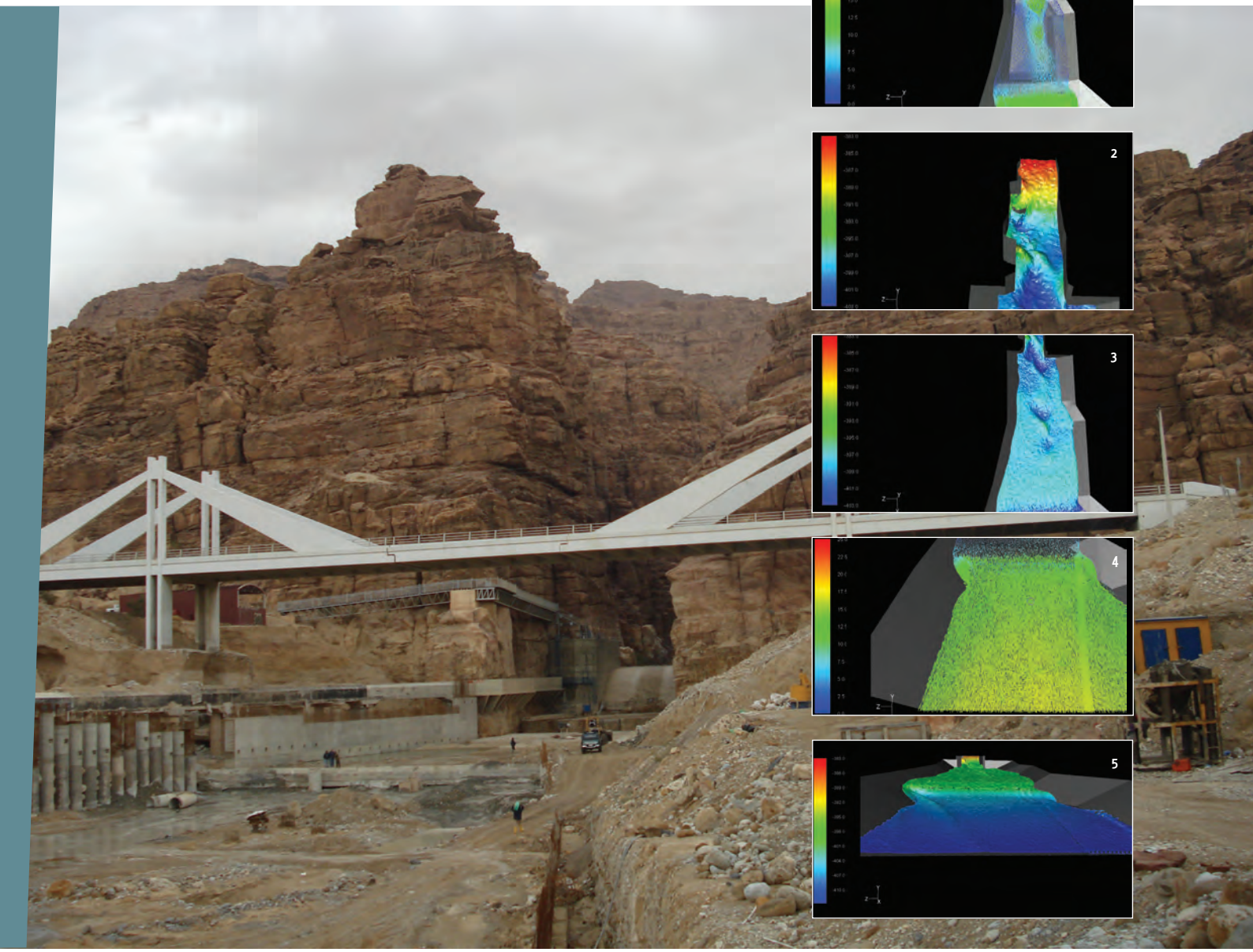




1,2 Holy Haram Precincts 3-D air pollution model
3 Flow diffusion of one of the pollutants tested

Wadi Al-Mujib Flood Flow Analysis

Wadi Al-Mujib is the largest wadi discharging into the eastern bank of the Dead Sea with a catchment area of 6,000 km^2. The wadi cuts a deep gorge into the rocky eastern bank overlooking the Dead Sea and emerges from this gorge into a relatively small alluvial fan which extends about 1 km beyond the mouth of the gorge towards the sea.
The consistent lowering of the Dead Sea level (at an almost constant receding rate of 1 to 1.2 m/year) is increasing the wadi bed slopes and consequently the flow velocities in the reaches between the rock faces of the eastern foothills and the sea. Velocity increase was the cause of severe scour around the piers of the three-span Sweimeh-Aqaba



Main image Wadi Mujib downstream view and Irish crossing
1, 2 Water surface velocity and water depth inside the gorge
3 Water surface velocity and water depth downstream the gorge up to the Irish crossing
4, 5 Water surface velocity and water depth downstream the Irish crossing

Bridge during a flood event in May 2000 when the wadi level dropped by 5 m. A reconnaissance visit following a even stronger flood event saw evidence for a change in wadi flow direction, damaging sand trap and water pumping station protection works, eroding the Irish crossing downstream of Mujib Bridge, and scouring the wadi bed to expose the water conveyor pipeline. The flood flow inside Mujib is a complicated wadi flow that was tested by a numerical simulation. The model checked the flow resulting from the implementation of an access road connecting the Irish crossing with the bed of the gorge, modifying the wadi bed, revising the levels of pile rows, and accounting for the profile of the wadi after the 2010 flood (the proposed profile of wadi in 2014 in case of maximum flood during 2010-2014 is limited to 500m³/s) and the deposits between the end of the gorge and the Irish crossing and upstream of the Mujib weir (two scenarios).

3-D model

- Multiphase flow (water and air)
- Unsteady highly turbulent flow
- 100 years food (2750m³/s, 1500 m³/s, 1000 m³/s)
- Model length: 433 m
- Model width: 240 m
- All Vertical and inclined drops
- Actual profile of the Mujib spillway
- Irish crossing
- Access roads

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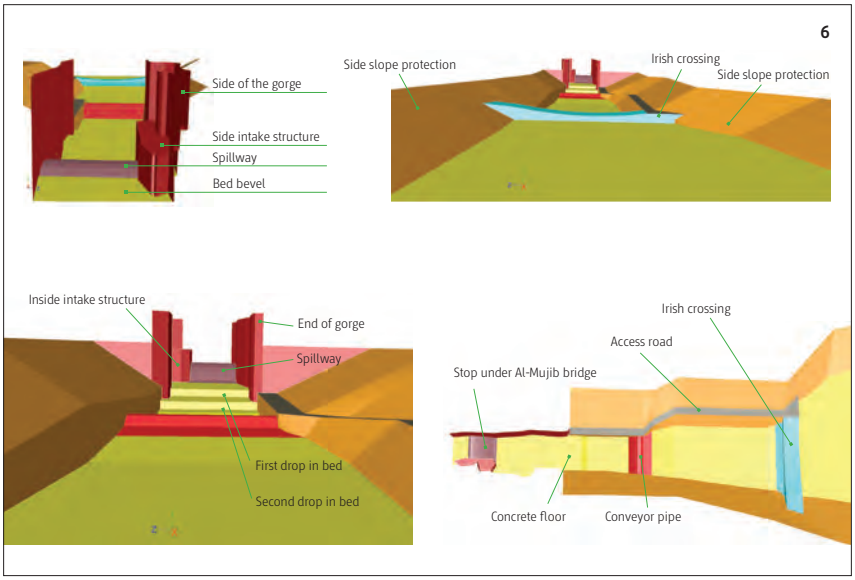
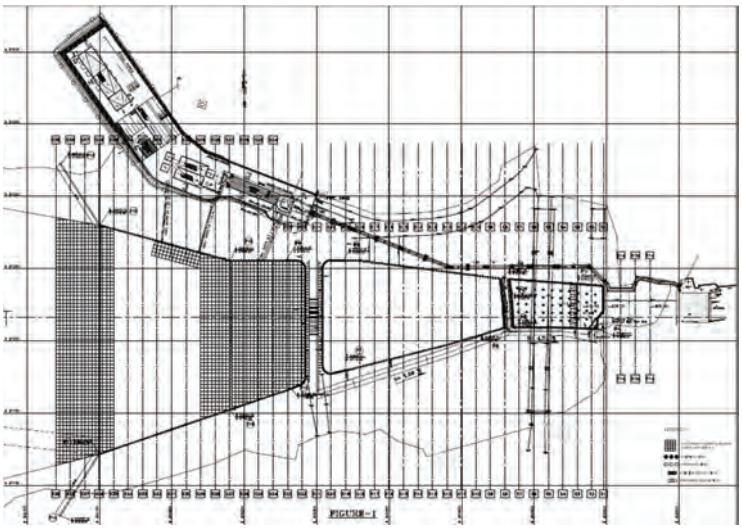


Model's results

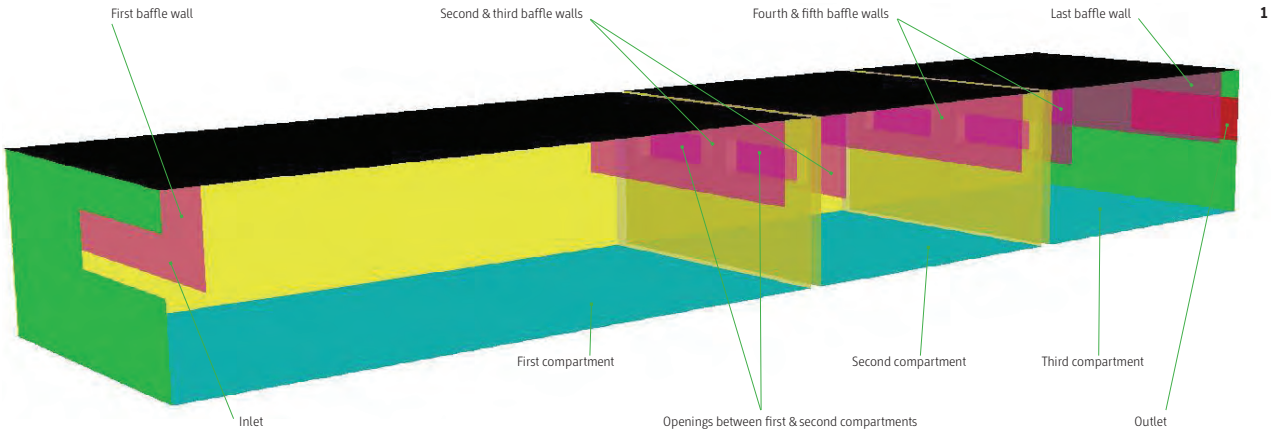
The high velocities inside the gorge in both scenarios confirm that sediments will be washed out during the next flood. The next flood would, according to the model, generate new sediments, high velocities downstream the Irish crossing (13-14 m/s for a 2750 m³/s flood). As a result of the 2-senario model a preferred alternative solution was proposed for flood bed protection.

7



6 Top: Upstream and downstream views of the model. Bottom: Downstream view of the gorge, conveyer pipe and Irish crossing
7 Proposed flood bed solution following the result of the model

Water Run-off Protection: Oil Seperator at Blaise Diagne Airport



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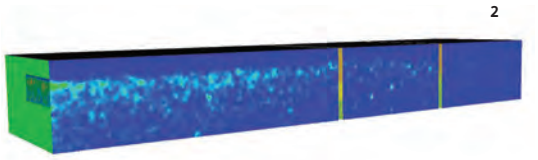
One of the main pollutants in water runoff is oil containing harmful constituents such as metals and polycyclic aromatic hydrocarbons (PAHs). The extent by which these materials are polluting storm water run-offs and the ultimate receiving waters is largely unknown but needs mitigating measures to curtail the residues they produce. Oil separators are generally used to remove the oil from water flow in open areas such as airport airfields and runways by setting a percentage of safe remaining oil residue margin below a a predetermined allowable limit.

The 3-D numerical model created to determine the optimum dimension and the efficiency of a proposed oil separator for the Dakar, Senegal Blaise Diagne Airport's airfield and infrastructure determined the optimum three-compartments size removing at least 98% of the oil.

Oil separator 3-compartments and 6-baffle walls 3-D model

- Multiphase flow (water, oil and air)
- Unsteady turbulent flow
- 150 million tetrahedral cells



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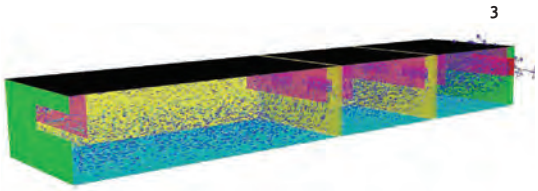

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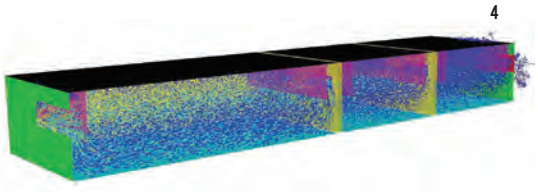

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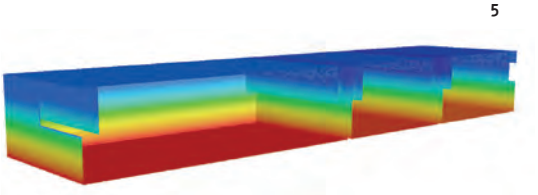

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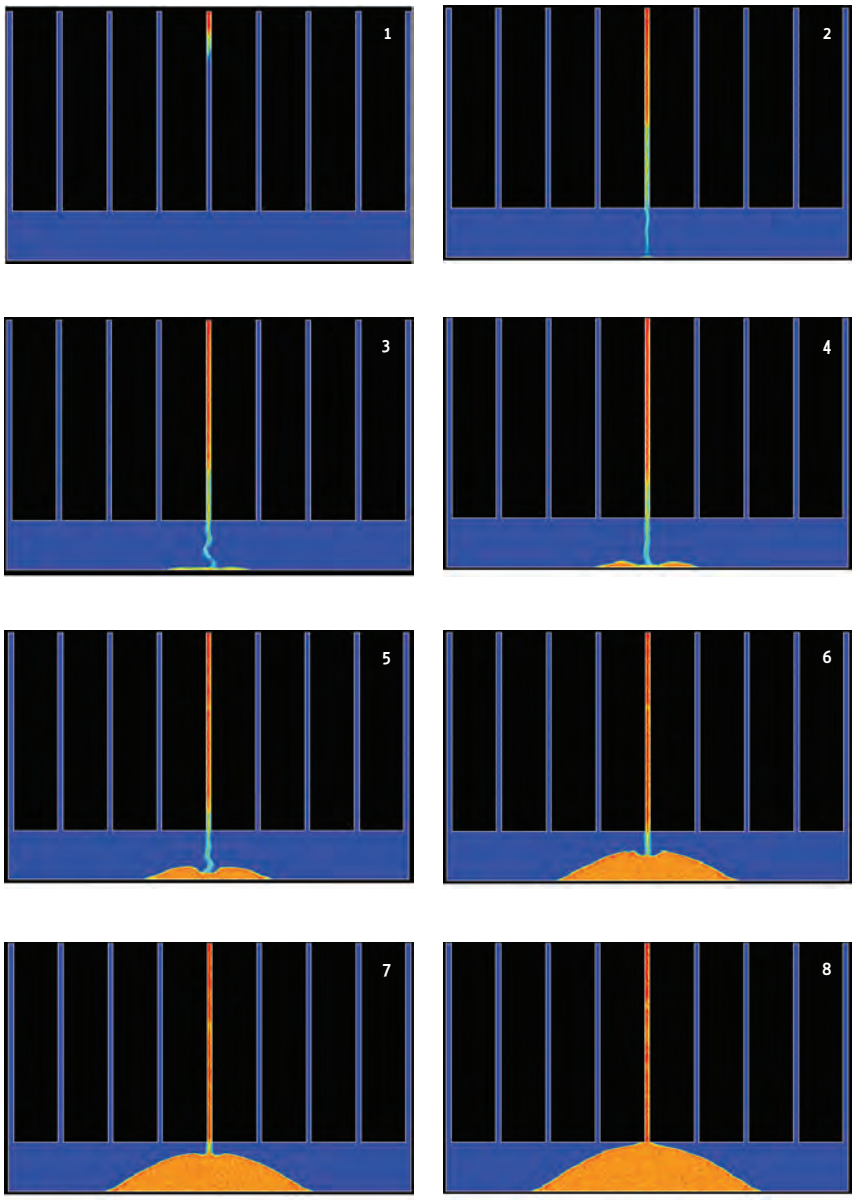
1 Suggested structure of the oil seperator
2 Percentage of oil inside the oil seperator
3, 4 Velocity vectors of the mixture inside the oil seperator
5 Hydrodynamic water pressure acting on the oil sperator walls

Sediment Movement and Settlement in Fluid

This one-of-a kind-model tested the settlement of sand and gravel propelled through a series of tube-like openings some traveling a distance of 3 to 5 m deep before reaching the water-filled cavity where the particles will settle at depth varying from 20 to 35 m. Settling first on the cavity's floor bed, the particles will then form evenly spread small sand mounts designed to fill the cavity with the minimum percentage of voids. The model tested the particles' trajectory at water surface penetration, through pressurized water movement from an initial dynamic condition in continuous flow down the tubes in a decreasing settling velocity.

3-D model parameters

- Multiphase flow (water /sand/ gravel)
- Unsteady turbulent flow
- Different grain size
- Different initial settling velocity
- Different water head
- Different friction angle

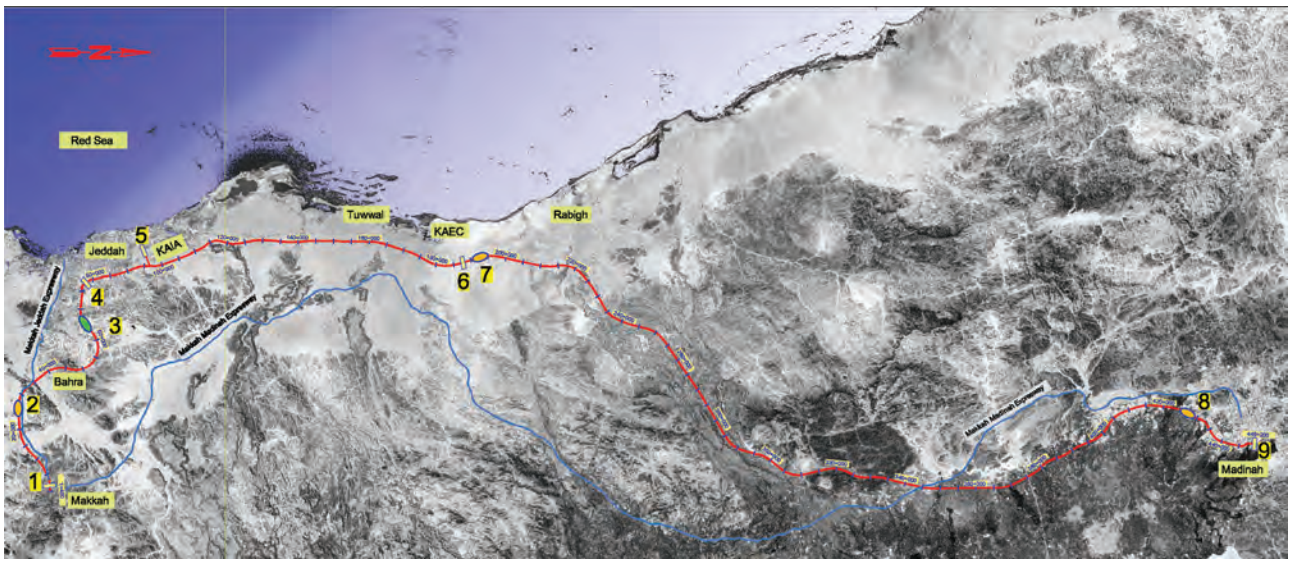


1 Particle pressurized penetration
2 Particle's trajectory decreasing velocities
3-7 Particle's settlement, horizontal expansion and mount built-up
8 Completed mount

The Haramain High Speed Rail

First High Speed Rail Project in the Middle East

by Ted Bolger, Transportation Engineer



The Haramain High Speed Rail key plan

Overview

Travel demand between the Holy Cities of Makkah and Medinah has been steadily increasing each year, especially during the Hajj, with an associated increase in road traffic congestion. In order to reduce delays to travelers, and as part of the Kingdom's program to encourage the use of public transport, the Saudi Railways Organization (SRO) has initiated the Haramain High Speed Rail (HHR) project. This electrified passenger railway line will link the two Holy Cities via Jeddah, and will have a commercial operating speed of 350 km/h. In addition to the benefit of reducing travel time, the HHR will improve travel safety, journey time reliability and environmental conditions, and will enable passengers to relax, use their phones or even work on their laptops while traveling.

Project components

The HHR is approximately 450 km in length and will have twin tracks, and the project includes 4 stations, 3 depots, 43 rail bridges, 12 wadi bridges, 29 road crossing bridges, 13 camel crossings, 30 vehicular culverts and 300 drainage culverts. In addition, modification of 8 road interchanges in Jeddah and 4 interchanges at Medinah is necessary where the road network is affected by the railway line.

Dar's scope of work

Dar's scope of work includes route selection, the development of an advanced concept design of the civil works, preparation of tender documents, assistance with the tender process, design review of civil works, superstructure and stations, project management and supervision of construction. Design review and supervision are based upon a fast track approach, in which the key is to keep construction flowing. The documents to be reviewed include: drawings, specifications, BOQ, reports, calculation notes and test results. The review is being performed by Dar's departments and covers the following disciplines: railway geometry, roads, geotechnical, structural, mechanical, electrical, drainage, architectural, landscaping, irrigation and environmental.

The challenge

Crucial to the efficient planning of a high speed rail line is the determination of passenger demand so,

a region which has not experienced high speed rail, Dar faced an interesting challenge.

The firm undertook a comprehensive review of existing traffic, in order to gauge the likely attraction of passengers to this express form of transport. This required a series of surveys including automatic and manual traffic counts on the main road network, a survey of domestic and international passengers passing through King Abdulaziz International Airport, as well as an examination of the historic flows of Hajj, Umrah and Ramadan pilgrims. The results of these surveys were integrated with forecast factors, derived from the Saudi National Transport Plan, to produce passenger forecasts for the years 2012 and 2042.
This detailed set of passenger demand flows laid the foundation for the design of the complete rail line. Based upon these flows, Dar was able to deliver a design framework comprising route structure (including rail service frequencies and timetabling), platform widths, number of escalators/elevators etc., which formed the basis for the design of the stations and rail terminal building. Train performance simulations were carried out to determine approximate travel times between stations. In particular, the complexity of handling the occurrence of the short-term surge of pilgrims during the Hajj, with design headways of very short periods, was addressed.

A further principal challenge for Dar has been the need to modify existing design criteria related to high speed rail, as used in other countries, to suit local Middle East conditions.

These criteria, concerning railway geometry, structures, geotechnical works and drainage, were modified by Dar's team within a short period, and have been adopted in the preparation of the Concept Design.

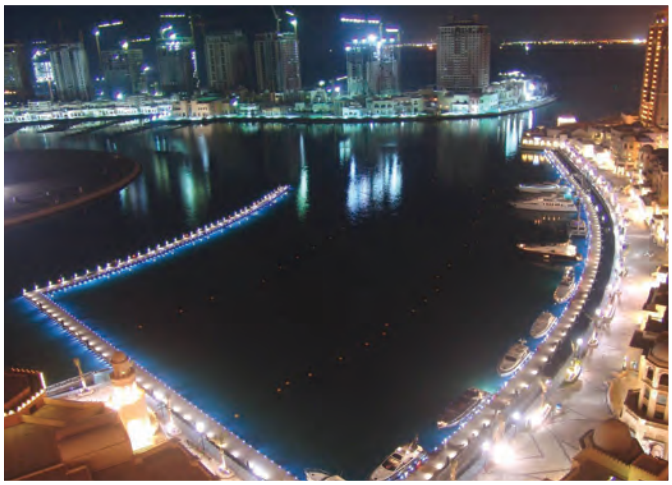
DarDoha, set up in the early 80's, is part of Qatar's continued transformation. Today more than 250 professionals working on a number of active projects at different stages of development or implementation split between office and site ensure close follow up and coordination with clients and other consultants. Our work in Qatar runs the gamut of our specialization with projects in master planning, transportation, infrastructure, industrial engineering, marine engineering and building design. With plans to host FIFA's 2022 World Cup shifting into high gear, we have already signed on to design Doha's New Khalifa Stadium one of 12 stadiums proposed and we are lined up to play a vital role readying Qatar for two weeks of football - a game that unites the world and a global event that will be played for the first time in the Middle East fulfilling FIFA's slogan: " For the game. For the world".

2005 - 2010: A five-year retrospective of Dar projects in Qatar

Main causeway into the Pearl Island

A sealed partnership

The Pearl Qatar, the iconic 400-ha man-made island on the Arabian Peninsula's eastern shores of the State of Qatar, is a United Development Company (UDC) development boasting 40 km of reclaimed coastline and 20 km of pristine beaches.
Dar Al Handasah has been with UDC from day one, the technical arm for management and monitoring of design activities and construction supervision, a partnership sealed for the project's entire run.
UDC is one of the largest private sector shareholding companies in the State, with a vision to create a unique living and cultural experience with the best of Qatar's past and present. The Pearl is a reflection of the strong ties that bind the people of Qatar to the sea and pearl harvesting - a long standing tradition. The result is a spirited community inviting residents to a way of life inspired by the idyllic natural setting, respectful of nature's bounties and mindful of the distinctive Qatari way of life.
The Pearl is a phased mixed-use community of themed districts counting beachfront villas, elegant town homes, luxury apartments, exclusive penthouses, five star resorts, marinas and upscale retail and restaurants part of this multi-billion dollar project.



Porto Arabia Marina day and night views

To each cove its own yacht and sailing marina.

- Total capacity = 1002 berths
- Porto Arabia = 782 berths
- Costa Malaz = 117 berths
- Viva Bahriyah = 103 berths
- Yacht range = 10 to 60 m
- Marina access = Porto Arabia marinas are accessible through 11 gates operated by access control system and controlled by the Harbor Master Office
- Floating system = precast concrete pontoons filled with polystyrene pontoons held in position by tubular steel piles
- Access to pontoons by aluminum gangway
- Fuel supply at the entrance of Porto Arabia and Costa Malaz marinas
- Fuel berthing via pontoon accessed by gangway
- Fuel storage = underground tanks
- Fuel supply = high capacity dispensers controlled by a fuel management system
- For super yachts and marina visitors fuel supply is directly at the berths via fuel outlets and portable dispensers
- Floating system components = pontoons, piles, gangways, timber decking, berth furniture including mooring cleats/bollards, fenders, ladders, safety equipment and signage, navigation aids
- Electrical services = ELV system for power, lighting, CCTV, telephone, broad-band and wifi internet, management control system/ metering and pedestals for electrical services
- Mechanical services for potable water, firewater, vacuum sewage system, pump-out system, oil/water treatment, fuel facilities, oil spill equipment and a ship-lift
- Separate shuttle/taxi/limousine berths transport services
- Control and Monitoring = Harbor Master Office

Mooring docks:
Porto Arabia, Viva Bahriyah & Costa Fayrouz

Marked as a prime world class yachting destination, Pearl island is constructed by dredging and filling the 400-ha reclaimed offshore land to an elevation of approximately +2.5 m QNHD. The shoreline was then stabilized using plain concrete seawalls, rip-rap revetments, and sandy beaches using marine sand.
The island is conceived with three distinct and unique coves: the Porto Arabia, the Viva Bahriyah and the Costa Fayrouz, each harboring a destination-island developed around a 5-stars hotel, luxury retail, international cuisine, entertainment, and aquatic activities. The seabeds around the island are dredged to -2.5 m QNHD, while the navigation channels and marinas reach -4.0m QNHD. The main channel to Porto Arabia and the super yacht marina basin are dredged to -5.5 m QNHD.

The Marina's mooring docks

The Four Seasons Resort at Marsa Arabia


1

Project Managers	Dar Al Handasah
Client	Marsa Arabia/ Four Seasons Hotels and Resorts
Architect	WATG
Interior Architect	Frank Nickelson
Landscape Architects	EDSA
Security Consultants	Olive Group

Spa Design	Blu Spas
Lighting Consultants	LLD
Food Service Consultants	Romano Garland
Accoustics Consultants	Accousystem
MEP Engineers	Dar Al Handasah
Infrastructure Design	Dar Al Handasah

Transport Planning	Dar Al Handasah
Structural Engineers	Dar Al Handasah
Geotechnical Engineers	Dar Al Handasah
Marine Engineers	Dar Al Handasah
Construction Management	Dar Al Handasah

The centerpiece of the Porto Arabia is the luxury 300-key, 100,000 m² built-up area Four Seasons Resort Island designed to capture the distinctive feeling of the Island's location in the center of the Porto Arabia Marina. Dar Al-Handasah acted as project manager, and building services engineer for this cross-continent multi-discipline collaboration involving a number of specialty consultants working to distinct Four Seasons Resort and UDC design guidelines. Dar is project coordinator reviewing concept designs, detailed design submissions, tender documents, in addition to designing all marine preparation and enabling works, building engineering and transportation planning. Dar also acts as construction management consultant for the 40-months expected construction period.

2


3

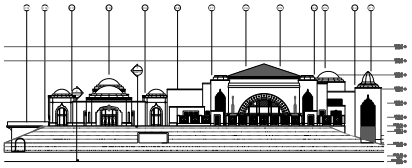

4

1 The Four Seasons Resort location site in the middle of the Porto Arabia Marina
2 Site location map
3 An aerial view of the completed resort
4 The resort's main entrance night shot

FOUR SEASONS
Hotels and Resorts

مرسى أرابيا
MARSARABIA

7



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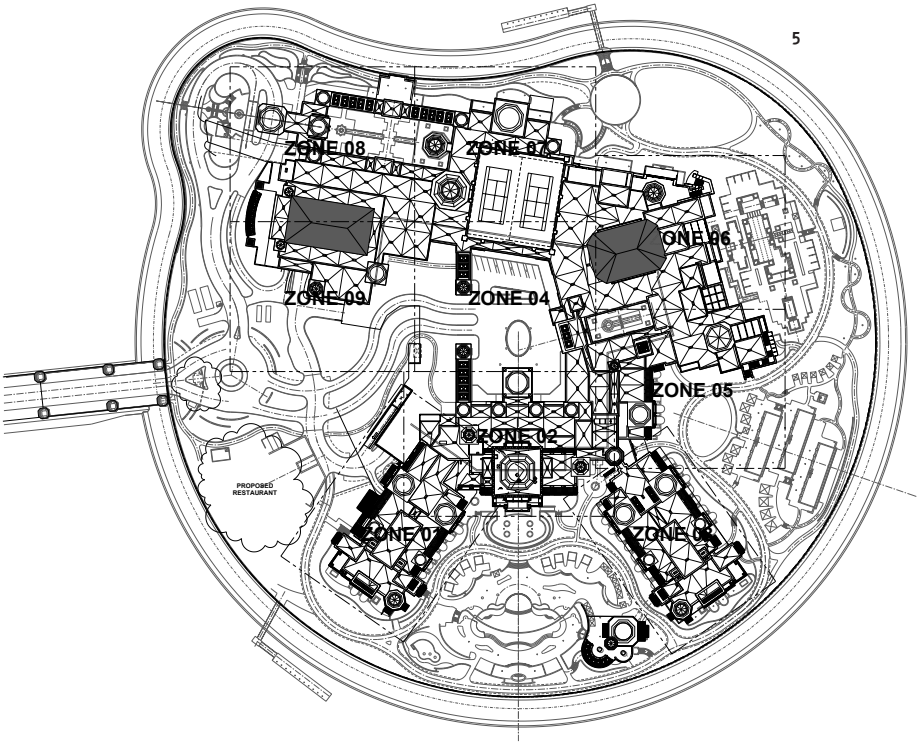

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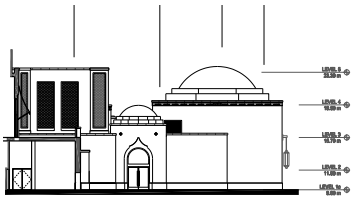

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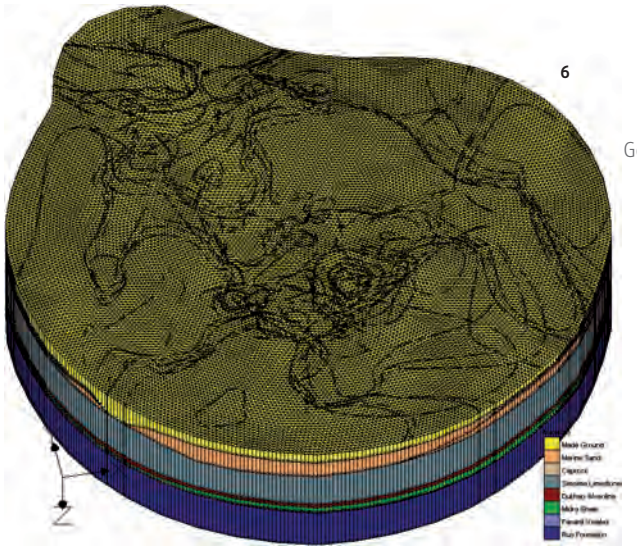


Geotechnical design provides design criteria for foundation, dewatering activities during excavation works, temporary shoring system design, stability analysis of subgrade under high fills, and assessment of liquefaction hazards.

Protective measures for concrete elements with respect to chemical agressivity of the natural terrain and ground water table asphalt concrete pavement design and temporary berth design were also part of the work scope.

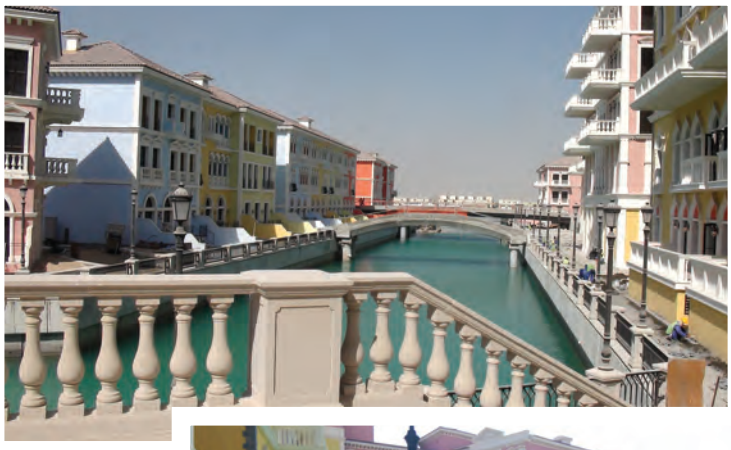
5 Overall site and roof plan
6 3-D soil model
7 Elevations, white aerial perspective
8 Exterior elevation detail

Living by the beach: La Plage South

La Plage South, a Pearl precinct designed by Dar Al Handasah, is located at the southern tip of the island overlooking extensive beaches to the skyline of Doha in the distance. Taking advantage of the shoreline, the plot is configured into five semi-circular apartment groupings progressively stepping down from a maximum of seven to one storey encircling a pool, landscaped gardens, and retail venues. The architecture is rich with emphasis on facade diversity, Mediteranean colors, and unique detailing. A terraced staggered design is used to enhance the human scale and maximize visual integration.

Qanat Quartier

Venice-inspired Qanat Quartier is planned around intricate canals, pedestrian-friendly squares and plazas. Now in the final construction stages, this residential quarter is a Dar-design and supervision project. With over 450,000 m² of built-up of residential islands separated by man-made canals and interconnected by vehicular roads, and pedestrian bridges, the sea-fronted project comprises townhouses, apartment buildings and retail promenade areas.



Qanat Quartier's now completed colorful building facades and Venise-inspired canals

A common thread

Fully coordinated landscape, hardscape and infrastructure design

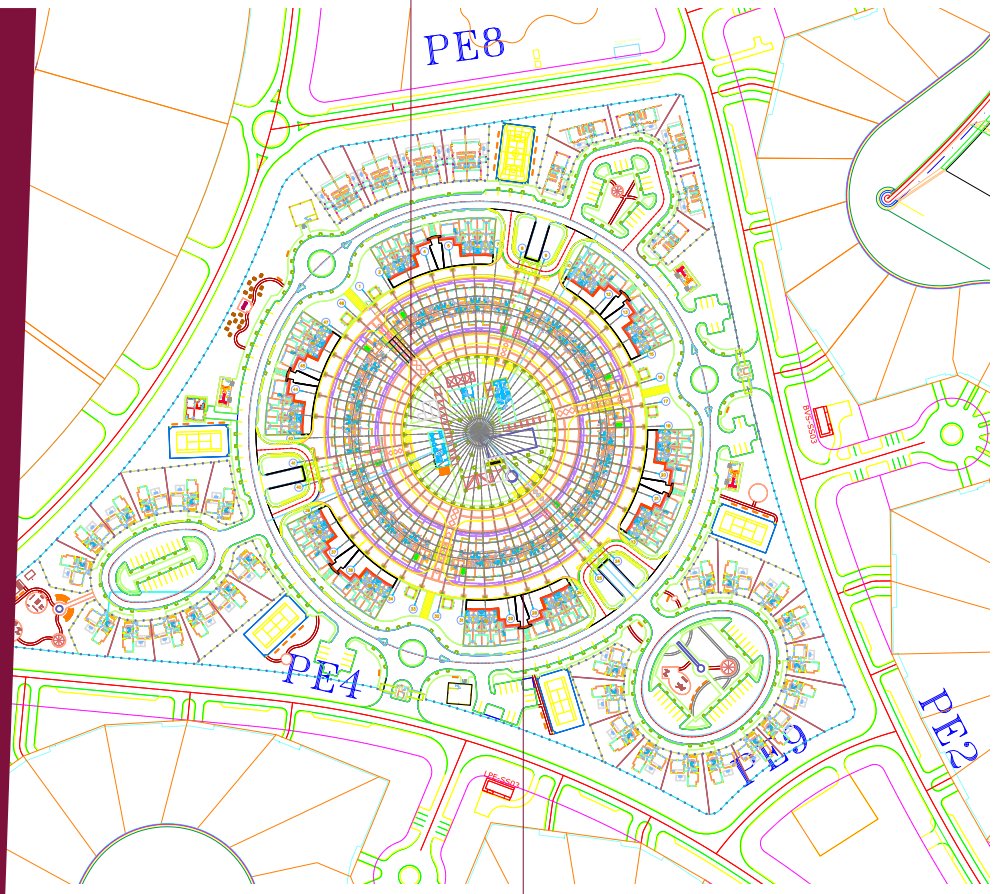
Public space design is at the heart of urban development and the Pearl landscape strategy is being reviewed by Dar landscape architects to pull one common thread among the island's elements fully coordinated with all infrastructure works.

Community living

Floresta Gardens

The core living center and soul of the Floresta Garden community is the Club House and the promenade around it.

A community of apartment buildings, detached and semi-detached townhouses situated east of Viva Bahriya is one of the most prized locations on the island. Home to an estimated 1,400 residents, consisting of 285 apartments and 100 townhouses, this master concept revolves around a concentric introvert coliseum style layout.



Masterplan southern exposure

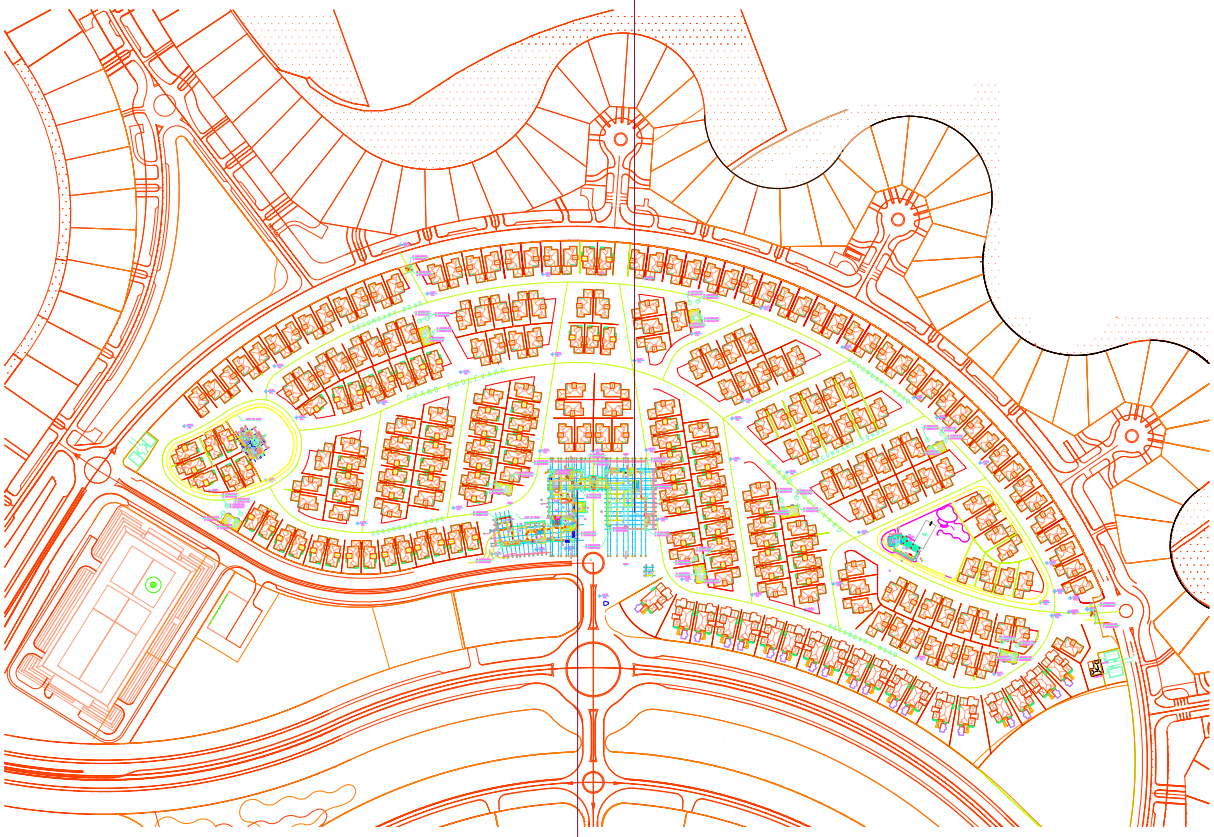
Floresta site location

Green pedestrian and cycling promenade

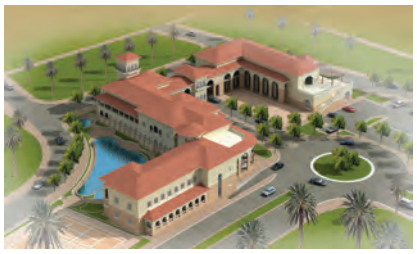
Giardino Villas

Giardino Villas is a 23-ha private residential development functioning as a connecting element and conceptual transition between a stretch of water-front villas and Porto Arabia. Focused around a U-shaped 5,000 m² central club house, Giardino villas follows an organic, garden-themed layout.

Giardino clubhouse and pool



The leaf-shaped site is laced with street patterns that echo the veins and textures of a leaf.



The community clubhouse is on a direct axis and line-of-sight with Porto Arabia gated community. The connecting road between the two communities continues through the gated entrance and beneath a colonnaded Grand Arcade.

State-of-the-art infrastructure design and facility management

Pneumatic solid waste collection-compaction station

Solid Waste Collection System

The pneumatic vacuum solid waste collection system collects and transports a total 950 m^3/day (124 tons/day) of mixed refuse from buildings, villas and retail outlets throughout the island. The refuse is dispensed into loading doors (inlets) and sucked up via four separate underground piping networks (in 500 mm pipes) using compressed air at different pre-set times of the day to four collection-compaction stations. Air is cut off at this point and the refuse is directed to separator-compactor stations then to the handling unit station where the now compacted waste is loaded onto disposal trucks and driven away from the island.

Temporary WWTP
(Total capacity: 5,000 m^3/day)

Waste Water Treatment Plant

The waste water treatment plant designed to treat domestic sewage for the preliminary phase and labor camp (total capacity 5,000 m^3/day) serves a population of 18,500. Built over 4,000 m^2 of temporary facility and applying SBR (Sequential Batch Reactor) technology, construction works for the QR30 million WWTP took a little less than a year to complete. The treated sewage effluent is being reused, filling recreational lakes within the project that are doubling as irrigation storage reservoirs.

Commitment to environmental values and state of the art monitoring and operations were systematically developed and integrated into the Island's design program.

Integrated District Cooling Plant (IDCP)

Built on a 16,000 m² site, the rectangular Integrated District Cooling Plant (IDCP) building (footprint: 203m X 75m X 37m) houses the DCP and the sea water Reverse Osmosis (RO) treatment plant supplying the entire Pearl Island.

Mechanical features

- 130,000 tons of refrigerant
- 52 centrifugal chillers of open water electric drive (134a refrigerant)
- 52 constant flow primary pumps of the split-case centrifugal type
- 26 cooling towers (field erected induced draft counter flow, FRP double mounted on concrete water basins)
- 120 ETS and 14 HEX rooms

Electrical features

- 170 MW substation
- 120 MW required for operation
- 43 transformers (66/11/3.3/415 kV)
- 43 Motor Control Centers (MCCs)/Main Distribution Boards (MDBs)
- 130 high voltage motors

Control & communication

- Advanced SCADA system
- Fiber optic network for complete digital communication
- Remote monitoring and optimization of chilled water delivery

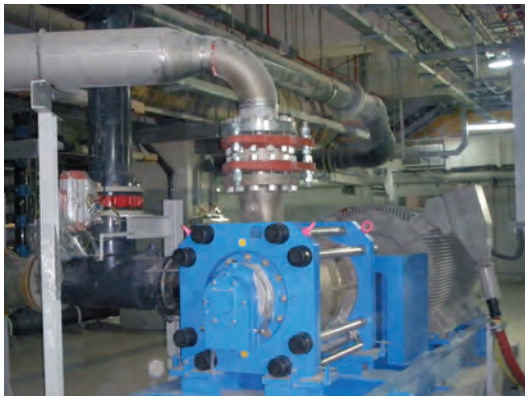
Telecommunication Network Solution

A fully converged IP-based network with redundant node cores, primary data center NOC1 (Network Operating Center) and back up data center NOC2, is designed and developed to carry telecom and non-telecom traffic using the MPLS VPN technology. Internet, IP telephony and IPTV/VoD (video-on-demand) for residential and retail users, IP-based point of sale services for retailers, a 24-hour contact center, indoor/outdoor WiFi hotspot, MPLS VPN services for business customers and Triple Play services for marina boats are offered to the end-user.

District cooling chillers

Reverse Osmosis Plant

The RO (Reverse Osmosis) plant within the IDCP building produces 35,000 m^3 of water/day covering the total demand for the Pearl development including cooling, fire fighting and irrigation. The RO occupies 3-levels, the basement reserved for filters and main raw and permeate water tanks, the ground floor and mezzanine for the chemicals and the first floor for the RO and membranes' skids.



RO cartridge filtration and pressure pump

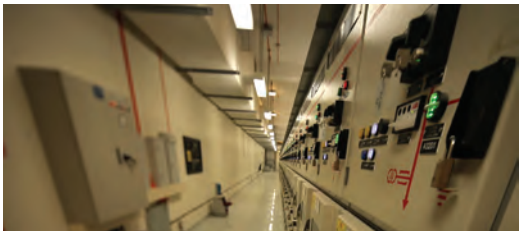
The sea water RO supplies the island with potable water, in addition to water for the DCPs' cooling towers and irrigation needs. The seawater intake discharge and pumping station are designed and sized with enough capacity for the full 35,000 m^3/day production of water quality containing no more than 400 PPM for TDS, fully compliant with local water quality and service standards.

Mechanical features
- Pretreatment (including fine band screening)
- Chemical treatment
- Multi-media filters
- Cartridge filtration
- 1st and 2nd pass pressure pumps
- Energy recovery device
- 1st pass membranes
- Partial flow (two stages) second pass membranes
- Post chemical treatment

Electrical & instrumentation features
- Motor control centers
- Panel boards
- Stand alone management system PLC
- Local PLC panel (SCADA)

Marine works (intake & outfall system)
- Ø 1200mm HDPE intake pipeline (total length = 1670m on/offshore)
- Ø 900mm HDPE outfall pipeline (total length = 1700m on/off shore)
- Ø 90mm HDPE chlorine injection pipeline (total length = 1670m on/offshore)

Electrical Power Network



Electrical power supply GIS switchgears

The electrical power supply is secured by KAHRAMAA (Qatar General Electricity and Water Authority) via two 132 kV redundant feeders providing 250 MVA and an additional 132 kV feeder with the same capacity providing a total secured load of 500 MVA.
The 132 kV feeders are connected to the main primary substation (SS1) where the voltage steps down to 66 kV. A 66 kV network is provided internally within SS1 (SS1 also contains 66/11 kV transformers & 11 kV switchgear) and extended between SS1 & other four 66/11 kV substations distributed throughout Pearl Island and the IDCP 66/11kV substation.
Each of the five 66kV primary substations contain GIS switchgears, 3x50/60MVA transformers, 11 kV switchgears and control systems. The substations are core points from which outgoing 11kV cables in loop configuration are transmitted up to 11/0.415 kV substations within the high rise buildings and to the external substations distributed throughout the island. MV / 415V feeders extend to the low rise buildings, public utility plants, street lighting, and other lit features on the island.

Smart Island Integrated System

Designed with a unified command and operating philosophy, the Operation Command and Control Center (OCCC) functions, built and developed for the Pearl Island's Smart Island Integrated System or SIIS, serve all networks and server related to building management and facility security and control.

SIIS operation room

SIIS security and control systems

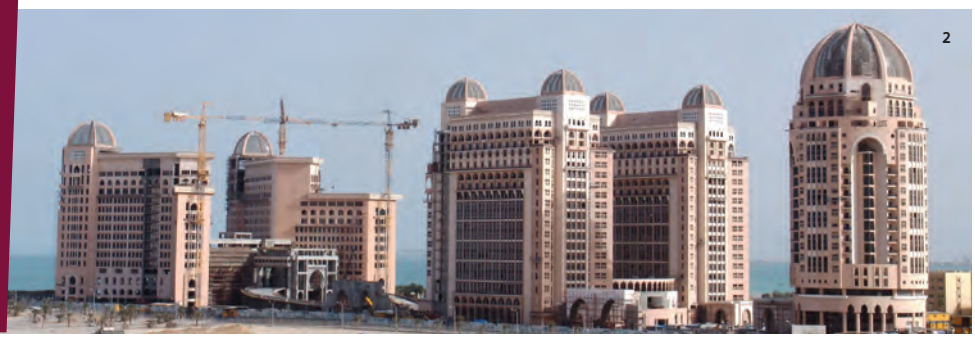
- Security access control (monitoring and smart card system)
- Video surveillance system (CCTV)
- Radio communication system (Tetra)
- Guard tour applications

SIIS facility management systems

- BMS (Building Management System)
- Fire alarm system
- Lighting control
- Traffic light signals
- Parking management system
- Utility billing systems
- Utility monitoring, control and automation

Saint Regis Hotel & Residential Towers at West Bay

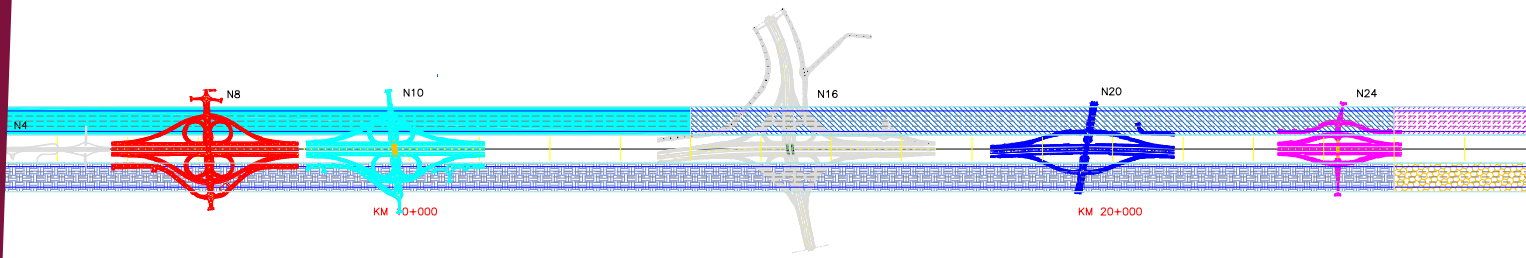
The St. Regis Hotel and Residential Towers in Doha's spectacular West Bay are nearing completion. A Starwood Chain® elite brand hotel, it is set for grand opening in late 2011.
Dar was planner, designer (architectural and engineering) and construction supervisor for the 240,000 m² built-up area high-end mixed-use project. The St. Regis is a 334-key full-service luxury beach front hotel and the residential towers consist of 422-high-end apartments.



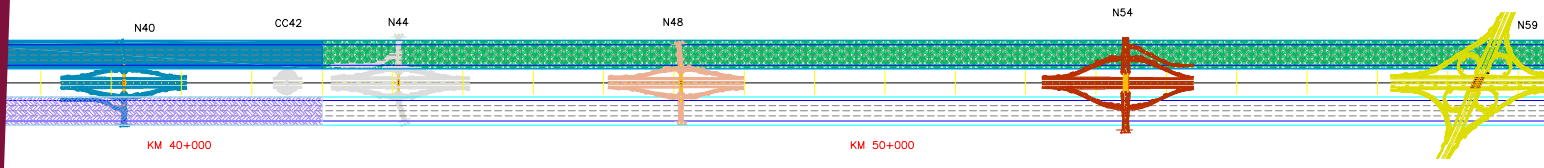
1 Hotel entrance ramps during construction viewed from the adjacent West Bay Towers
2 The St. Regis hotel (background) and Towers at West Bay (foreground)

St. Regis under construction viewed from the jetty

The North Road

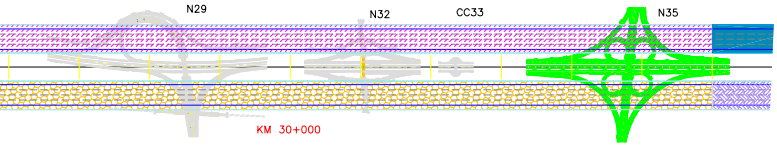


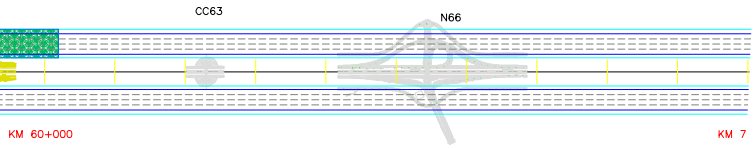
The bulk of the national road network of Qatar was constructed in the 1970s and 80s, as single or dual 2-lane carriageways. The North Road, part of a government plan to improve the country's road system, is a 141-km thoroughway upgraded to a 4-lane expressway.

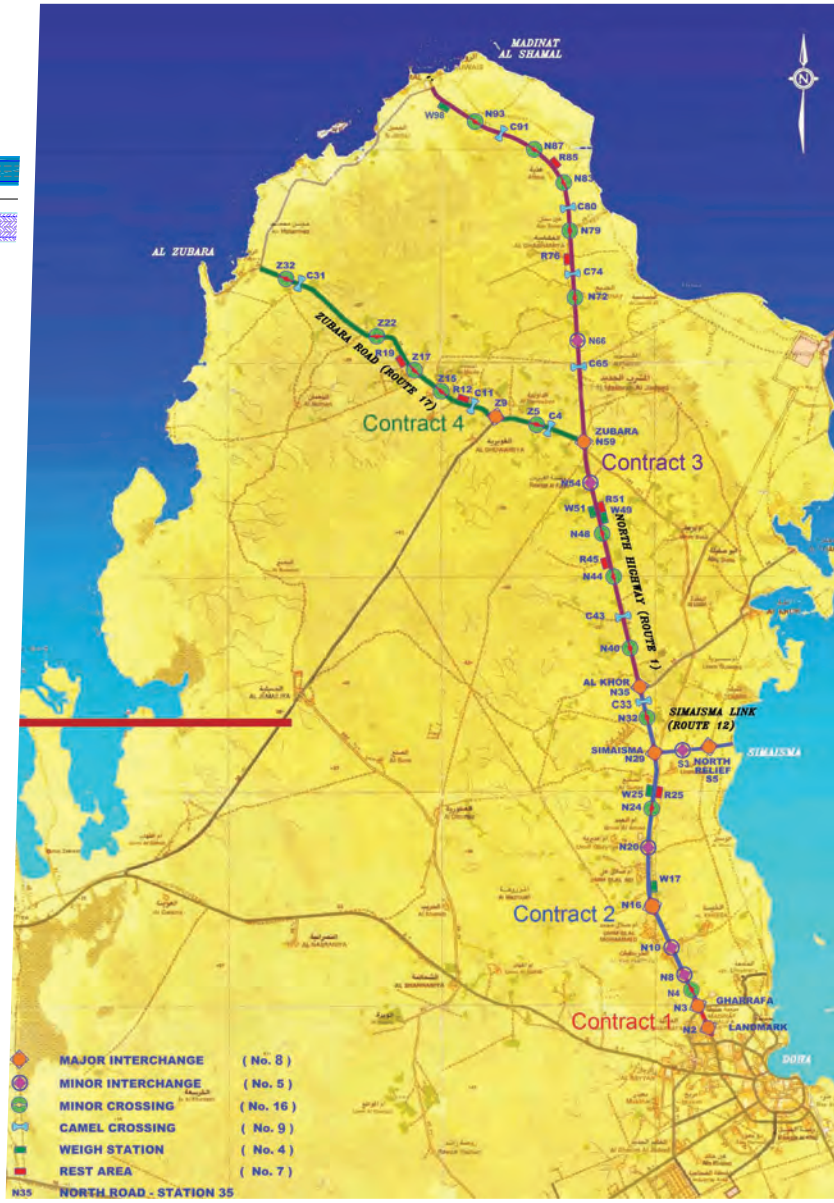


Three roadways comprise this segment, which forms the main link between the capital city Doha and northern part of Qatar:

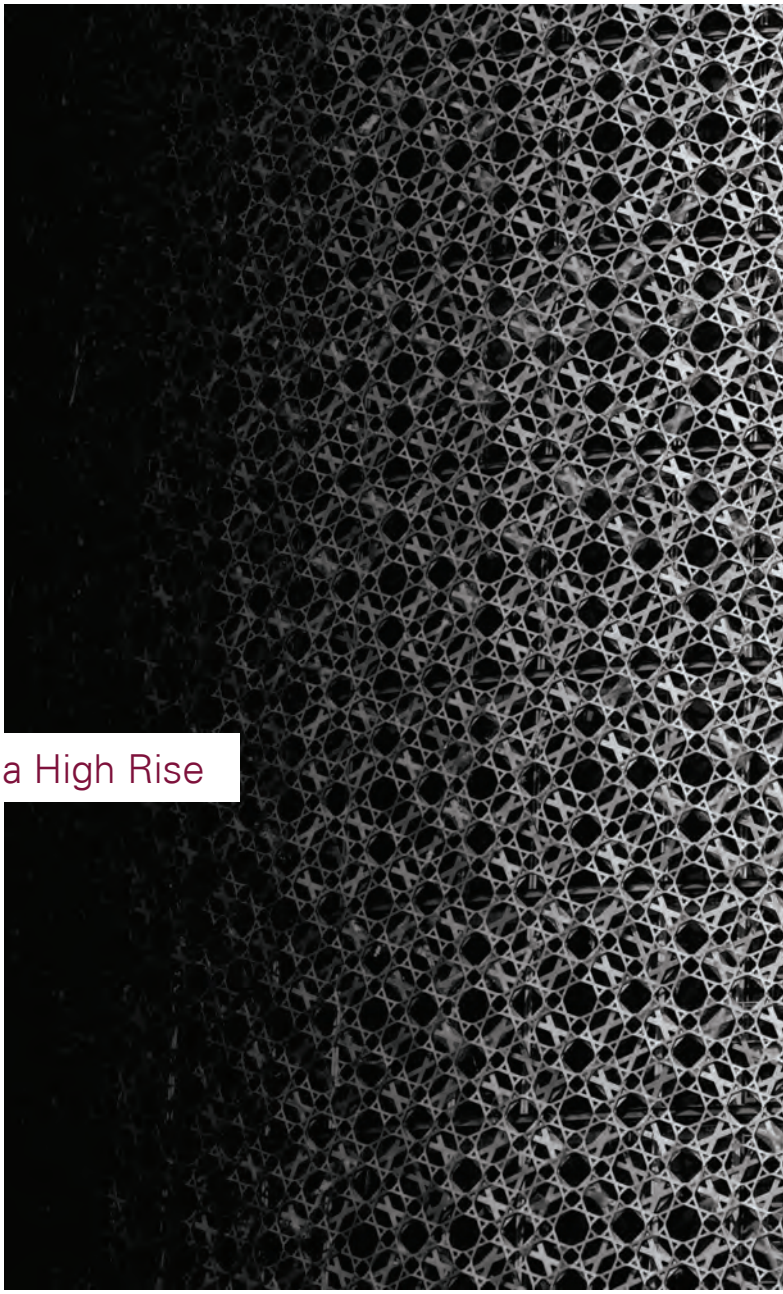
- North Road (98 km) links Doha with Madinat Al Shamal/Al Ruwais on the north coast.
- Al Zubara Road (35 km) forms main approach to the future Qatar-Bahrain Causeway.
- Simaisma Road (8 km) connects North Road to a rapidly developing area on the east.



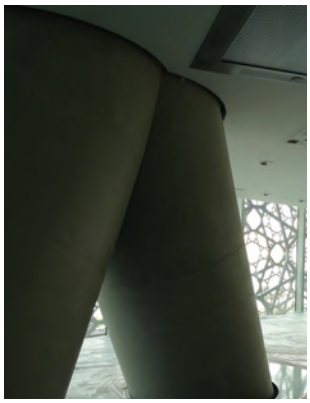




Top Route 1 and Sumaisima link construction photos
Right North Road project location map



Supervising Jean Nouvel's Doha High Rise



Top Doha skyline
Bottom The tower's circular reinforced concrete 1.7-m diagrid columns, metal decking and reinforced concrete slabs structure and double cladding facade

Dar was contract manager and lead site supervisor for the famed architectural firm Atelier Jean Nouvel's Sheikh Saoud Bin Mohammed Bin Ali Al Thani iconic high rise in downtown Doha. The231-m high singled out unique tower structure encases a 113,000-m² built up space including 3 parking basements, 44 office levels around a 127-m high internal atrium. The tower's circular reinforced concrete 1.7 m diagrid columns, metal decking and reinforced concrete slabs structure and double cladding facade is wrapped by a intricate musharabiah-inspired outer aluminum layers. The contemporary design's dual sun shade and sunlight diffusing function complements the inner aluminum screen and high quality clear glass for added occupant comfort and limited energy use. Each floor boasts spectacular cardinal views eastwards to the Gulf, southward onto Doha Sea Port, westward toward the city of Doha and magnificent Pearl Island view to the north.

Main image Outer aluminum detail
Inset Atelier Jean Nouvel High Rise views

1

Upward Mobility
Improving the Urban Environment in Taiz

by John Davey, Environmentalist

Having been weaned on the travelogues of Freya Stark and Wilfred Thesiger, Yemen always held intrigue. The Prophet Muhammad (PBUH) said the Yemenis had ... *the kindest and gentlest hearts*.., and having traveled from the sands of the Rub al Khali to the Red Sea, from the northern mountains to the Gulf of Aden and beyond to the magical Island of Socotra, I can confirm the country remains one of the most intriguing and its population one of the most friendly.

Of Dar's many projects throughout this fine land, one of the more recent has been the Integrated Urban Development Project (IUDP) for the City of Taiz, located in the Yemeni Highlands 260 km south of the capital Sana'a, where the climate and the people share a common temperance broken only by the ruggedly towering presence of Jebel Sabir.

The renowned Arab traveler Ibn Battutah (1304-1369) described Taiz as ... *one of the largest and most beautiful cities of Yemen.* It was the capital from 1175 to 1500, and again from 1948 to 1962. It remained walled until 1948 and still contains many old and beautiful quarters with much traditional architecture.

The present day economy is based on agriculture and food processing, the fertile wadi valleys yielding coffee, mango, pomegranate, citrus, banana, papaya, vegetables, cereals and Qat.

With rainfall more than 1,000 mm/year on Jabal Sabir, storm runoff was frequently catastrophic and for more than a decade the World Bank has been funding flood alleviation works. The risks to life and property have now been reduced to the extent the Yemeni authorities and the Bank can now turn their attention to improving access to public infrastructure and community facilities in densely populated but unplanned and largely unserved residential areas in the city's suburbs. Despite boasting the first purified water distribution system in Yemen, dating from the 1960s, the Ministry of Public Works and Highways identified 22 informal areas, three of which, Al-Maftash, Al-Haraziyah/Al-Arous, and Madinat Al-Nour, were prioritized for upgrading.

The project is founded on extensive public consultation. Following social surveys by the Ministry and household surveys by the design consultant, Dar undertook two series of focus group discussions during October 2009 and January 2010. In October, women freely expressed themselves at Al-Maftash and Madinat Al-Nour, but in Al-Haraziyahh/ Al-Arous, one-to-one interviews were held to overcome reluctance to attend with men. In January, separate male and female sessions were held in each community, together with a central institutional stakeholders meeting.

Overall, Dar have provided independent review of the conceptual designs through environmental and social impact assessment, the development of an Environmental and Social Management Plan (ESMP) and preparation of a Resettlement Policy Framework (RPF).

1 Typical Yemeni village on the edge of Jabal Sabir
2 The author at a local recycling point in Taiz


2

Overall, Dar have provided independent review of the conceptual designs through environmental and social impact assessment, the development of an Environmental and Social Management Plan and preparation of a Resettlement Policy Framework.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Existing conditions

The combined population of the three settlements is 21,000, of which 70 percent live on less than $1/day. Rapid growth and the lack of public infrastructure have resulted in severe environmental degradation and the prevalence of vector-borne and water-borne diseases such as dengue fever, malaria and enteric disorders. While unsurfaced tracks afford vehicular access to the outskirts of these communities, narrow alleyways and stepped walkways characterize their interiors. With no storm drainage, residents, particularly those enduring impaired mobility, suffer eroded pathways after rain, while those needing hospitalization have to be stretchered by hand to the main road. Throughout Taiz there is a scarcity of water and even formally developed areas receive state water only once or twice each month. In Al-Maftash, water tankers deliver to communal plastic tanks from where water is hand-carried to homes; elsewhere there is rudimentary distribution.

Most raw sewage is discharged to cesspits or nearby wadis but 10-20% of people have no access to proper sanitation. Household refuse also ends up in wadis, where it festers until the next rains wash it downstream, ultimately to the Red Sea.
Each community has rudimentary power distribution that provides for limited street lighting, but levels of illumination are inadequate for basic safety and security. Given the general level of poverty, the rate of crime is relatively low but drug-related theft, particularly against women and at night, is increasing.
All three communities include members of the Akhram ethnic minority, popularly believed to be descendants of Ethiopian soldiers of the Aksumite Empire that occupied Yemen over 1500 years ago and remained as servants when the occupation ended. Once severely discriminated against, they are now largely integrated into Yemeni society.

3 Street market
4 Watersource near the existing Taiz landfill site

Benefits and beneficiaries

The proposed urban upgrading provides for improved access pathways, water supply, sewage, drainage and street lighting. Additional flood protection will be provided for Al-Maftash, and retaining walls will be built at Al-Haraziyah and Al-Arous to improve slope stability.
While the immediate benefits are obvious, the long-term gains will be of even greater value. Increased access to water not only improves personal hygiene and household cleanliness, it also permits more conscientious food preparation, reduced vector-breeding sites, and general improvements in public health. Furthermore, cleaner, healthier and better fed children are more motivated to attend school, resulting in better educational attainment, while adults are more likely to realize their optimum earnings potential, consequentially improving family relationships and community harmony. Similar downstream benefits with a greater health component accrue from improved sanitation.
The provision of storm drains and surfaced walkways will prevent erosion by rain and improve access for the elderly, young children, mothers with babies, expectant women and others with impaired mobility. The response time for doctors, community nurses and other emergency services will be shortened, and refuse collection facilitated.
The upgrading of street illumination will improve night-time accessibility, public safety on stairs, and personal security, while the use of photovoltaic panels and motion sensors will limit power consumption.

Mitigation of adverse impacts

Against these benefits must be balanced the adverse impacts. By its nature, urban upgrading construction activities intrude throughout the community. While only temporary, this inherently disrupts pedestrian and vehicular access to homes and community facilities, increases noise, vibration, odor, dust and atmospheric pollution, and generally imparts a public danger. Dar's ESMP identifies a wide range of measures to avoid, mitigate or manage these impacts, and contractors will prepare a Construction Environmental Management Plan to show how they will be implemented.
Potentially permanent negative impacts include the risk of structural damage to buildings with inadequate foundations, caused by trenching operations in the narrow alleyways. Much excavation work will therefore be undertaken by hand, open trenches will be adequately supported, and where there is no vehicle loading, pipes will be laid at shallow depths.

1 Madinat Al-Nour
2,3 Scenes from Al-Maftash
4 Al-Haraziyahh
5 Limit of vehicular access to Al-Maftash
6 Local kids posing for the author's camera
7 View below Al-Qadah castle


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Because road improvements have been limited to existing rights-of-way and empty government-owned plots taken for structures such as pumping stations, no land-take over the 25% permitted under Yemeni law for projects for the public good is anticipated. The conceptual plan avoids involuntary resettlement but should this change during detailed design, Dar's RPF provides appropriate procedures under both Yemeni law and World Bank operational policy to redress any loss.

While a formal land-ownership registration system is now in place for new transactions, many existing residents, be they long-term squatters, tenants, or those who have purchased the land they occupy, lack formal documentation and hence security of tenure. Because land and property values will inevitably increase with upgrading, previously disinterested owners, absentee landlords and others will claim property to sell or rent at inflated prices beyond the means of existing occupants.

Also detrimental to the existing communities will be *gentrification*, the social and cultural changes that occur when previously poor but newly improved and serviced communities attract wealthier residents. Average incomes increase and average family sizes decrease, resulting in the economic eviction of the original residents as rents and property prices escalate. Consequentially, there is inward migration of new businesses to cater for more affluent consumers that simultaneously decreases accessibility to previous residents.

Mitigation for both these situations focuses on the registration of property and occupant interests prior to the commencement of upgrading works, and

procedures to ensure present occupants receive improved security of tenure and/or are fully compensated for any loss of property, assets, and livelihood. In addition, the government will consider house repair grants or loans for pre-project residents, 'right-to-buy' schemes, mortgages for the poor, and incentives for owners or tenants to upgrade rented housing.

The third significant impact is that water, sanitation and other public utility service providers services will expect to levy prevailing subscriptions and charges throughout the beneficiary communities. With 70% living on less than 1 US$/day, this will place an unacceptable burden on many household budgets, and some families will be forced to move to informal settlements elsewhere.

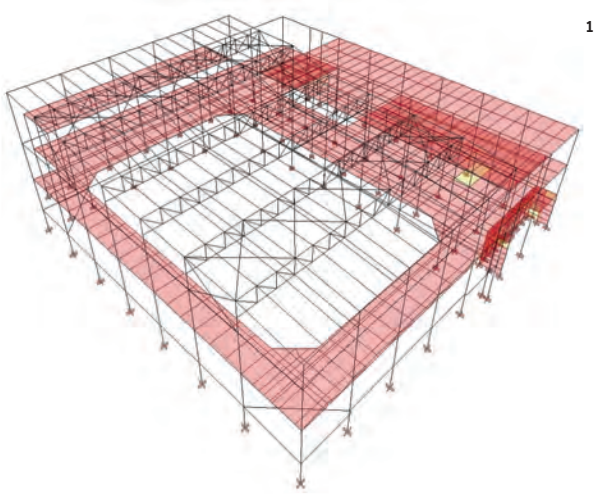
To alleviate this, tariffs should be restructured to allow services, particularly water, to be charged progressively, so the basic requirements for health and hygiene are affordable by all, i.e., charged at a rate well below the economic cost of provision, while profligate consumers pay substantially more than the economic cost, simultaneously deterring high consumption and subsidizing basic users. On completion of construction, the impacts accruing from system operation will generally be limited to leakage from broken pipe, overflows from broken sewers and blocked manhole chambers. NGOs and CBO will be encouraged to organise public awareness campaigns in schools and community groups, to promote more effective household management, including the use of water and the maintenance of sanitation facilities.

Looking to the future

The original concept for the IUDP included for solid waste management but this was put on hold pending the identification of a new landfill site acceptable to the wider Taiz community.

In the longer term, the Taiz urban upgrading will provide a model for the development of a National Urban Upgrading Framework that will formulate a coordinated approach to future country-wide upgrading, for which the government will establish an inter-ministerial committee to provide guidance and support.

1 Al-Arous
2 Scenes from Al-Maftash
3 Al-Haraziyahh
4 Daily scene in Al Maftash



1

Floor Vibration Analysis A Case Study:

The Staff & Faculty Community Center at Princess Nora Bint Abdul Rahman University

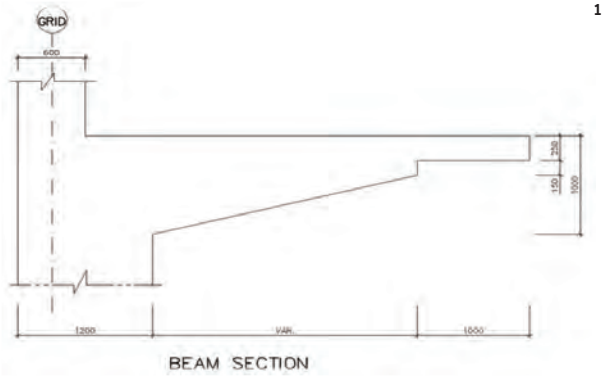
by Shekhar Palshikar & Vaibhav Singhal, Structural Engineers

When large-span floor systems are subjected to crowd-induced vibrations, occupant comfort is an important index of serviceability, and the control of deflections stipulated in current code requirements cannot sufficiently represent the serviceability requirements of floor systems.

Take for example the Staff & Faculty Community Center at Princess Nora Bint Abdul Rahman University (PNU) in Al-Riyadh. The first floor 3.8 m wide jogging track is cantilevered from a single row of columns on one side. The track floor system consists of a cast in-situ 250 mm thick reinforced concrete slab continuously supported on a 1000 mm deep 600 mm wide RC beam cantilevered from 600 mm X 1200 mm RC column. The whole system is monolithic cast in place reinforced concrete. The first floor is 5 m above the ground floor and the roof is 5.5 m above the first floor. The column size is reduced to 600 mm X 600 mm above the jogging track slab. Due to its flexible nature, it is susceptible to vibrations, and hence needed to be analyzed for dynamic effects.

2

1 3-D model of building in SAP2000
2 Architectual view of jogging track



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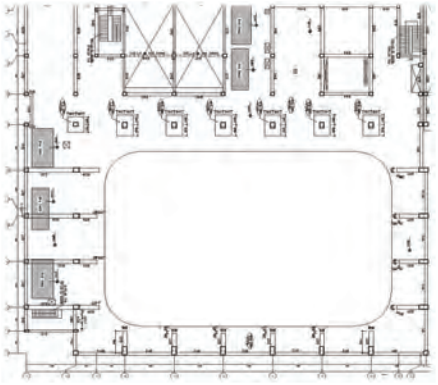
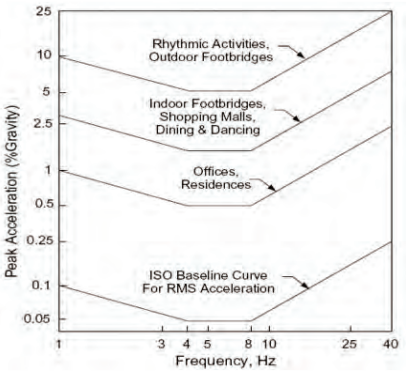


2

Human Comfort Acceptance Criteria

Acceleration limits as recommended by the International Standards Organization (ISO 2631-2: 1989) are shown in graph 3 for intended occupancy as a percentage of gravity. The baseline curve represents accelerations up to which the resulting vibrations are not perceived by humans. The acceleration limits for structures depending upon their occupancy and functionality are defined as multiples of this baseline curve. The multipliers for the proposed criterion, which is expressed in terms of peak acceleration, are 10 for offices, 30 for shopping malls and indoor footbridges, and 100 for outdoor footbridges. The PNU jogging track is categorized as a 'rhythmic activity' structure and the maximum acceleration limit is 5% of gravity.

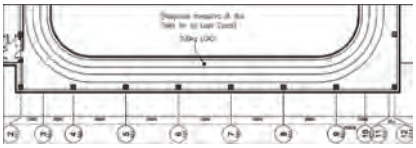


3

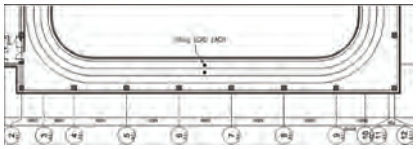
Vibration Analysis

Modal analysis of the building was carried out in SAP2000 (Finite Element Software) to find out the fundamental modes of the structure that is modeled as a full 3-D geometry. Mode shapes were restricted to 50 to curtail the frequency in the range of 2-12 Hz. Mode shapes were sorted out which involved the vertical degree of freedom of the slab. It was found that the slab became excited in a vertical direction for a few frequencies ranging from 3 to 8 Hz. Since this is the range of frequency at which vibration perception is greatest (as it coincides with people stepping or jogging frequency), further analysis was required to ascertain the acceleration value at these frequencies. Forced vibration analysis was the most reliable way to find the response of the structure at given frequencies. SAP2000 has built in functions to carry out such analysis.

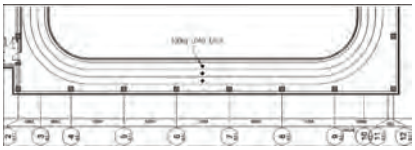
4



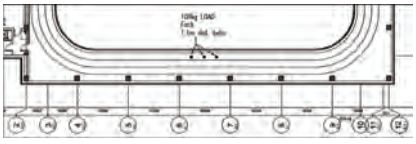
A Single load applied on innermost track



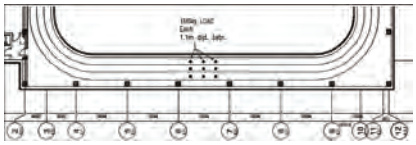
B Two loads applied on innermost adjacent tracks



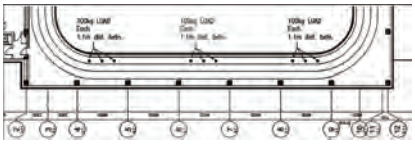
C Three loads applied on all tracks



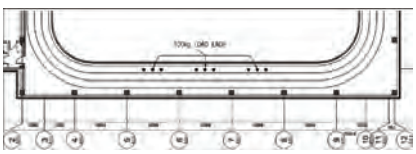
D Three loads applied on innermost track



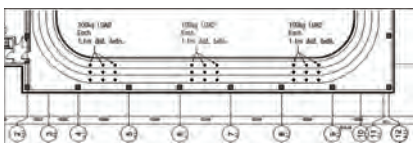
E Nine loads applied on one span



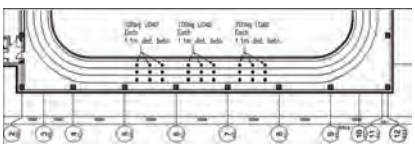
F Nine loads on inner track, alt. spans, (3 loads /span)



G Nine loads on inner track, adjacent spans (three loads per span)



H 27 loads on all tracks alternate spans (9 loads per span)



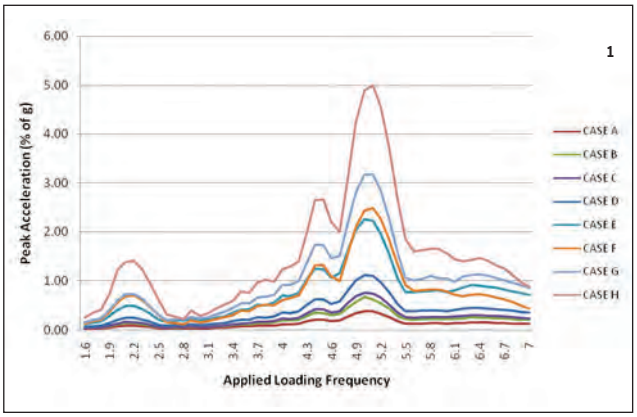
I 27 loads on all tracks adjacent spans (9 loads per span)

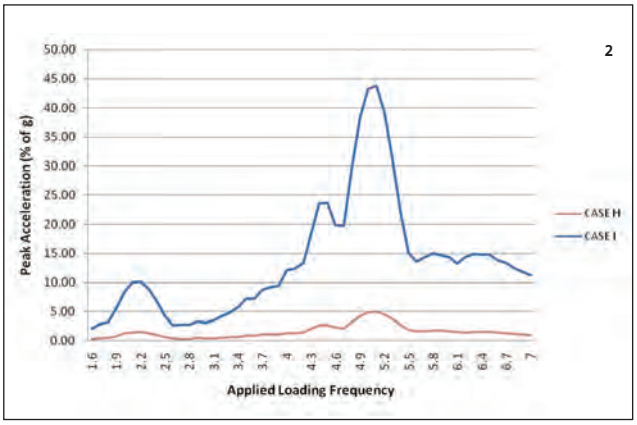
1 Jogging track supporting cantilever beam
2 First floor framing plan showing jogging track
3 Recommended peak acceleration for human comfort for vibrations due to human activities (Allen and Murray, 1993; ISO 2631-2: 1989)
4 Time history functions with frequencies ranging from 2 to 12Hz. applied on 100 kg mass (representing human), placed at various locations on the track

Forcing functions were generated in SAP2000 for frequency ranging from 2-12 Hz to include the jogging frequencies as well as to include the fundamental frequencies of the structure. The unit forcing mass was considered as weight of a single person, assumed as 100kg (including dynamic factor of 1.2). A total of nine load cases were considered on the most flexible part of the jogging track, by varying the position of load points and number of load points to cover worst possible cases that could occur.

Results

Response curves indicated that the Fundamental Frequency at which the slab resonates is 5.0-5.1 Hz. Even though this is not a desirable value considering human comfort, the peak acceleration measured at resonance when compared with the human acceptance criteria is within limit (5%g) for load cases A to G. For load case H, the acceleration value reaches to 5%g, which just satisfies the acceptance criteria. For load case I, however, the acceleration jumps to 43%g, which is substantially high compared to other cases, but the possibility of having 27 joggers at any one time is extremely remote, thus basing design on this extreme load case is too stringent. Decision by the team was to run the case J - which is case I with alternate loads 90° out of phase and carrying a higher probability of occurrence than case I. The response for case J was measured to be 4.76%g, well within the acceptable 5%g limit.





1 Response spectrum for load cases A to H
2 Response spectrum for load cases H and I

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