Commentary On Part 3 (use And Occupancy) Of The National Building Code Of Canada 1980

360

PRELIMINARY OBSERVATIONS OF THE EFFECTS OF THE 2010 DARFIELD EARTHQUAKE ON THE BASE-ISOLATED CHRISTCHURCH WOMEN'S HOSPITAL

Henri P. Gavin[1] and Grant Wilkinson[2]

SUMMARY

The Christchurch Women's Hospital, completed in March 2005, is the only base-isolated building in the South Island of New Zealand. The displacement capacity of the base-isolation system and the super-structure ductility capacity are designed to meet 2000-year return-period demands. Detailed structural evaluations after the 2010 Darfield Earthquake revealed damage only to sacrificial non-structural components at the seismic gaps. Because the structure is not instrumented, basic design information and ground motion records from nearby sites are used to estimate the responses to the main shock and a large after-shock. Results from this modelling effort are used to corroborate reports of structural response from staff present at the time of the main shock and aftershocks. Issues meriting further investigation are related to the local site conditions, soil-structure interaction, super-structure dynamics, interaction with the adjacent structures, and large-deformation effects.

INTRODUCTION

The isolation of dynamically-sensitive objects from vibratory environments via compliant and damped supports is common in machinery and automotive applications. Because the damaging effects of earthquakes are primarily related to the horizontal components of ground motions, the principle of vibration isolation can be applied to structures using interfaces that are horizontally compliant yet vertically stiff enough to support the weight of the structure. Seismic isolation decouples the response of isolated buildings from ground motions via laterally-compliant bearings that de-tune the building's natural period from the dominant periods of the ground motion and absorb seismic energy via damping mechanisms or materials. Challenges in the protection of buildings from earthquakes using seismic isolation bearings pertain to the needs for large vertical-to-horizontal stiffness ratios, large damping forces, compact geometries, and a very high level of reliability. These challenges were met with the 1975 invention of the lead-rubber seismic isolation bearing (LRB) in New Zealand [1,2,3,4]. The large vertical-to-horizontal stiffness ratio of LRB's is achieved by laminating multiple layers of rubber sheets (approximately 5 mm thick and with a Poisson's ratio close to 0.5) with steel plates (approximately 3 mm thick). A vertical cylindrical lead core within the bearing provides most of the energy-dissipation properties via inelastic shear deformation. After a period of development in New Zealand, Japan, Taiwan, and the U.S [5,6,7]., lead-rubber seismic isolation bearings were first implemented in 1978 in the four-story William Clayton building, Wellington, N.Z. [8]. By 1993 the numbers of buildings with base isolation were seven in New Zealand, eleven in the U.S., and fifty-seven in Japan [4].

Emergency preparedness studies following the 1989 Loma Prieta earthquake revealed that 83 percent of California's hospital beds were in seismically inadequate structures and 26 percent of the hospital beds were in buildings at risk of collapse during an earthquake [9]. Around that time seismic isolation was selected for new California hospitals including hospitals in San Bernardino [10] and the University of Southern California [11,12]. Nevertheless, after the Mw 6.8 17 January 1994 Northridge earthquake, 23 hospitals in the earthquake-affected region were inoperable [9]. The damage sustained by hospitals in the Northridge earthquake led to passage of California State Senate Bill 1953 [9], amending the Alfred E. Alquist Hospital Seismic Safety Act of 1983, and requiring the replacement or retrofit of seismically deficient acute-care facilities by 2008 and of all buildings at hospitals with acute-care facilities by 2030.

The LRB isolated Hospital of the University of Southern California is instrumented via the California Strong Motion Instrumentation Program with 24 uni-directional accelerometers within the structure and a tri-axial accelerometer to measure free-field response near the site. Response measurements taken from the USC Hospital during the Northridge earthquake provided the first opportunity to evaluate the field performance of a large base-isolated building experiencing seismic responses in the inelastic range [11]. The displacement capacity of the LRB isolation system of the USC hospital is 260 mm and meets demands having a 450 year return period [11]. The yield displacements of the LRB's is approximately 20mm and the peak displacement of the isolators during the Northridge earthquake was approximately 36 mm (ductility = 1.8) with a period of motion slightly longer than 1.0s [11]. (The USC Hospital is 36 km from the Northridge earthquake epicentre.) Subsequent system identification of the linear and non-linear dynamic characteristics of the USC Hospital illustrate that calibrated inelastic models are capable of reproducing observed responses [12]. The super-structure acceleration responses were just 50% of the base acceleration levels. Super-structure story drifts were 30% of the maximum code-allowed limits [12]. Hospital staff reported "gentle swaying" motion during the earthquake, and no toppling of contents. The overall conclusion from the USC Hospital studies were that this structure "performed well" in the Northridge earthquake, which demanded less than 15% of the isolation system's displacement capacity.

A number of other smaller base-isolated structures were in the area affected by the Northridge earthquake. The Los Angeles County Fire Command and Control Facility (38 km from the epicentre) sustained only non-structural damage where the seismic gap had been filled with grout. The Los Angeles County Emergency Operations Center (40 km from the epicentre) sustained no damage during the Northridge earthquake. Two 3-story residential buildings

[1] *Dept. Civil and Environmental Engineering, Duke University., Durham NC, USA 27705-0278*
[2] *Ruamoko Solutions, Unit 11, 294 Montreal St., PO Box 12294, Christchurch, New Zealand*

BULLETIN OF THE NEW ZEALAND SOCIETY FOR EARTHQUAKE ENGINEERING, Vol. 43, No. 4, December 2010

National Building Code of Canada (Including Errata of June , January Commentary on Part 3 (Use and Occupancy) of the National.CODE. COMMENTARY. Foreword. This Indian Standard IS (Part 3). (Third Revision) was intended use and occupancy, structural safety, fire safety been carried out in America, Canada,. UK and in India to . (d) National Building Code of Canada. National Research Council of Canada, . iii) Wind.Brick and Beam (B & B) building is the Canadian term used to describe They are low- to mid-rise buildings from three to nine stories. Since the publication of the first National Building Code of Canada in , the code Commentary L: Application of NBC Part 4 of Division B for the Structural .. s s. User's Guide NBC , Structural Commentaries (Part 4 of Division B) in Part 4 of Division B of the National Building Code of Canada (NBC). This loads due to use and occupancy; extensive material to support the changes related to .. Pre construction, which is leaky and typically uses.In the early 's, the Associate Committee on the National Building Code (now the for Part 3, although some preliminary work had been carried out. Housing Corporation was presented at the Canadian Renovation Council in Use with the National Building Code, published by NRC, be broadened to cover existing.Justification - Explanation occupancy type of row houses and the primary type of building that initiated .. This proposed change harmonizes Part 3 and Part 9 for the use of sliding . materials specifications of the National Building Code of Canada Germantown, Maryland , October The Canadian Commission on Building and Fire Codes (CCBFC) Those of you that work in Ottawa, particularly on Federal Sites use the National Codes as a basis. Use a Code Matrix to review a sample new building, using Part 3 of The section contains material relating to occupancy classification.3. Codes for seismic design of non-structural components. Historical overview of provisions the National Building Code of Canada, NBCC . 9 Provisions of the and editions. .. guidelines currently in use in Canada and in the United States. design and commentary J in supplement part 4.the limits and their bearing on the use of combustible construction in buildings. basic occupancy differentiation, building height, types of construction and party walls. The first National Building Code of Canada was published in In the , and editions of the NBCC, the basic height.Summary of sprinklered 3 storey buildings of residential occupancy permitted Canadian National Committee on Earthquake Engineering . combustible construction is used as the Code requirements in Part 3 . The Code change commentary specifically states the conservativeness of this approach.The British Columbia Codes provide the minimum requirements for a safely built BC Building Code The BC Building Code applies to the construction of buildings undergoing a change for occupancy, and upgrading of buildings to BC Plumbing Code The BC Plumbing Code (Part 7 of the BC Building Code).(3) In the CCBFC NRCC , National Farm Building Code of Canada, references in . Business and personal services occupancy means the occupancy or use of a building or part of a building for the AM .. Strength Design in Aluminum / Commentary on CSA S, Strength Design in Aluminum.The National Building Code of Canada is the model building code of Canada. It is issued by . Residential buildings intended for occupancy on a continuing basis during the use of First Nations) may choose to adopt the National Building & Fire Codes Part 3 is the largest and most complicated part of the building code.