AIRFIELD PAVEMENTS ON SETTLEMENT-PRONE SOILS

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AIRFIELDS ON ARTIFICIALOFF-SHORE ISLANDS

- Kansai Airport
- New Kitakyushu Airport
- Kobe Airport
- Chubu Centrair Airport
- Hong Kong Airport
- Trend toward using deep fill in marine environment
- Lack of military experience with this construction

Kansai Airport

Hong Kong Airport

MILITARY AIRFIELD PAVEMENTS

- Heavy Loads
  - Wheel loads up to 62,500 lbs
  - Tire pressure over 300 psi
- Unusual Operations
  - High Temperatures
  - Formation take offs
  - World wide
  - All surfaces: soils, landing mat, compacted snow, ice, etc.
- Own and Operate 180+ airfields

US MILITARY FIRST EXPERIENCE WITH LARGE FILL AIRFIELD IN MARINE ENVIRONMENT

- Airbase “A” Characteristics
  - Construction start 1997
  - Opened runway May 2010
- Cross Section
  - CRCP surface
  - 3 m Fill
  - 10-30 m CH Marine Clay
  - Underlain by sandy silts and sandy gravels
- Site Improvements
  - Sand piles (liquefaction)
  - Sand drains (primary consolidation)
  - Surcharging (primary consolidation)

ISSUES AT MILITARY AIRBASE A

- Pavement
  - CRCP selected for ductility
  - Host nation ran CRCP tests
  - CRCP appears to be cracking normally
  - EXCEPT taxiway on deepest fill starting to show unusual “Y” shaped cracks
    - Differential settlement?
  - Expansion joints showing large movement and tearing sealant
  - Could we have voids under the CRCP?

- Designer predicted differential settlement of 30 mm
- Settlement predicted for 2005-2023 of 0.6 to 1.0 m (COE analysis not designer)
- In 2010
  - 13 buildings showing moderate settlement damage
  - five buildings showing severe settlement damage
- Liquefaction not totally mitigated (COE analysis not designer)
- Surface drainage disrupted
  - Seabirds now pose aircraft hazard

PROPOSAL FOR NEW AIRBASE “B”

CONCERNS FOR AIRBASE B

- Much deeper fill than Airbase A (38 m vs. 3 m)
- Nonuniform runway/taxiway transitions
  - Shallow bay (3 m deep)
  - Existing land
  - Deep ocean (30 m deep)
- Large volume of fill
  - Not available locally
  - Very little limitation on fill
- Site investigation not yet done
- Carryover Issues from Airbase A
  - Settlement
  - Drainage
  - Liquefaction
  - Pavement Surface

SETTLEMENT

- Pavement engineers expect no settlement
- Large fill in marine environment
  - There will be settlement
  - It will go on for long periods
- Sources of settlement
  - In the fill
  - Marine foundation sediments
  - For pavements differential settlement is crucial issue

- Criteria
  - The military has no criteria for tolerable settlement for airfields
  - ICAO
    - Isolated settlement ok
    - 2.5 to 3.0 cm max over 45m length
  - PCI
    - Equates to high severity faulting for rigid or depression for flexible
    - 25% density PCI rigid 56
    - 25% density PCI flexible 33

SETTLEMENT THEORY ISSUES

- Typical Approach
  - 1D oedometer tests
  - Terzaghi consolidation theory
  - Require 90 or 95% primary consolidation before paving
- Past Experience
  - More settlement than expected
  - Lasts longer than expected

- Theoretical Problems
  - Terzaghi is special 1D small strain
  - Large strain/finite strain theory
  - Hard to define drainage paths
  - 3D effects
  - Secondary consolidation has to be considered and this is difficult
- Consolidation of fill results in demand for more fill than expected

SETTLEMENT ASSESSMENT

- The major problem with large-scale land reclamation projects is that it is almost impossible to provide an accurate prediction of rates of settlement based solely on the results of site investigation and laboratory consolidation tests.
  - Large spatial variability of soil properties and drainage paths
  - Lab tests of coefficients of consolidation and secondary compression often only within 2 orders of magnitude of field values
- Theoretical calculations must be used as initial conditions of design and then supplemented with continuous field observations and measurements to allow adjustments to theoretical calculations and changes in design (classical observational method of soil mechanics)

SETTLEMENT ISSUES

- Excessive differential settlement cause excessive roughness
- Airbase B is particularly worrisome because of transitions between shallow bay, solid land, and deep ocean beneath the runways and taxiways
- Settlement causes deterioration of pavement materials (cracking and distortion)
- Voids form under rigid pavement
- Surface drainage disrupted and can pose bird-aircraft strike hazard

- Long wavelength roughness
  - Normal specification smoothness only addresses quality of construction (straight edges & profilometers)
  - Aircraft do not respond to this short wavelength roughness
  - Now with potential differential settlement may end up with long wavelength roughness
- This requires special dynamic analysis of aircraft and actual pavement profile.

LIQUEFACTION DAMAGE, KING COUNTY INT. AIRPORT, WA, 2001

SELECTION OF PAVEMENT TYPE

- Flexible Asphalt Surfaced
  - Will conform to settlements
  - Easier to fix/overlay/patch to deal with excessive settlement
  - Does poorly where fuel and lubricant spillage is an issue and where sustained hot exhaust is an issue
  - Military policy is not to use AC on aprons, runway ends, and primary taxiways
- Flexible Concrete Block Surfaced

- Rigid Portland-Cement Concrete
  - Will not conform to settlements
  - Cracking and faulting likely
  - Voids may form under PCC with catastrophic failure possible
  - Hard to fix
- CRCP will provide more ductility
  - Much harder to fix and maintain
  - Actual performance under this scenario remains uncertain
  - Voids are still an issue
  - Wartime repairs are much harder

MILITARY AIRFIELDS ON DEEP FILLS IN A MARINE ENVIRONMENT

- No existing guidance or criteria
- Experience with civil airports suggest issues with settlement prediction remain
- Airbase A was 1st experience and was not totally satisfactory
- Need to develop better approach and criteria for Airbase B

- Preliminary Thoughts
  - Settlement calculations are only starting point
  - Continuous program of settlement monitoring required to adjust theoretical calculations to meet field conditions
  - Final design must be flexible:
    - Site improvement
    - Pavement concepts
    - Drainage
  - Liquefaction must be prevented
  - Long wavelength roughness analysis will be needed

QUESTIONS