BC Smart Infrastructure Monitoring System (BCSIMS)

2013 UBC-Tongji-CSRN Symposium

Sharlie Huffman, P.Eng.
Sr. Seismic & Structural Health Engineer

Bridge Engineering

Ministry of Transportation
BCSIMS

- BC Seismicity
- Monitoring networks
- BCSIMS
- Early Warning System
Two of the three largest tectonic plates colliding on our doorstep.
Monitoring Networks

• “Weak” Motion Network
• Strong Motion Network
• Structural Monitoring
• Early Warning Systems
“Weak” Motion Network

- Sensitive – (high gain) but is overwhelmed by near large events
- Used to locate (in 3D) source of earthquake and determine magnitude
- Provide “firm ground” readings
- Need geotechnical estimate of ground effects to estimate surface values on other soils
- Needs staff to review and interpret data
Strong Motion Network

- Not overwhelmed by strong, local events
- Not able to detect far events - higher internal noise
- Can function without the existence of a seismological data center *(very handy attribute)*
- Internal instrument calculation of Intensity, A, V, D
- Ground motion is *measured* (as opposed to being estimated) in situ. The source, propagation and local site effects are already incorporated, no corrections are required
- Instruments inexpensive enough for dense deployment
Haida Gwaii 2012-10-28

Figure 2: QCC01, main event, acceleration record. Time axis starts at 3:04:30 UTC
Powell River Strong Motion Sites
Structural Monitoring

- Provides response of structure to the ground shaking
- Damage detection
- Damage location – this is complex
- Bonus – ongoing structural health monitoring
  - Response of structure to ambient vibration
  - Confirmation of design hypotheses
  - Rehabilitation planning
  - Detection of impact, dislocation and deterioration
Early Warning Systems

- Japan is the leader in these systems - has an advanced system – worked very well during last earthquake
- Turkey also has a small but excellent system
- Mexico, California have limited systems
- BC has a very limited system – GMT
- The next step for many of us – to expand and improve our systems

- BC EWS – in development
Concept of BCSIMS

- Autonomous and remotely operated
- Parameters relevant to engineers and responders
- Structural sensors respond to EQ, wind, traffic, impacts
- Results displayed online at the website www.bcsims.ca either through the public or authorized access, and emails reports (alerts) to subscribers
- Shake maps enable emergency managers, responders and inspectors to estimate damage, location and need
- Engineers use shake maps/values to compare with what structures designed for – decide potential for damage
- For instrumented structure, estimate potential damage and location
- Facilitate attention to structural & utility problems to avoid escalation
The Team

1. BC Ministry of Transportation and Infrastructure
2. UBC Earthquake Engineering Research Facility (EERF), Department of Civil Engineering
3. Pacific Geoscience Centre of Geological Survey of Canada
4. Institut National de Recherche en Informatique et en Automatique (INRIA) – of France
5. Structural Vibration Solutions A/S (SVS) of Denmark
BCSIMS - Why MoTI?

- MoTI Responsibility
  - Aged bridges and rehabilitation challenges
  - Post earthquake inspections
  - Keeping the routes open

- Being prepared (planned retrofits, awareness)

- Field intelligence – damage, severity?

- Prioritization

- Changing plans

- Risks/decisions

- Post Disaster Response & Recovery
2005 and Prior – SM notice
2006 - SM notice
BCSIMS Home Page
Using BCSIMS - Earthquake Response

- Zoomable Shake Maps with
  - Intensity
  - Acceleration
  - Velocity
  - Displacement
- Structural status
- Historical event data
JMA Intensity map for 6.3 on Nootka Fault
Instrument Intensity map for 6.3 on Nootka Fault
Using BCSIMS - Earthquake Response

- Real-time field intelligence
  - Compare measured seismic Demand with predetermined Capacity
  - Rapid plan adjustment
  - Effective deployment of response resources
  - Damage estimations – global & local
  - Earlier start to recovery efforts
  - Ongoing monitoring – aftershocks
Simulation – zoomed shake map
System Alerts

- Notice that the shake maps do not show station dots (just the instrumented bridges)
- We can overlay the shake maps with relevant layers
  - bridge inventory layer – for us
  - Disaster routes, other major routes - for iNet
  - Hospitals, first aid stations - ?
  - Water/sewer lines - ?
Using BCSIMS – To Come – layers
2011 April 14 Rockslide Sea-to-Sky
Using BCSIMS: Structure Information

- Reports: Summary and comprehensive set of information in HTML format (can be received by email or accessed through website)
- Information on monitoring system, photos, drawings, bridge information
- Public data and authorized data access
- Results: statistics for each measured channel, drift, modal analysis, damage detection
- 3D model with results
Instrumented Provincial Bridges

Currently instrumented
- Queensborough
- French Creek
- Portage Creek
- George Massey Tunnel
- William R Bennett Bridge
- Pitt River Bridge
- Port Mann
- Fraser Heights
- Kensington
- Gaglardi
- 176th St
- Second Narrows
French Creek Bridge
Carries Highway 19 over French Creek near Parksville
Opened in 1996
Monitored with 12 sensors

George Massey Tunnel
Carries Highway 99 under Fraser River between Richmond and Delta
Opened in 1959

William R Bennett Bridge
Carries Highway 97 over Okanagan Lake between Kelowna and West Kelowna
New partially floating bridge opened in 2008 replacing original 1958 bridge
Ironworkers Memorial Second Narrows Crossing
Carries Highway 1 over Burrard Inlet between Vancouver and North Vancouver
Opened in 1960

Pitt River Bridge
Carries Highway 7 over Pitt River between Port Coquitlam and Pitt Meadows
Opened in 2009 replacing the two existing bridges

Queensborough Bridge
Carries Highway 91A over Fraser River in New Westminster
Opened in [date]
Instrumented Provincial Bridges

- **To Come – New**
  - Hwy 17 overpass/SFPR
  - Sunbury
  - BNSF
  - Tannery

- **To Come – Existing**
  - Powell R bridge
  - 5 more being identified
Additional SHM – to come

City of Vancouver – Cambie – Burrard
Additional SHM – to come

- Ministry of Education
  - Undecided number of retrofitted schools
- Catholic Archdiocese of Vancouver
  - 20 schools identified – potential 60 total
### Pitt River Bridge

**Station ID:** 3233  
**DBID:** 2  
**Longitude:** W122.73  
**Latitude:** N49.25

### Logs

<table>
<thead>
<tr>
<th>Date/Time</th>
<th>Top Channel Name</th>
<th>Bottom Channel Name</th>
<th>Drift [m]</th>
<th>Threshold [m]</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>06/06/2012 12:19:30 PM TA-03</td>
<td>TA-03</td>
<td>0</td>
<td>0.011</td>
<td></td>
<td>Drift between two columns</td>
</tr>
<tr>
<td>13/06/2012 1:30:00 PM TA-03</td>
<td>TA-03</td>
<td>1.1E-07</td>
<td>0.011</td>
<td></td>
<td>Drift between two columns</td>
</tr>
<tr>
<td>05/03/2012 3:40:00 PM TA-03</td>
<td>TA-03</td>
<td>6E-08</td>
<td>0.011</td>
<td></td>
<td>Drift between two columns</td>
</tr>
<tr>
<td>09/09/2012 12:19:30 PM TA-03</td>
<td>TA-03</td>
<td>1.4E-07</td>
<td>0.011</td>
<td></td>
<td>Drift between two columns</td>
</tr>
<tr>
<td>05/05/2012 10:06:00 AM TA-03</td>
<td>TA-03</td>
<td>1.5E-05</td>
<td>0.011</td>
<td></td>
<td>Drift between two columns</td>
</tr>
</tbody>
</table>
In-process & Coming System Updates

- Major graphical interface overhaul
- Improved shake map algorithms
- Mapping for mobile devices
- Capability for messaging on the homepage
- Multiple user-selected data layers
- Simplified structure information pages
BC Early Warning System

- Network system
- MoTI/UBC developing/testing new instruments
  - Small
  - Low power usage
  - Combined with SMN – for economy
  - Must detect and measure P-wave & PGA
  - Inexpensive
- Ocean Networks developing system software
THANK YOU