




CAEE Canadian Association for Earthquake Engineering
ACGP l'Association Canadienne du Génie Parasismique

History of Earthquake Engineering in Canada

Lessons Learned and Impact on Today's Practice

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"On the fifth of February, 1663, towards half past five in the evening, a loud roaring was heard at the same time throughout the length and breadth of Canada. This noise made all rush outdoors people were much surprised to behold walls tottering, and all the stones in motion as if they had been detached."

(Jesuit Relations, 1663)

Thus begins the documented history of earthquake occurrence in Canada. This was an earthquake near Quebec City.



The First Documented Earthquake on the West Coast

The first account of an earthquake on the west coast is to be found in the journal of Captain George Vancouver. There he noted that in 1793 a severe earthquake shock had been felt at the Spanish settlement of Nootka on the west coast of Vancouver Island (Vancouver, 1793).

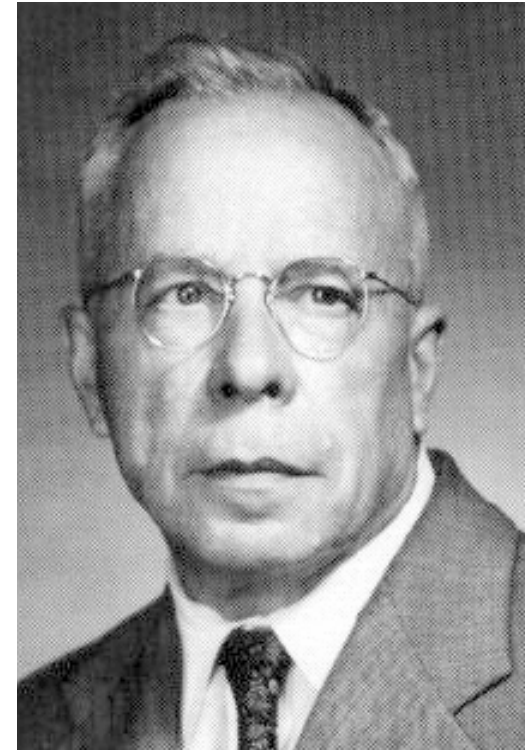


The Early Years

Scientific observation of earthquakes in Canada began, when the British Association for the Advancement of Science established a world seismograph network that included stations at Toronto (1897) and Victoria (1898). These stations were operated by the Federal Meteorological Services of Canada until they were turned over to the Dominion Observatory in 1936.

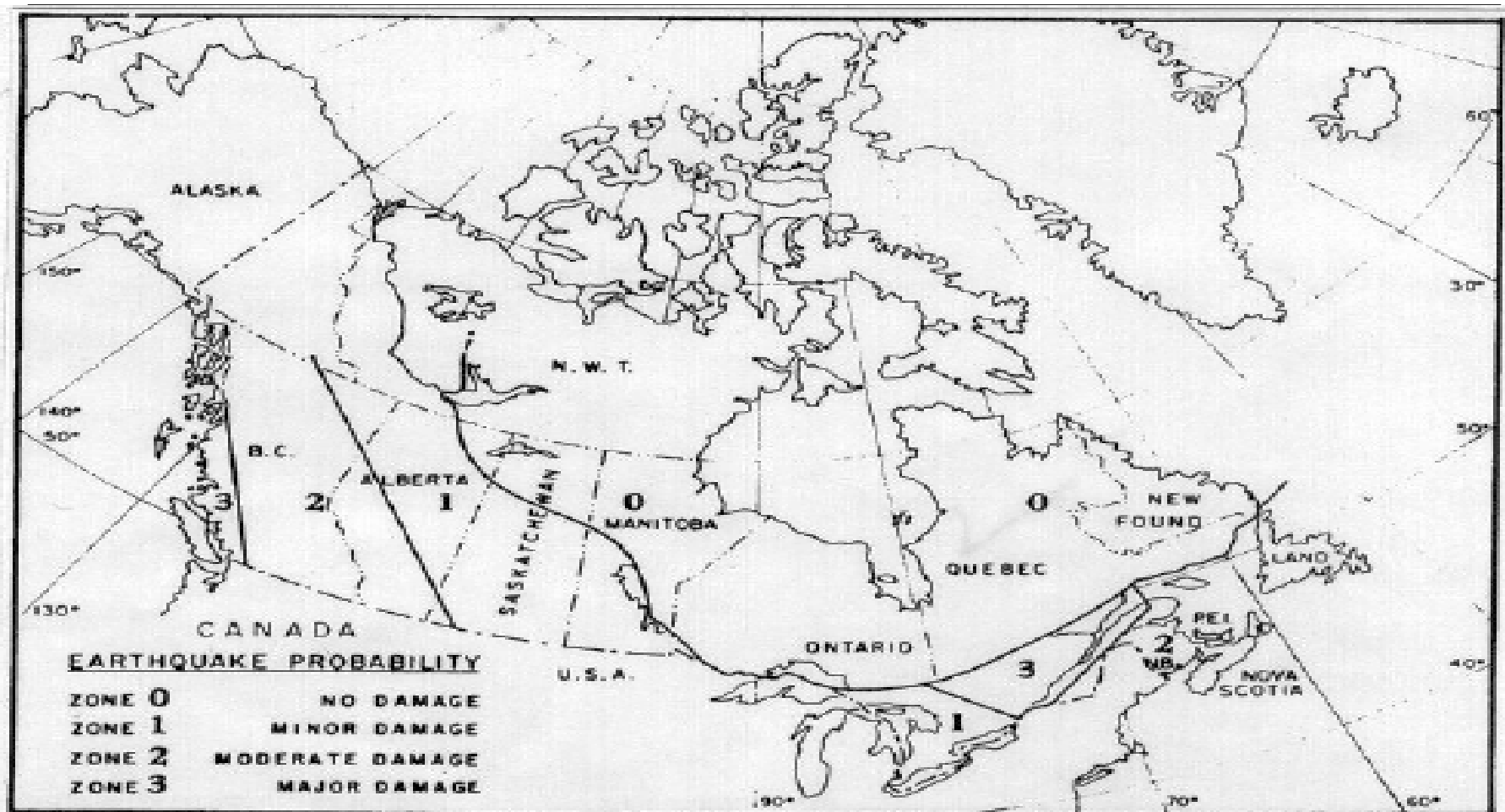
Beginning of Seismic Design Practice in Canada

- ❑ **E.. A. Hodgson became Head of the Seismological Division of the Dominion Observatory of Canada in 1924.**
- ❑ **He gained international recognition and successfully bridged the gap between seismology and earthquake engineering.**
- ❑ **His report on the 1924 M = 6.5 La Malbaie Earthquake in Quebec constitute the first detailed scientific study of a Canadian earthquake.**



E. A. Hodgson

The First National Building Code of Canada (NBCC) - 1941



The first seismic map of Canada, 1953

The First Probabilistic Hazard Map

- ❑ **The first probabilistic hazard map (indeed one of the first in any country) appeared in the 1970 NBCC. It was based on statistical studies of Canadian seismicity by W.G. Milne and included earthquakes from 1900 to 1963.**
- ❑ **Gumbel's extreme value method was applied to to establish peak ground accelerations. These accelerations were used to establish bounds for 4 seismic zones.**

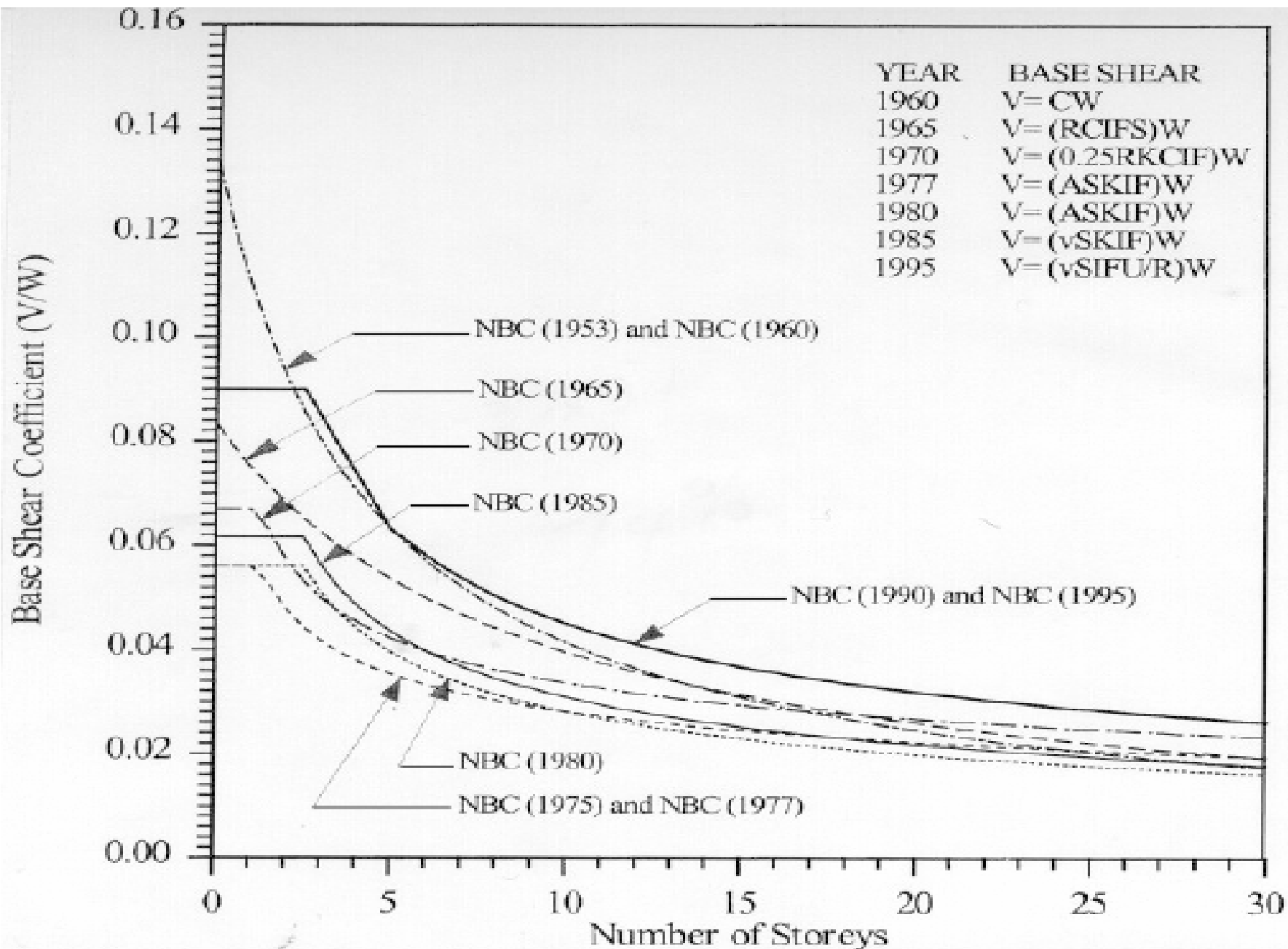


W. G. Milne



Canadian Practice Since 1985

- Two seismic hazard maps were developed for 1985 NBCC, one for accelerations and one for velocities to better represent the effects of different frequencies on structural response. PGA and PGV were based on 10% in 50 year earthquake.**
- New seismic hazard maps were published in 1999 that provided ground motions with a probability of exceedence of 2% in 50 years for NBCC 2005. The new maps reflect earthquake occurrence to 1990 in the east and to 1991 in the west.**





Current Canadian Practice Based on NBCC-2005

- ❑ Seismic hazard is defined by Uniform Hazard Spectrum (UHS) for each city.**
- ❑ UHS ensures an equal probability of exceedence at each period of structural response.**
- ❑ For the first time, the effects of the Canadian subduction earthquake have been taken into account. This has been done in a deterministic fashion.**



Current Canadian Practice (NBCC-2005)

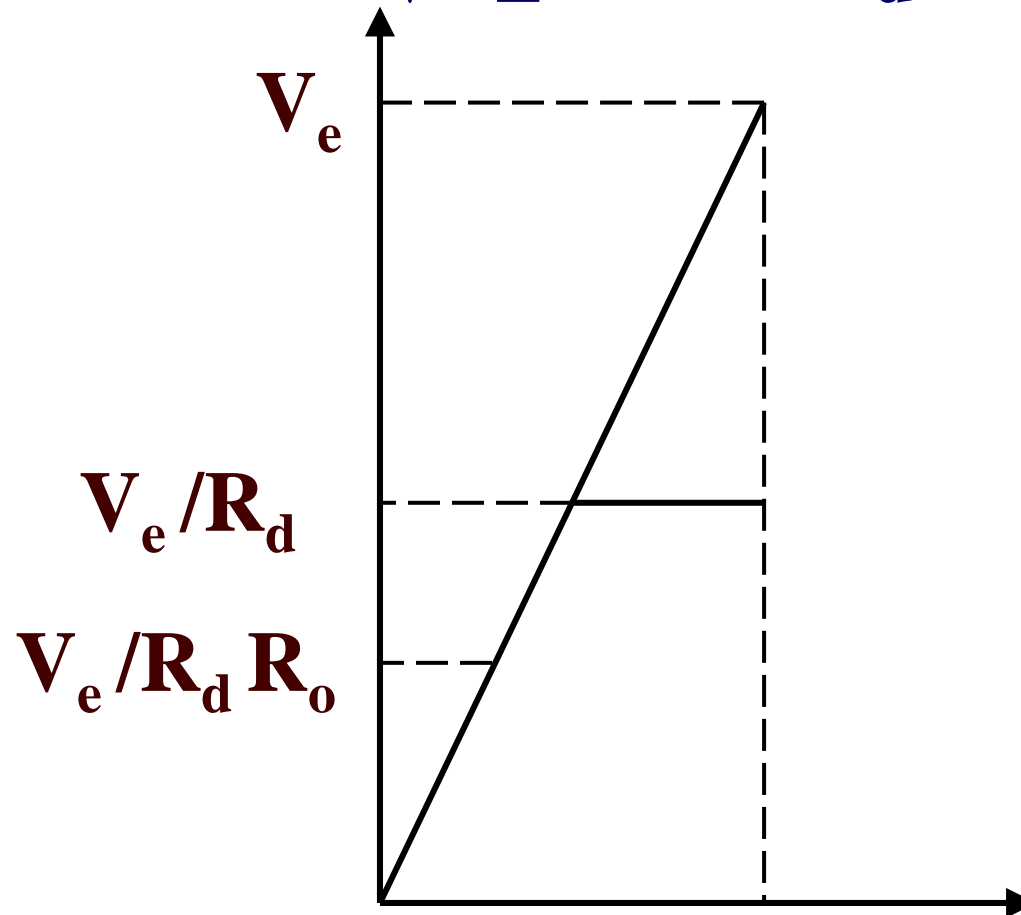
Seismic Design Forces

- ❑ Dynamic analysis procedure is the preferred method.
- ❑ Equivalent Static Load procedure may be used, if:
 - $I_e F_a S_a(0.2) < 0.35$
 - Regular buildings with height < 60 m and $T_a < 2$ s
 - Irregular buildings with height < 20 m and $T_a < 0.5$ s
and are not torsionally sensitive

Current Canadian Practice (NBCC-2005)

Equivalent Static Base Shear

$$V = S(T) M_v I_E W / (R_d R_o)$$





Earthquake Engineering in Canada

- Canadian National Committee for Earthquake Engineering (CANCEE); 1964 - Present**
- Canadian Association for Earthquake Engineering (CAEE); 1993 – Presents**
- Universities and University Research Centres (Over \$ 80 Million infrastructure investment in specialized equipment and facilities)**
- Government Research Laboratories**
- Consulting Industry**



Contributions to Earthquake Engineering Practice

- ❑ Previous research and lessons learned from past earthquakes have had impact on earthquake engineering practice, nationally and internationally.**
- ❑ Research in engineering seismology has led to new earthquake attenuation relationships and probabilistic hazard maps.**
- ❑ Uniform Hazard Spectra were developed and dynamic analysis approach has been implemented into the NBCC.**



Contributions to Earthquake Engineering Practice

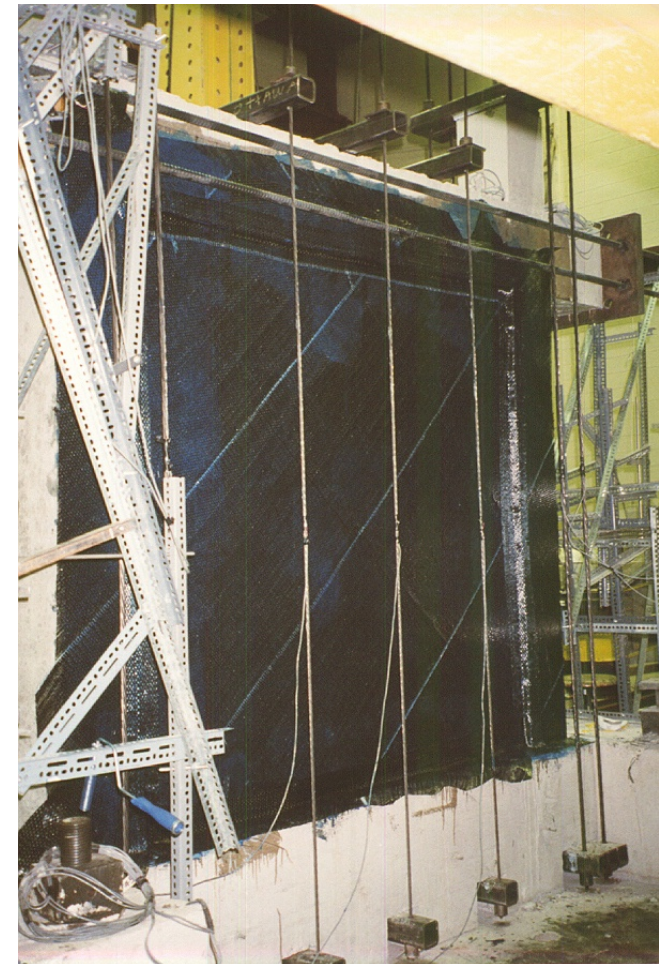
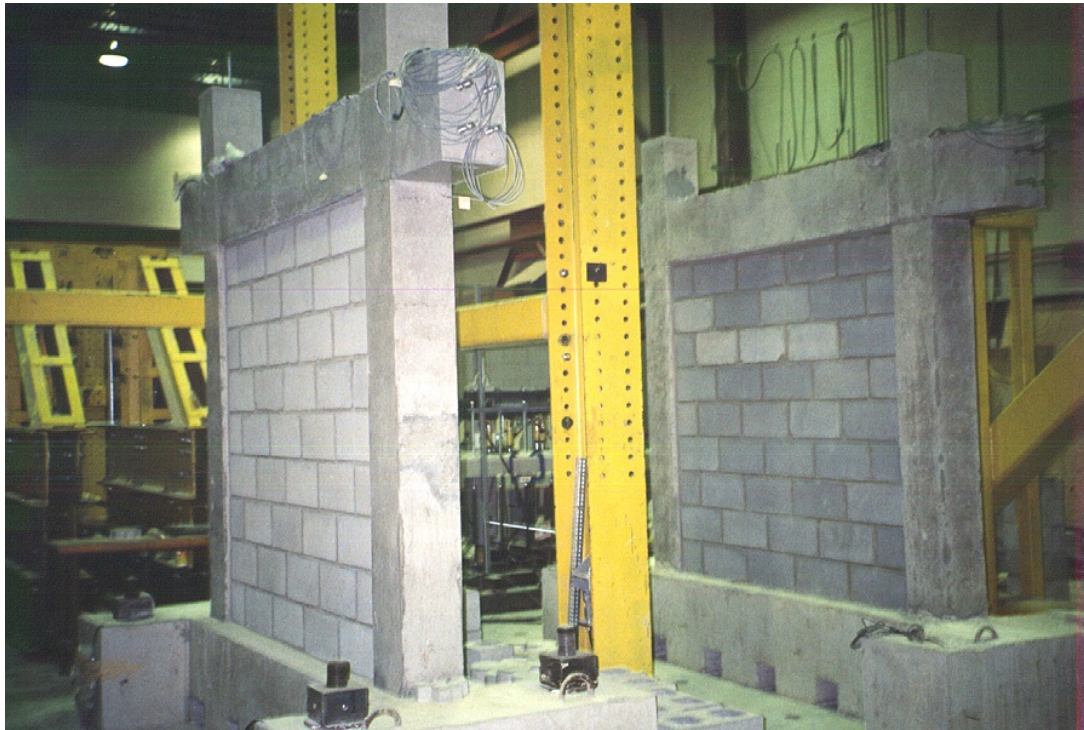
- **Extensive research on reinforced concrete structures resulted in seismic design and detailing procedures. More specifically;**
 - **Design requirements were developed for beam-column joints.**
 - **Column confinement models and design requirements were developed and adopted.**
 - **Ductile shear wall design and detailing requirements were developed and implemented.**
 - **Coupling beam design and detailing requirements were developed.**

Contributions to Earthquake Engineering Practice

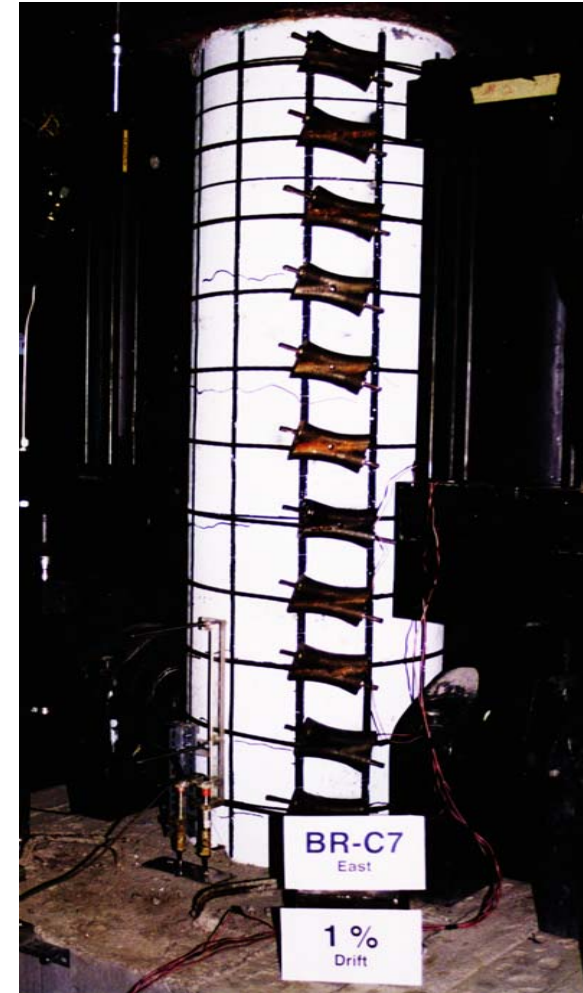
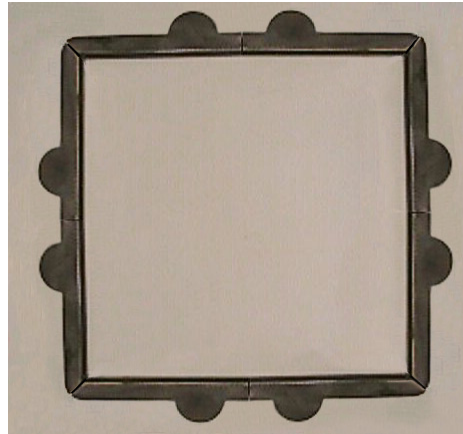
- ❑ FRP research has led to the development of one of the first buildings codes (CSA S806-02) in the world on FRP reinforced concrete structures, with a section on seismic retrofitting.



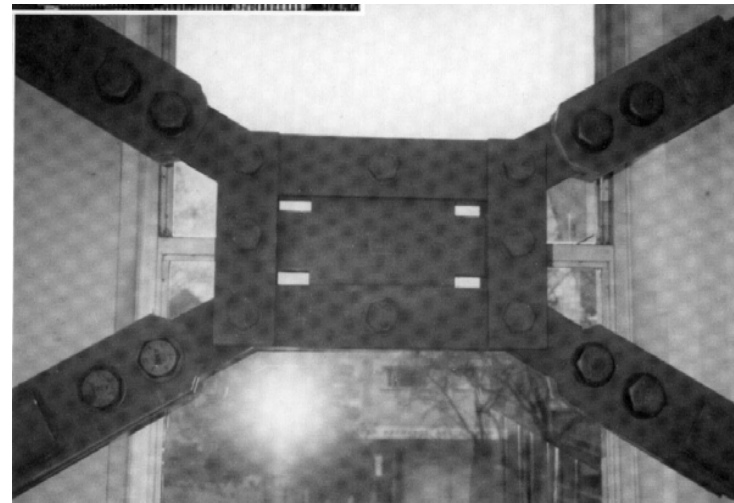
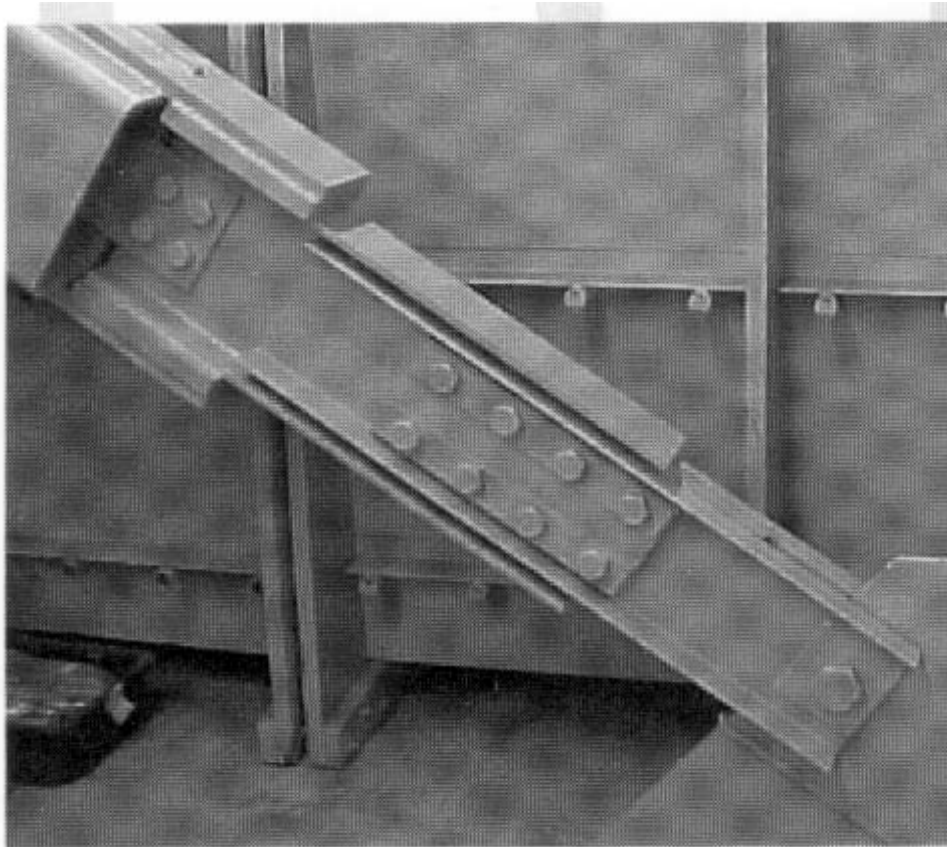
Contributions to Earthquake Engineering Practice – Masonry Retrofit



Contributions to Earthquake Engineering Practice – RetroBelt Technique



Contributions to Earthquake Engineering Practice – Pall Friction Dampers





Thank You...