

Infrastructure Project Risk Management & Mitigation: role of the ground engineering professional

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Director, Arup

Premise of presentation

- Client drivers
 - Maximise benefit
 - Minimise programme
 - Minimise cost
- What clients really want
 - Finish on time; within budget; to the required quality – Reliably
 - No surprises
- Typical outcome
 - Construction problems occur too frequently
 - Consequential delays and associated costs are high
 - Often problems can be avoided

Risks are typically inadequately managed and mitigated!

UK Government Treasury IRG report on best risk and contingency management in UK infrastructure projects

Published October 2013

Key Clients

- Heathrow Airport
- London Underground
- Network Rail
- Highways Agency

Lessons learnt: key projects

- London Olympics
- Crossrail
- HS2



**Managing Cost Risk & Uncertainty
In Infrastructure Projects**
Leading Practice and Improvement:
Report from the Infrastructure Risk Group 2013

INFRASTRUCTURE RISK GROUP

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Leading the risk profession



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Presentation outline

- Nature of infrastructure projects
- Typical risk library
 - Generic risk categories
 - Project specific risks
- Mitigation not contingency
- Ground risks: role of ground engineering professional
- Closing remarks



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Nature of infrastructure projects

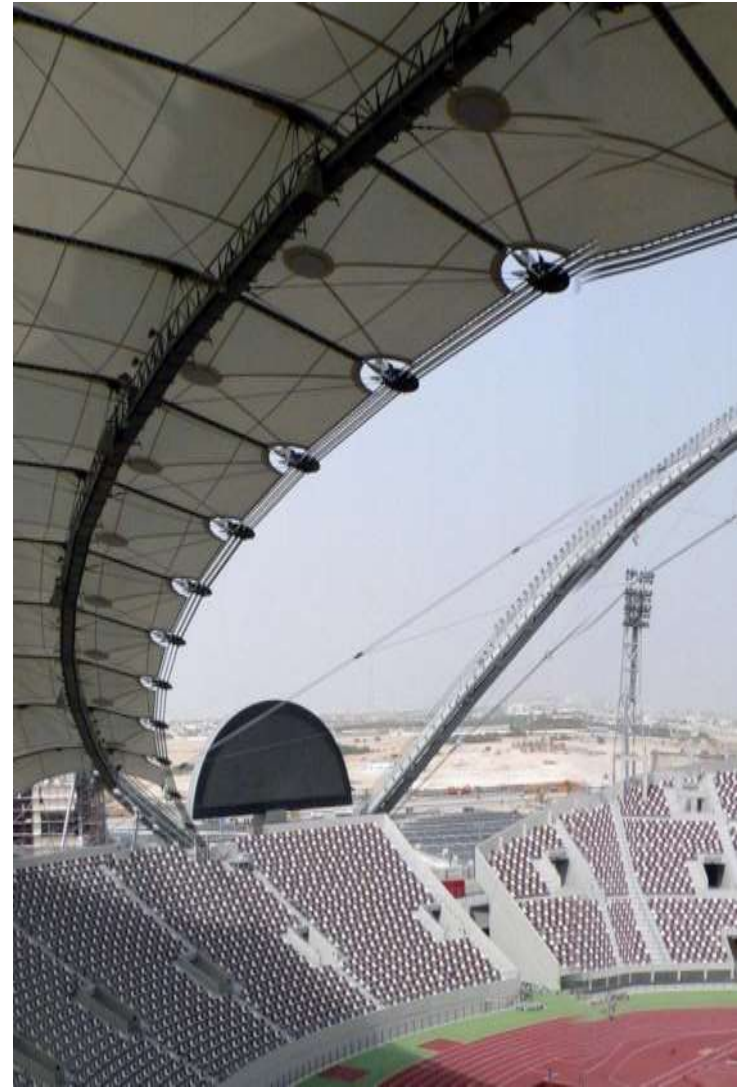
- Projects very varied:
 - big, small, simple, complex
 - discrete, long linear sites
- Middle East characterised by wonderful projects: many unique
- Fortunately all on, in or above ground
- Geo practitioners will continue to be at the core of these projects



Qatar University



Khalifa Stadium



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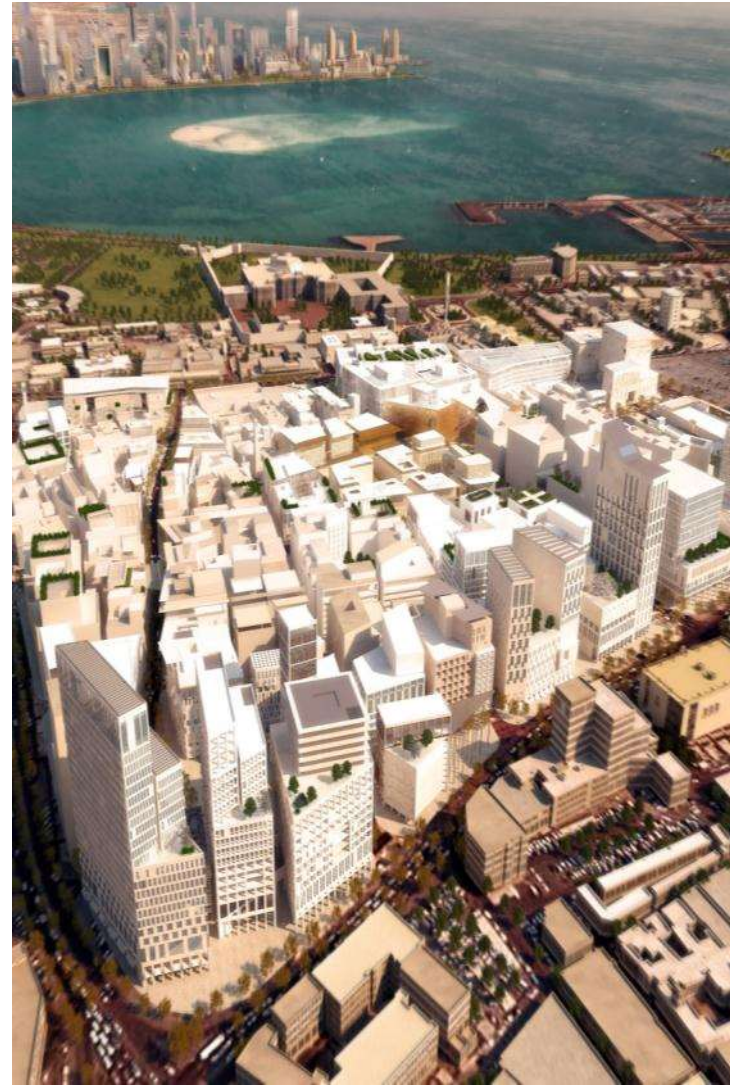


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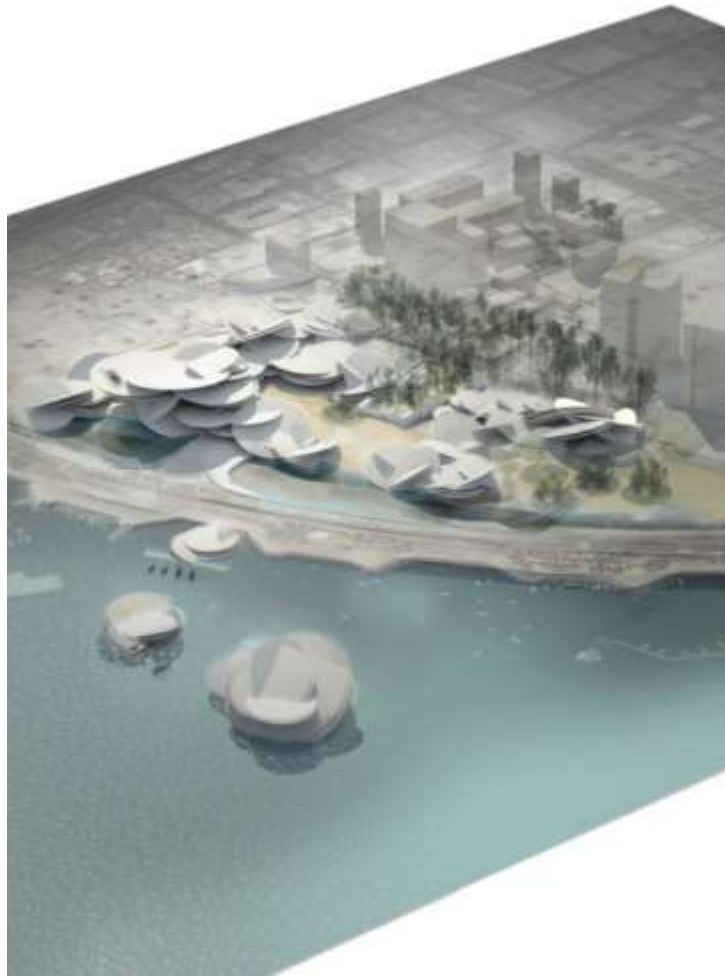
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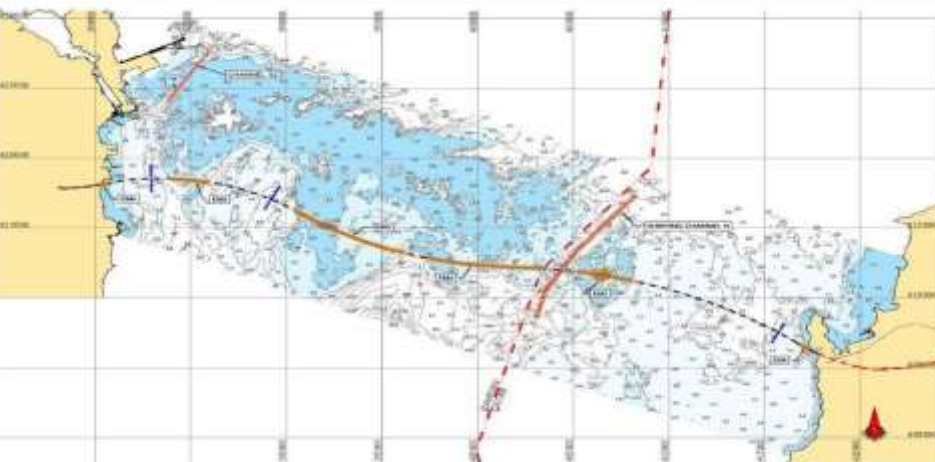
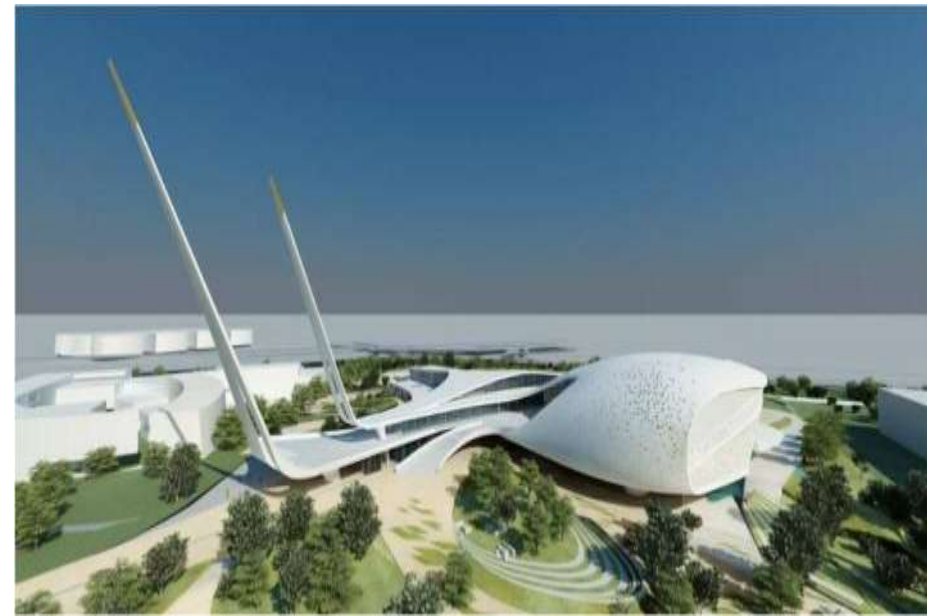
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Qatar Faculty of Islamic Studies



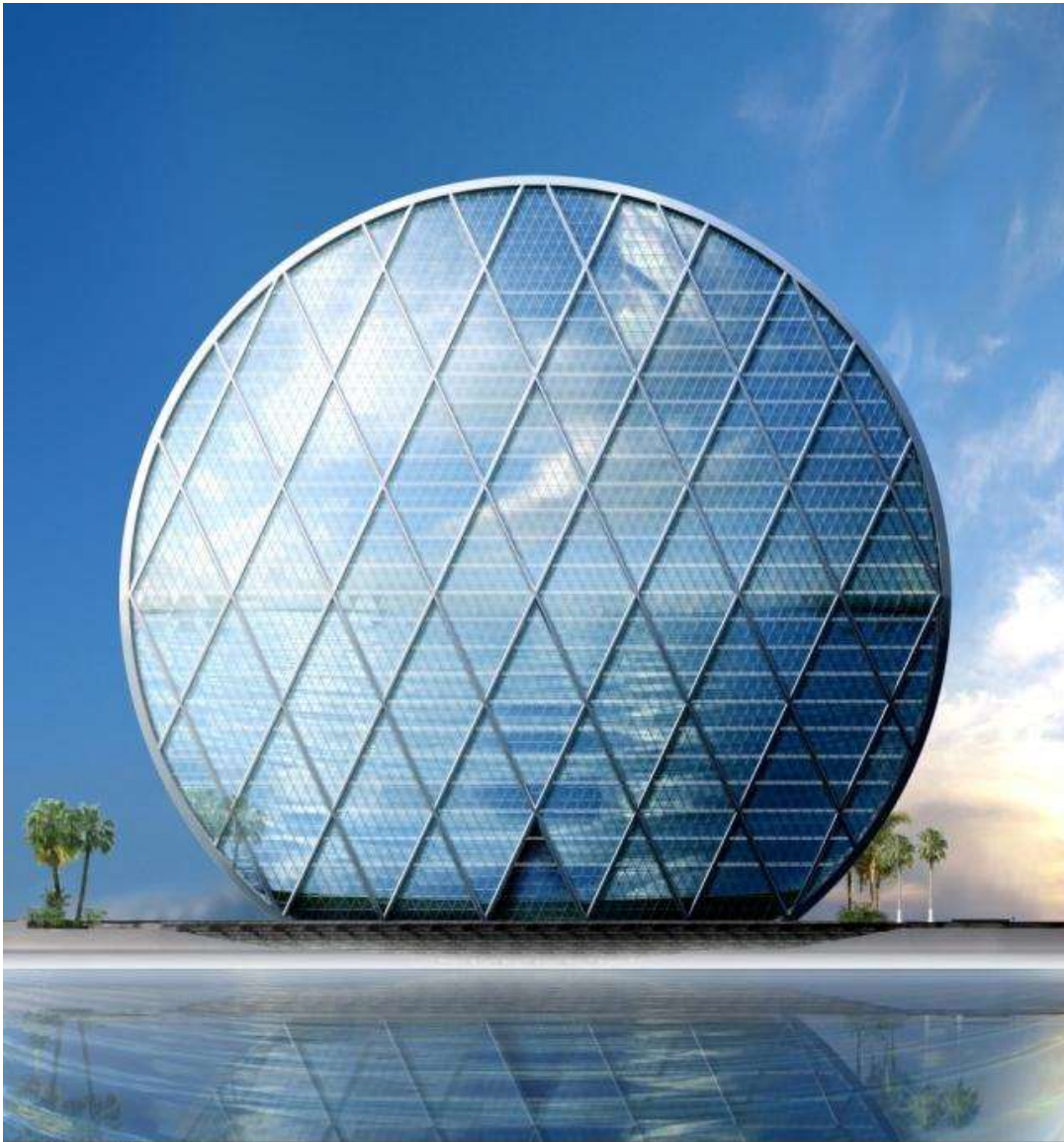
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Arabian Canal



Dubai Metro



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Middle East metros

Significant projects and challenges:

- Doha
- Riyadh
- Jeddah
- Mecca
- Abu Dhabi
- Kuwait
- Cairo

Doha Metro



Jeddah Metro



Riyadh Metro

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Typical risk library: generic risk categories

- Contractual/agreement
 - Variations and payment entitlement
 - Design change - when does design development end?
- Design (management and technical)
 - Inadequate GI and/or topographic information
 - Lack of project definition (scope)
- Programme
 - Unrealistic programme
 - Availability of information at the right time
- Financial
 - Cost overrun
 - Late payment
- Client and third parties
 - Approval from third parties

Project specific risk performance cycle

Uncertainty over project life cycle

Initially large: should reduce as requirements better understood, design develops and contractors selected and the project is built/implemented – but does it?

Bidding and implementation stages

- Contractors may price unrealistically low to win work
- Project managers tend to overestimate risk to maintain large contingency to avoid career threatening overspend
- Risk analysis done in different ways – decisions less clear cut than desirable
- Gaming by all parties – loss of focus on real risk mitigation
- Uncertainty and risk remains
- Reliance on fear of negligence not an appropriate way to manage risks



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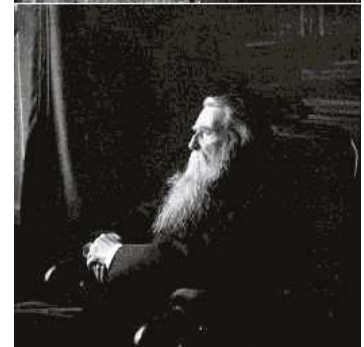
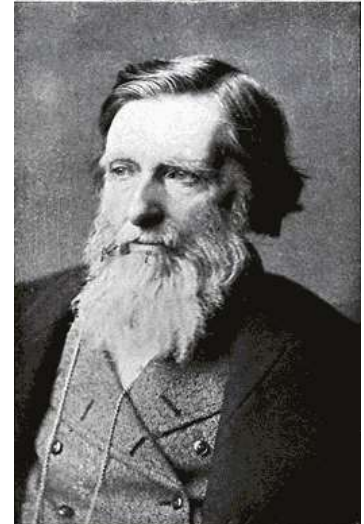
MITIGATION NOT CONTINGENCY

"It is unwise to pay too much, but worse to pay too little; when you pay too much, you lose a little money, that's all. When you pay too little, you sometimes lose everything, because the thing you bought was incapable of doing the things it was bought to do. The common law of business balance prohibits paying a little and getting a lot. It can't be done.

If you deal with the lowest bidder, it is as well to add something for the risk you run. And if you do that, you will have enough to pay for something better.

There is hardly anything in the world that someone can't make a little worse and sell a little cheaper – and people who consider price alone are this man's lawful prey."

John Ruskin (1819-1900)



Lowest tender price gives more contingency?

- “Better money in my pocket than his”
- But tight budget – more vulnerable to cost over-runs so lowest tender even more dangerous
- Therefore need experienced and well-resourced suppliers – MITIGATION NOT CONTINGENCY



Designer

- More experience & expertise – more cost – but reliably lower outturn cost and programme

Contractor

- Tackle issues expeditiously with best advice not cheapest advice

Mitigation: Investigation, Design & Construction

- Middle East construction environment fragmented
- Design is a continuous process
- Take care to follow good practice by maintaining:
 - Good communication
 - Team approach
 - Integrated total project process
 - Risk based approach to design & construction management
 - Clear allocation and ownership of responsibility

Continuity & communication essential between data collection (investigation), design & construction

Simple excavation example: ownership of risks?

- Demolition
- Temporary supports
- Obstruction removal
- Install new wall
- Transfer temporary support
- Construct new internal piles
- Dewatering for basement
- Basement excavation and propping
- Install anchors
- Demolition contractor
- Diaphragm walling contractor
- Piling contractor
- Dewatering contractor
- Excavation contractor
- Anchor contractor

Or...



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Key IRG recommendations

- Consider cost and risk estimates side by side
- Incentivise risk mitigation to ensure that risk actually gets managed
- Different organisations to cooperate on risk and contingency management of interfacing programmes to enhance mitigation and avoid duplicating contingencies
- Set up a nation-wide body to collect and share data



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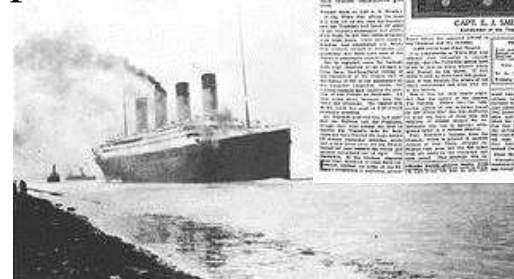
Ground risks: role of ground engineering professional

- Ground risks can be wildly random
- Can reduce likelihood but never entirely eliminate
- Understanding and humility – beware over-confidence/complacency
- Don't just rely on own previous experience – consider what might happen

Beware complacency

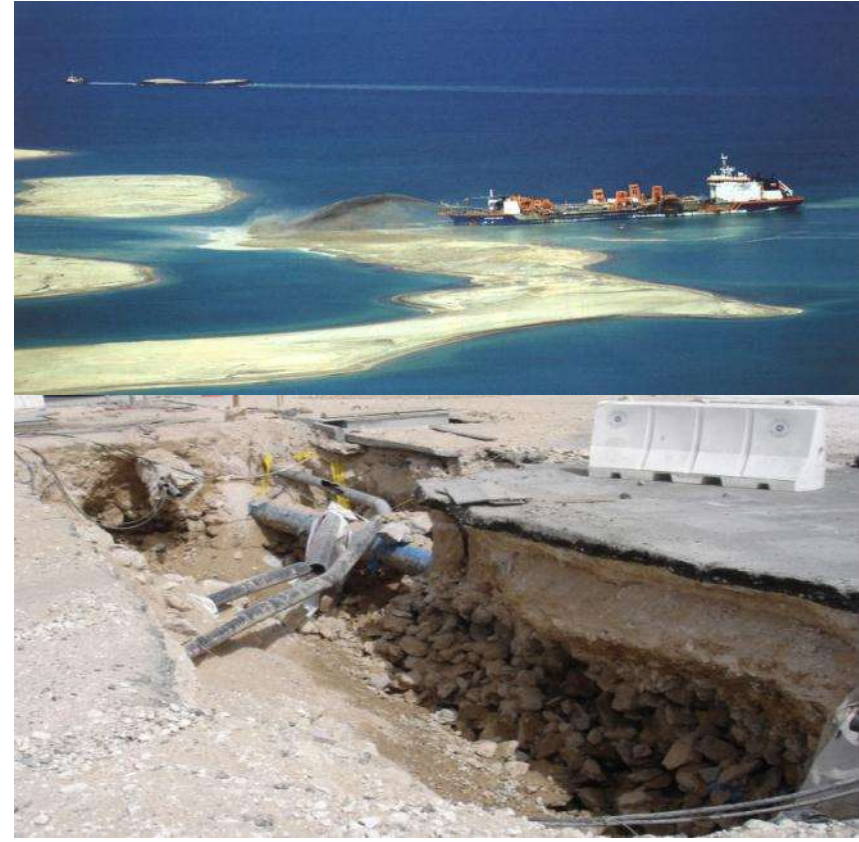
*“When anyone asks me how I can best describe my experience in nearly forty years at sea, I merely say, uneventful. Of course there have been winter gales and storms and fog and the like but, **in all my experience, I have never been in an accident ... of any sort worth speaking about. I have seen but one vessel in distress in all my years at sea. I never saw a wreck and have never been wrecked nor was I ever in any predicament that threatened to end in disaster of any sort.**”*

These words were spoken by Captain Edward John Smith in 1907, 5 years before he became captain of the RMS Titanic for her maiden voyage.



Typical ground risks

Highly variable fill and weak rock strata: difficult to characterise



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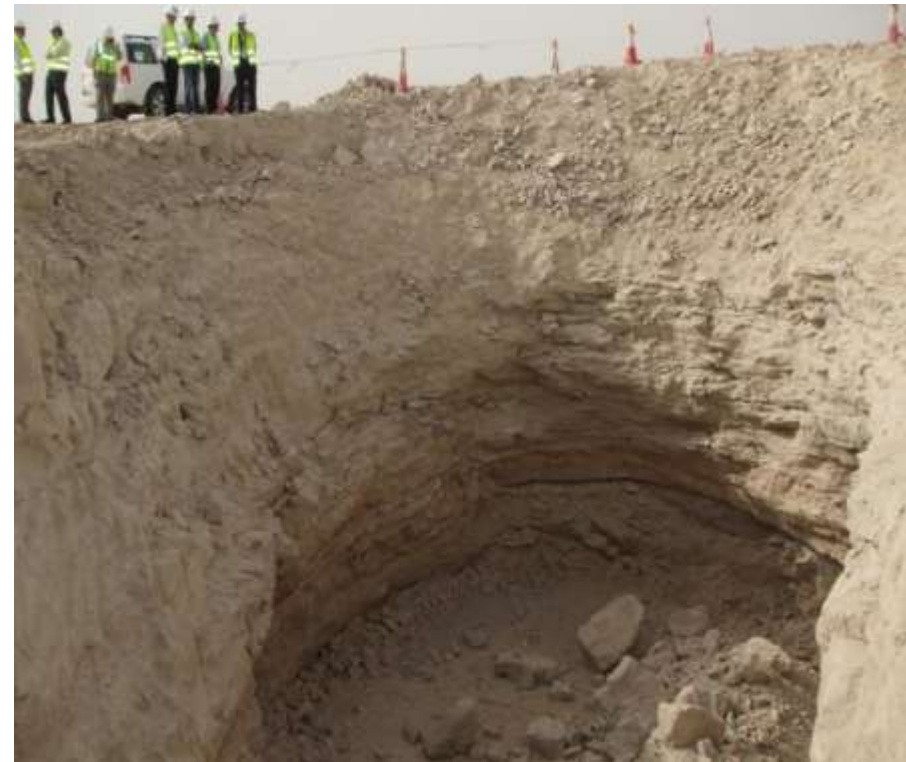
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Typical ground risks

- **Highly variable** fill and weak rock strata: difficult to characterise
- **Beware cavities** in ground:
 - evaporites (gypsum, anhydrite, halite) liable to dissolution



Typical ground risks

- **Highly variable** fill and weak rock strata: difficult to characterise
- **Beware cavities** in ground:
 - evaporites (gypsum, anhydrite, halite) liable to dissolution
- **Beware chemistry and mineralogy**:
 - adverse gypsum/bentonite reaction
 - palygorskite: dispersion/softening/swelling
- **Corrosive environment**: high humidity & temperatures and:
 - high concentrations of chlorides & sulfates in soil & water
 - high density concrete essential with sulfate resisting cement
- **Piping/erosion/collapsible soils** when de-watering
- **Heave/collapsible soils** (high inundation settlements in fills)
- **Seismic liquefaction** hazard in loose soils
- **Fatigue degradation** in weak rock: long term cyclic loading

Damage to Infrastructure

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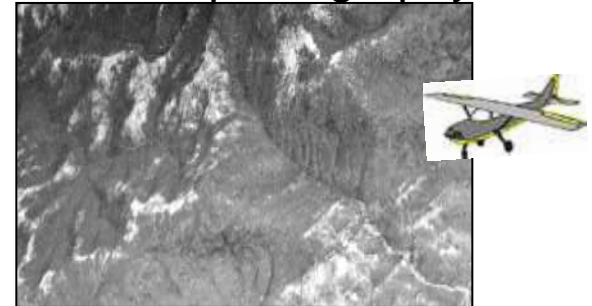
Literature searches



Remote sensing data



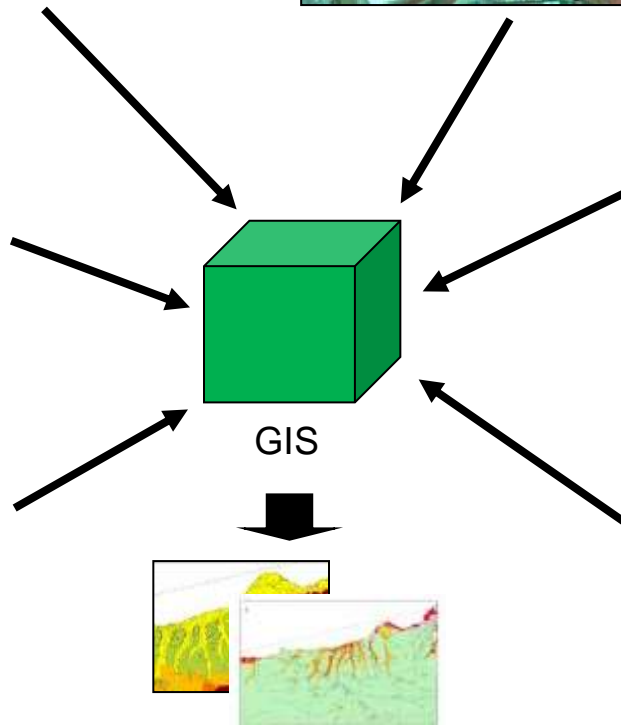
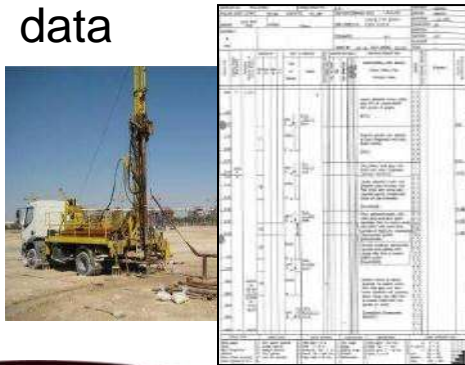
Aerial photography



Geological



Ground investigation data

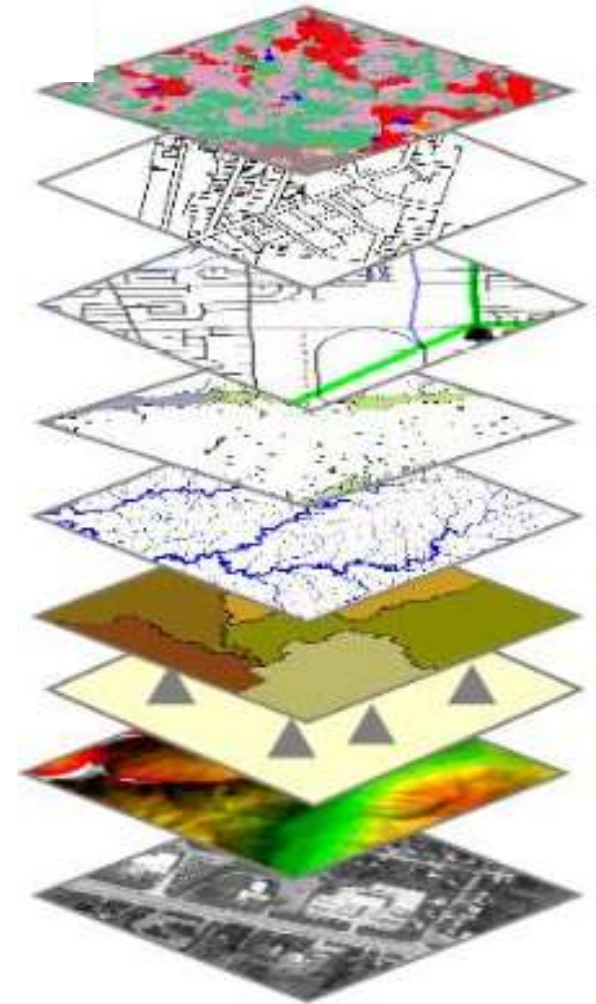


THEMATIC MAPS

Field mapping

Geographical Information Systems ARUP

- Database with graphical capability
- Combine layers of data / maps
- Visualize combinations of data
- Analyse data



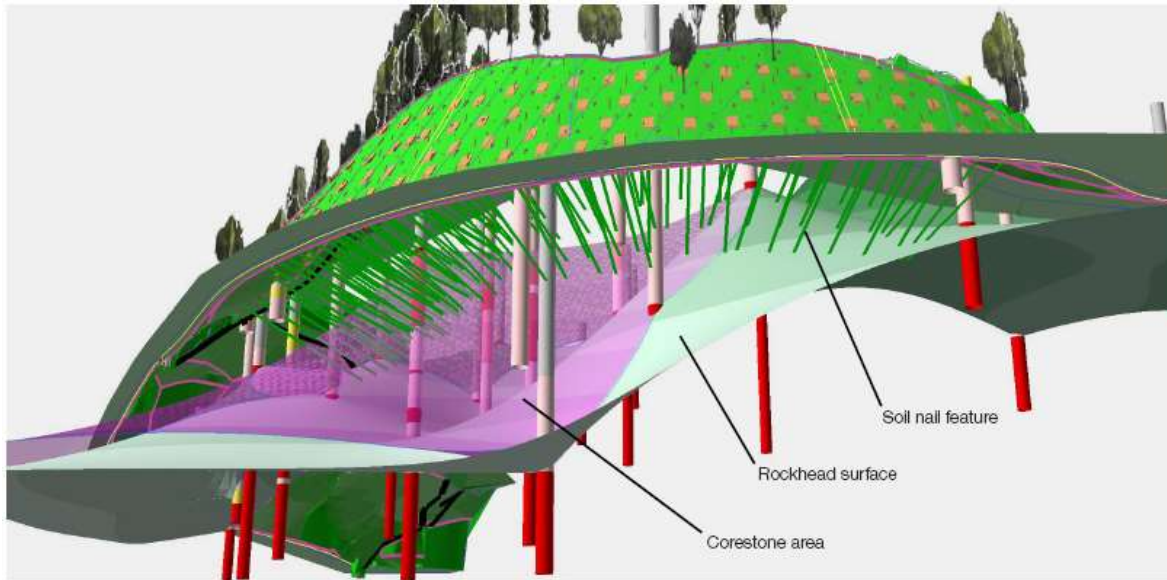
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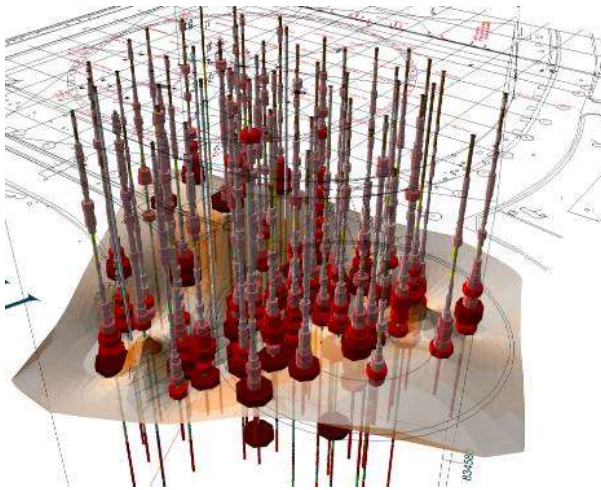
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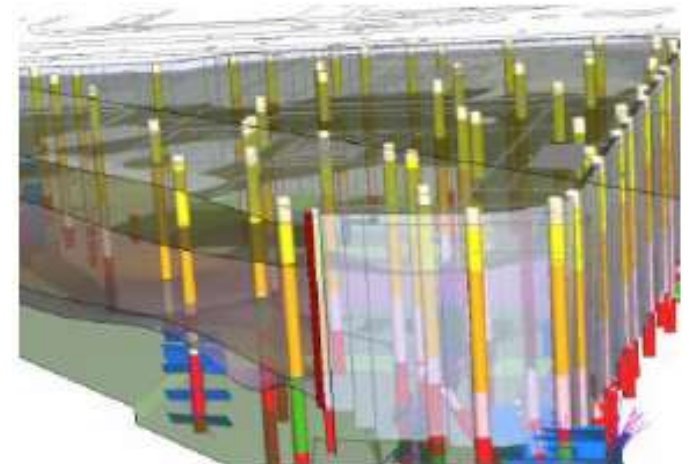
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3D geological modelling and analysis using GIS



3D borehole model showing SPT variation with depth & magnitude



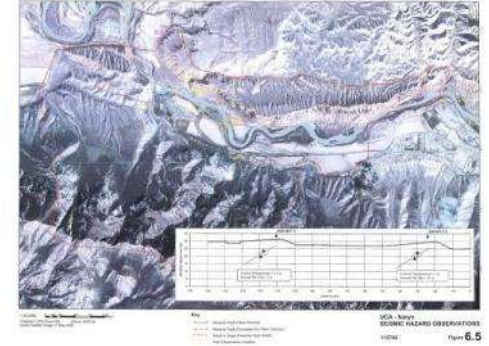
Ground risk: typical thematic mapping



Topography



Geology



Seismic



Hydrology & hydrogeology



Geomorphology



Geohazard Zones

Typical thematic maps: GIS software based on desk study, geological field mapping & GI



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Closing remarks

- **The Middle East** - very ambitious mega projects to very tight time deadlines and even tighter design fees!
- **Ground risks** – overall some 20% of projects are delayed by ground. Substructure design fees < 5% of civil construction costs, yet < 0.1% of this spent on mitigating such risks!
- **Ground engineering design risk considerations** – watch out for chemistry & cavities in the ground
- **Investigation, design & construction** – ensure continuity of design, despite fragmented construction environment
- **Geo Professionals** – thematic mapping; GCO?
- **Exciting dynamic future**: be part of it and play a pivotal role!

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