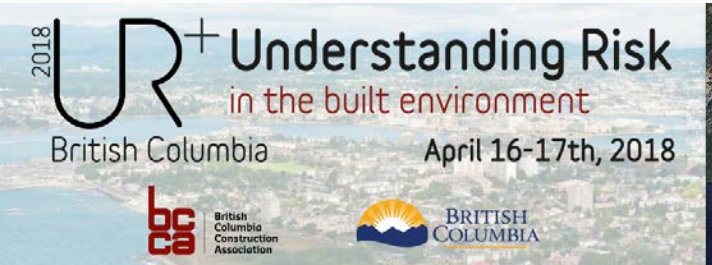
Inter-dependency and Transportation Networks

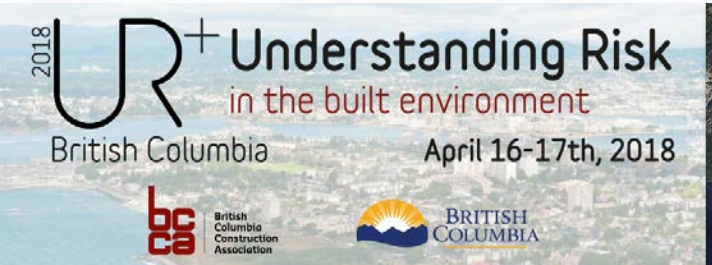
Don Kennedy, P.Eng.
VP Transportation Structures

Associated Engineering

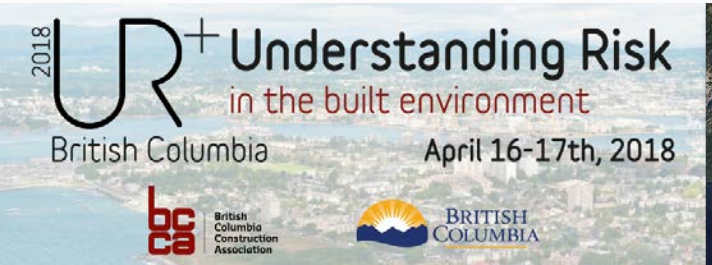


Three interdependent topics

- Lower Mainland highway / road network
- Bridge and network infrastructure status and directions
- Important aspects of performance – based seismic design of bridges



Transportation Networks . . .

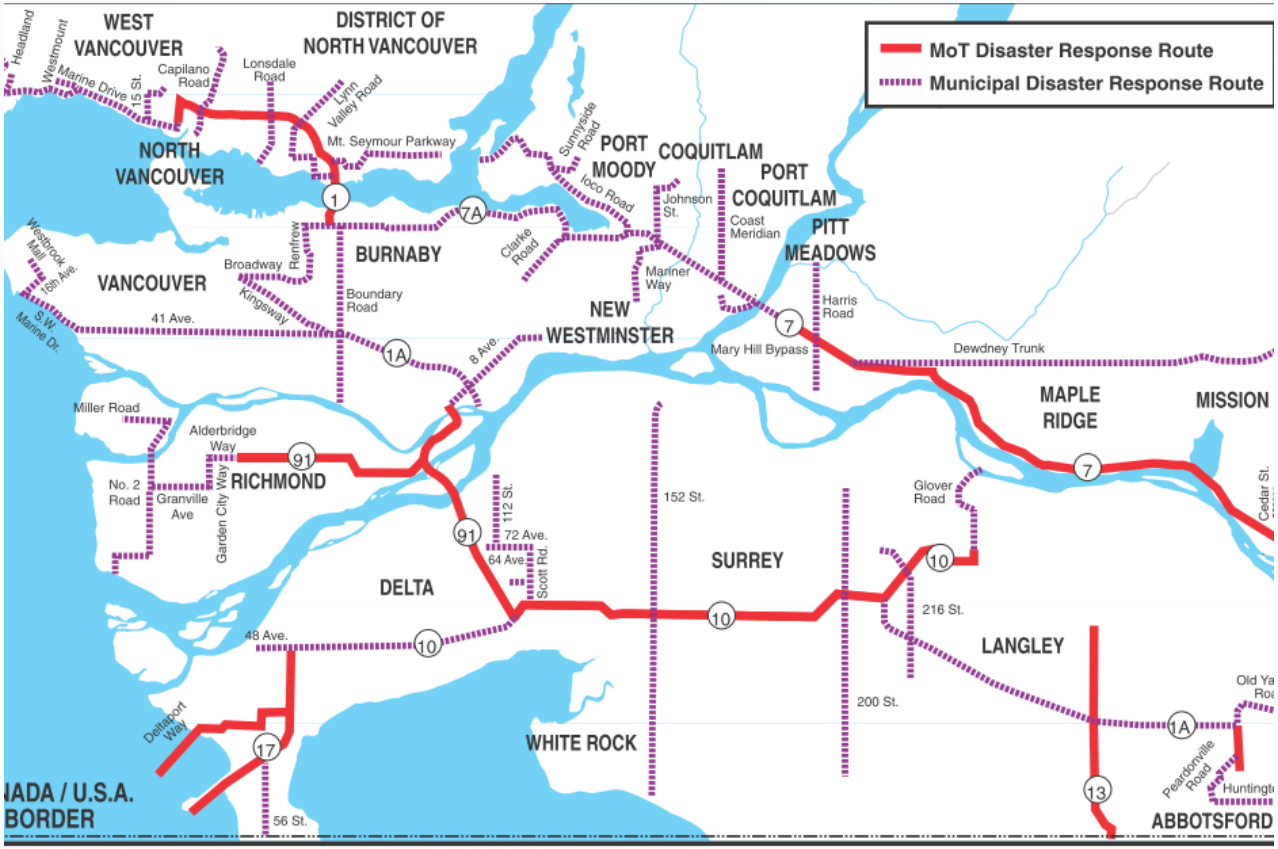


Transportation Lessons

Past Earthquakes

- A functioning transportation network is critical for immediate and for longer term recover
- Recovery times are measured in months or longer
- Damage plus aftershock or EQ sequences impede short term re-use

Lower Mainland Disaster Response Route (being updated)



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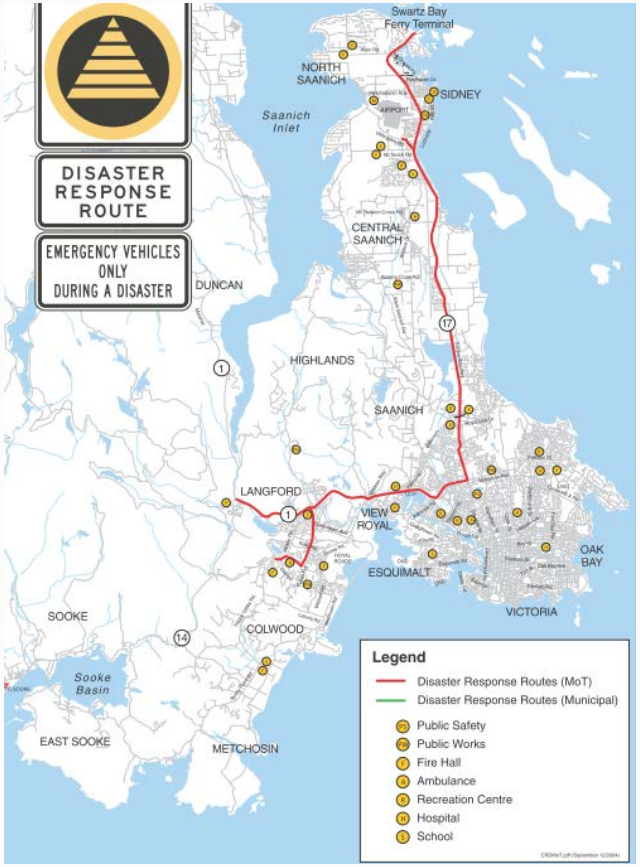
CRD Disaster Response Route



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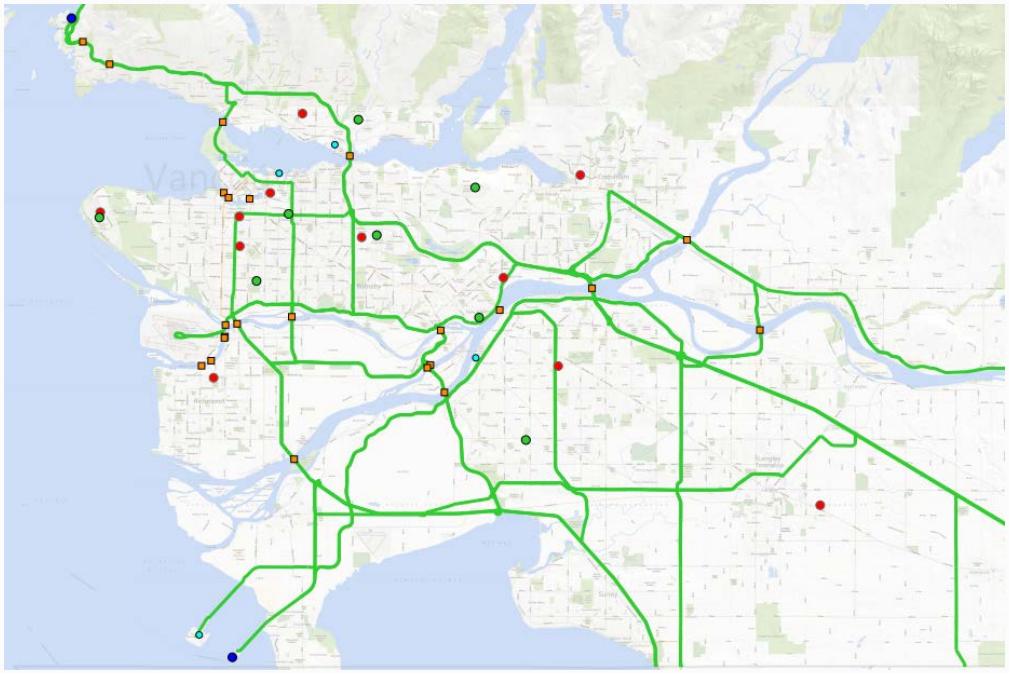
“Critical Route” development

A decision framework; requires integration of other key assets / staging areas. “Regional” elements shown; local roads to supplement. Bridges and tunnels on such routes are likely classified as “Lifeline” crossings.



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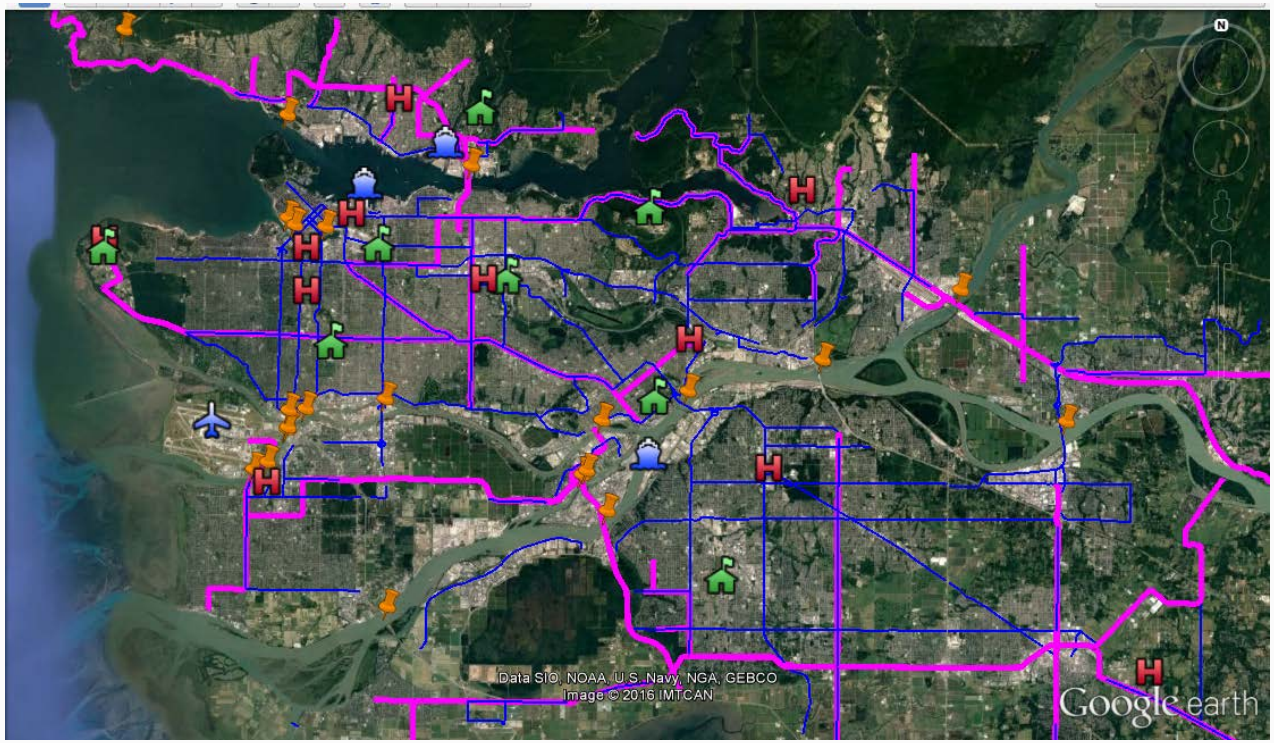
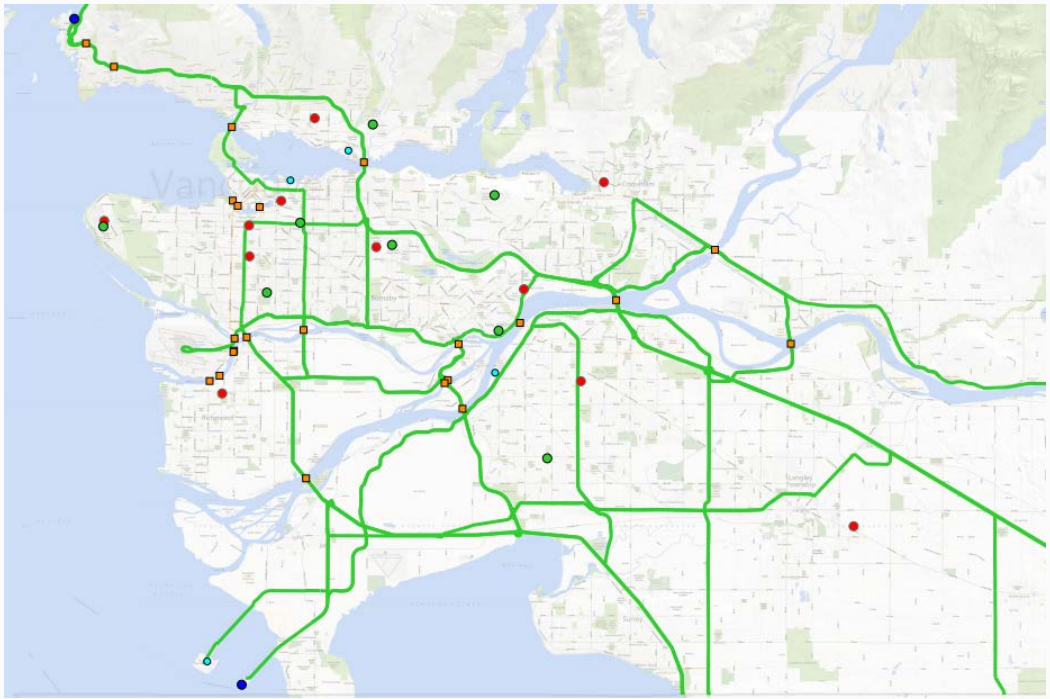
Network information

For planning, analyzing, prioritizing, recovery, reporting, budgeting – major bridges and some example assets



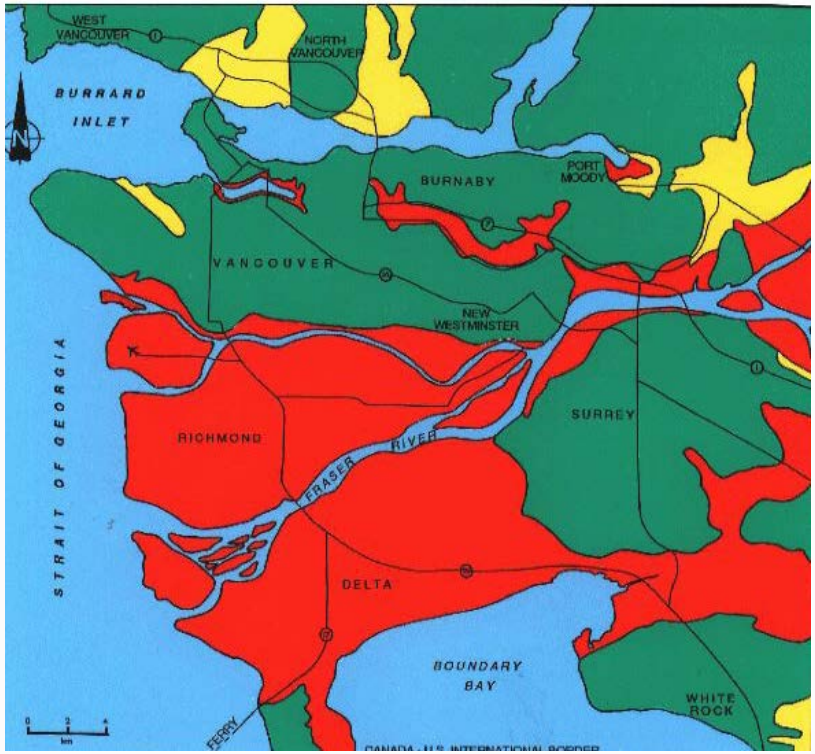
Redundancy of C.R. is important

Lower Mainland geography and infrastructure condition makes this uniquely challenging among major Cities



Lower Mainland soils

Network damage and cost – floodplains = loose, liquefiable soils



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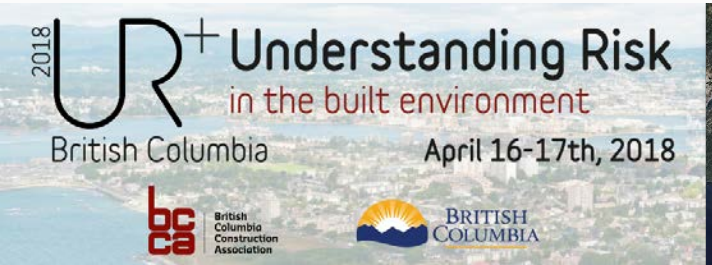
Bridge / tunnel status . . .



Lower Mainland Lifeline crossings (MoTI)

- PMH1 and Pitt River Bridge replaced (PBD)
- Golden Ears Bridge – new, PBD
- Five bridges retrofitted to collapse prevention for 500 year RP using displacement-based methods
  - Lions Gate, Oak Street, IW Second Narrows, Queensborough, Mission Bridges

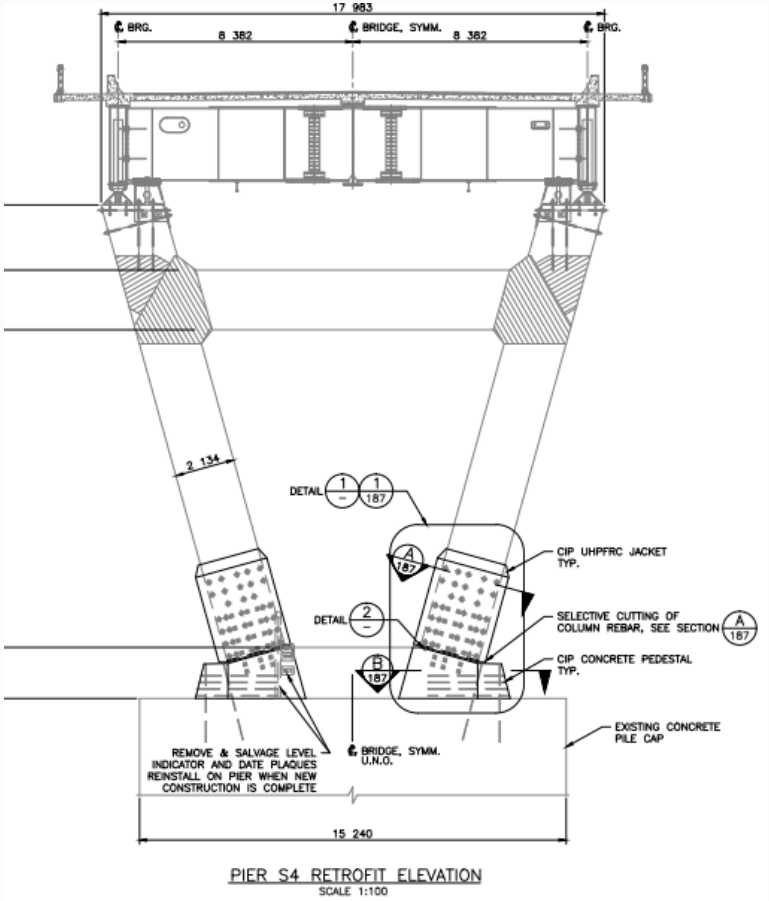
Lower Mainland Lifeline crossings (MoTI)

- George Massey Tunnel had some seismic improvements and may be replaced. It remains seismically vulnerable [… and difficult to inspect post-EQ for continued use]
- Agassiz-Rosedale Bridge retrofit under construction
- Knight St – collapse prevention / 1000 yr. Granville – upgrading to functional (use after a large earthquake)

Mission Bridge

- Bridge seismically retrofit ~ 2009 through 2016
- Strength, ductility upgrades
- Large liquefaction impacts on Pier S4 – 2015 upgrade

Mission Bridge Pier S4



PIER S4 RETROFIT ELEVATION
SCALE 1:100

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Oak Street Bridge – Half-scale testing

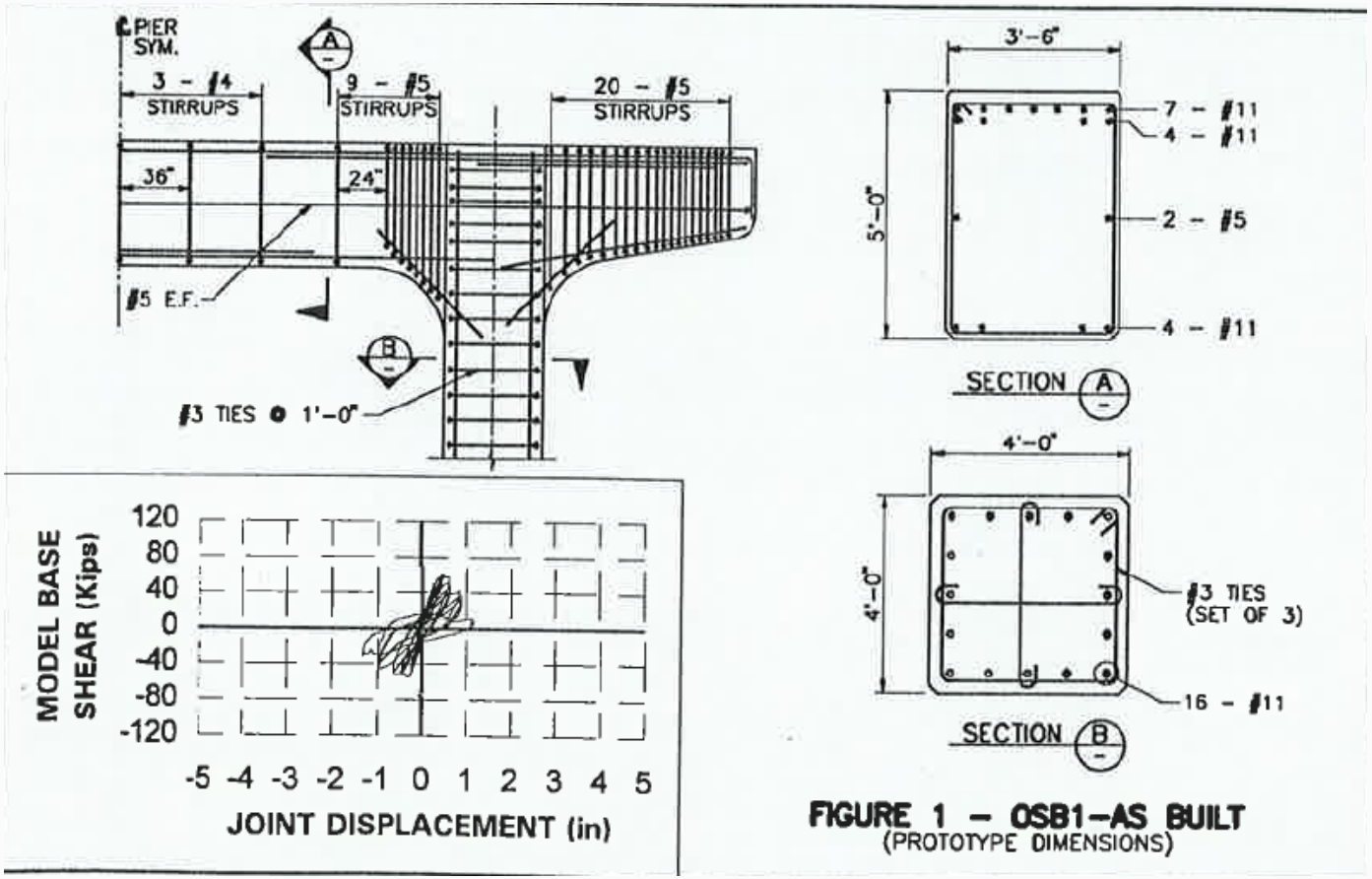

FIGURE 1 – OSB1–AS BUILT
(PROTOTYPE DIMENSIONS)

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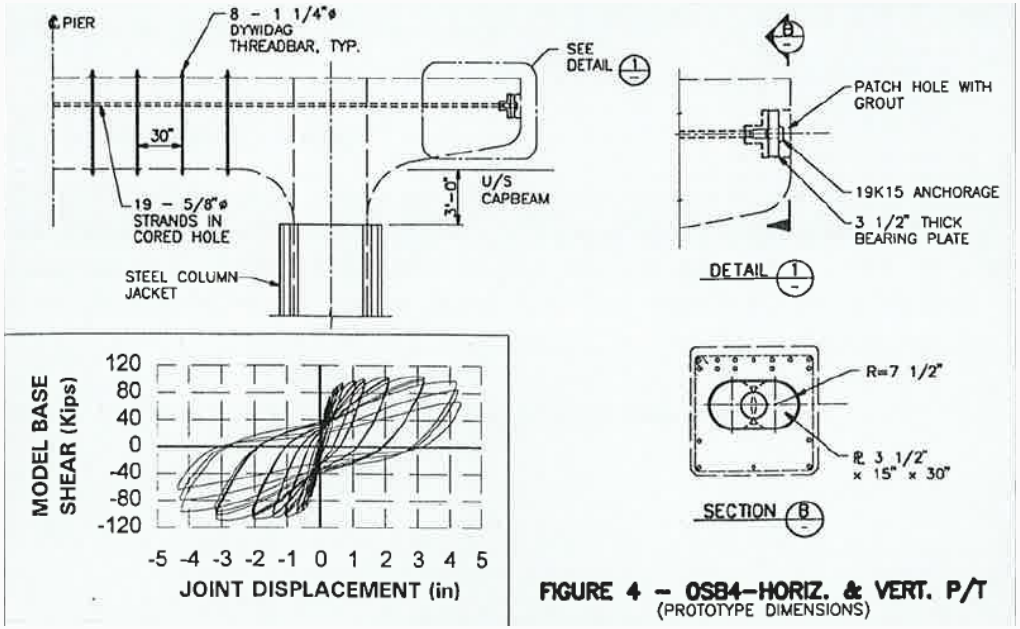
Oak Street Bridge

Typical Approach Pier Retrofit

Oak Street Bridge

Half-scale testing



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Knight Street Bridge

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Knight Street Bridge

Compaction piles

Knight Street Bridge

Compaction piles (trees – ground improvement + carbon capture and storage)

MoTI Seismic Retrofit

Progress and programs

- 19 bridge retrofits on DRR in the Lower Mainland and Vancouver Island, one to come
- 37 bridges retrofitted on other key routes in the LM and on Vancouver Island; 4 Northern
- Past retrofits used Canadian Highway Bridge Design Code; life safety for 1 in 475 yr RP
- Future retrofits targeting 1 in 2,475 year event, similar to new bridges

Retrofit opportunity for increased resilience

Seismic isolation can improve earthquake resilience to some of our remaining major bridges

(Granville Bridge seismic isolation bearing installation shown)

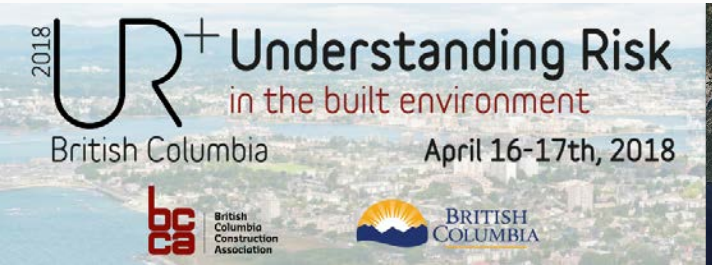
Tynehead Pedestrian Bridge

Isolation bearings – vibration risk and….

Seismic progress and programs

Each of these have renewal and function upgrading demands that will be essential over coming 10 – 30 years; a unique confluence of opportunities

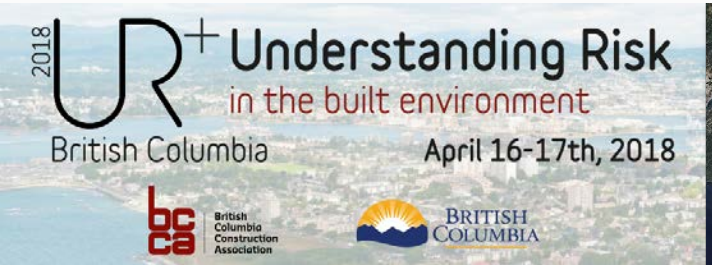
- **Oak Street Bridge** –deck renewal, steel re-coating, ltd capacity of four lanes, ~100,000 vpd max, population growth
- **IW Second Narrows Bridge** – Re-coating likely in coming years. Capacity limits apparent - rapid population growth; marine impact risk.
- **Massey Tunnel** remains seismically vulnerable [… and difficult to inspect post-EQ for continued use; use by first responders?]



MoTI Seismic progress and programs

Summary

- Much seismic upgrading has been accomplished on the LM's major crossings (except Pattullo), through a combination of seismic retrofit, structural rehabilitation, and bridge replacement. Additional work is needed for a rapid return to traffic after an EQ.
- Significant ***capacity and renewal*** projects on some bridges will be necessary within a decade or so. These projects can readily include EQ resilience improvements.

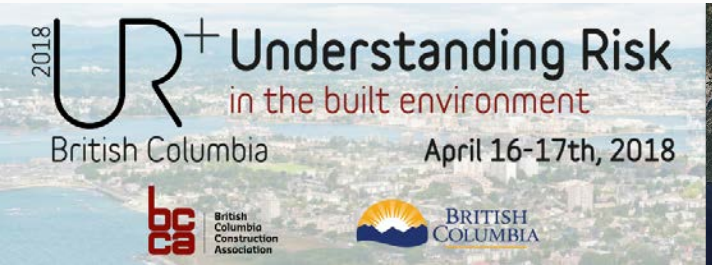


MoTI Seismic progress and programs

Summary

- The Lower Mainland / Vancouver region is divided by major rivers and harbours, limited major route redundancy in a high seismic environment. Yet…
- A complete Critical roads network is economically achievable.

Thank you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