RAISING VENICE

UNIVERSITY OF SURREY

COST/DURATION

TOTAL COST OF SOLUTION: £840 Million

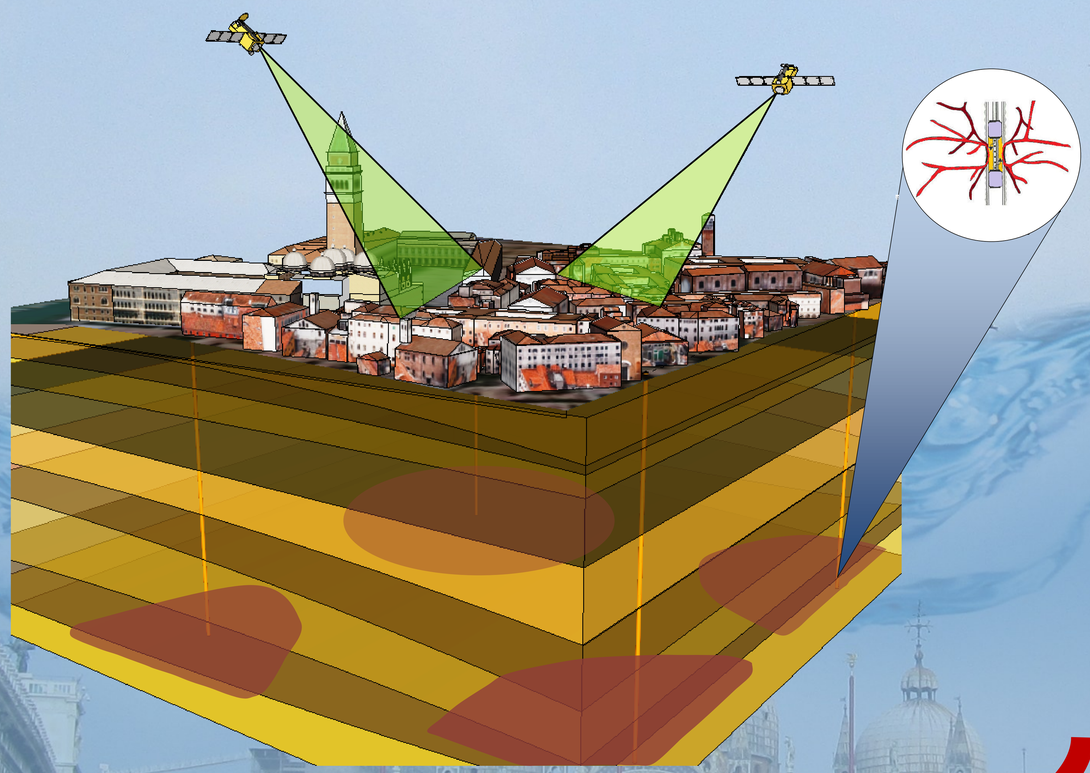
This can be compared to:

MOSE barriers - £3.7 billion
Hydraulic jacking - £6.0 billion

TOTAL PROJECT DURATION: 6 years

PROJECT BRIEF

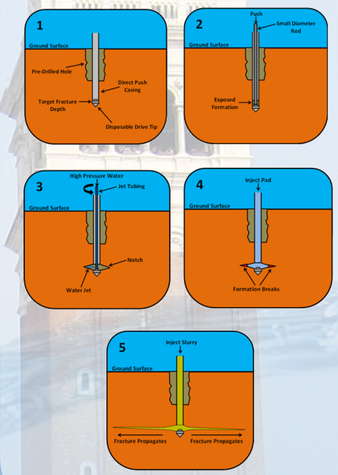
Venice is a world heritage city at risk of being destroyed by catastrophic flooding. The main contributors are sea level rise and land subsidence, both natural and man induced. The MOSE barriers, currently under construction, have been designed to protect Venice from flooding but have a limited design life and do not provide the full solution to Venice's problems. To save Venice from relative sea level rise, the city has to be raised. This will be carried out using a technology which has not been used before for such purpose– hydraulic fracturing.



SOLUTION

VENICE IS TO BE RAISED BY INJECTION OF GROUT AT 190m BELOW THE CITY BY MEANS OF HYDRAULIC FRACTURING.

HYDRAULIC FRACTURING



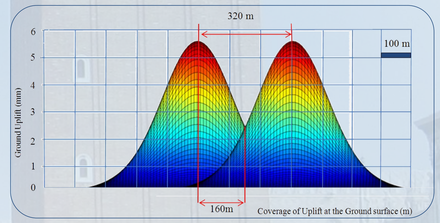
Process stages:

1. Drill a vertical well to reach the desired strata (silty-clay layer at 190m depth)
2. Push metal casing into the well and pump down cement to create a seal. This ensures the aquifers are not polluted during operations.
3. Pump down a grout mixture into the wellbore at a pressure that will cause tensile failure at the borehole wall i.e. the initiation of a fracture.

GROUT AND GEOLOGY

- PFA-cement blend of 1:7 to be used to initiate fracture. Alternate mixes are available to allow for adaptation.
- Wire line logging during drilling will further develop ground investigation.

UPLIFT PREDICTION



Graphic representation of the expected uplift at each wellbore at an injection rate (Q) of 0.0135m^3/s.

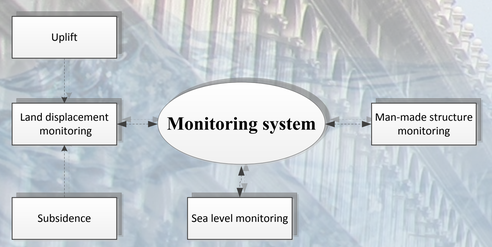
In order to achieve an even uplift the wells will need to be spaced 320m apart. There will be a total of 90 wells needed.

RISK REDUCTION

MONITORING

What will be monitored:

- Localised surface uplift
- Overall Uplift/subsidence of the city
- Sea level monitoring (Local and Global)
- Tilt of structures
- Cumulative tilting and horizontal displacement of buildings
- Pipes lines

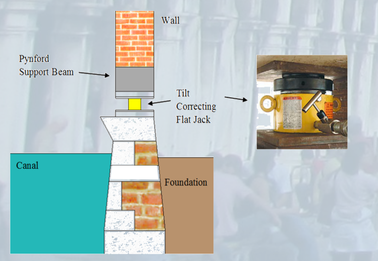


A 'traffic light system' controller will be implemented to prevent damage to assets.

MITIGATION—DIFFERENTIAL HEAVE

Depending on where differential heave occurs, the following mitigation measures will be implemented:

- Additional wells will be drilled in the city, pumping will take place at a controllable level in order to lift the immediate area.
- Hydraulic jacking will be used in the areas where it is not feasible to drill additional wells.



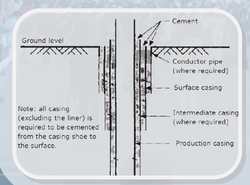
RISKS

SEISMICITY

Hydraulic fracturing is known to induce small earthquakes. Seismic activity in Venice is low hence, this is a low risk.

STRUCTURAL DAMAGE

Differential heave could occur as a result of non-uniform uplift and cause structural damage.



WELL INTEGRITY

To reduce the risk of contamination a protective casing and good well design and workmanship is needed.

(See left-hand figure)

CONFIGURATION OF WELLS

GROUP 2—Nick Adebanjo, Richard Archer, Emma Bruty, Oliver Currie, Sidong Ma, Rita Morgado Silva