DYNAMIC RESPONSE OF INELASTIC FIXED-BASE AND BASE-ISOLATED STEEL STRUCTURES UNDER WIND AND EARTHQUAKE

A. Athanasiou[(1)], L. Tirca[(2)], T. Stathopoulos[(3)],

[(1)] *Postdoctoral fellow, Concordia University, Montreal, Canada, anaj.athanasiou@gmail.com*

[(2)] *Associate professor, Concordia University, Montreal, Canada, lucia.tirca@concordia.ca*

[(3)] *Professor, Concordia University, Montreal, Canada, statho@bcee.concordia.ca*

Abstract

This study investigates the inelastic behavior of a multi-storey steel hospital building with and without base-isolation system under recurring winds and earthquakes. The steel braced-frame building, located in the seismic zone of Eastern Canada, is designed according to the current building code and the steel design standard. The base-isolation system is composed of 16 lead rubber bearings. Detailed, finite element models of the building are developed in OpenSees. The models account for both the hysteretic characteristics of the isolators and the plasticity of the superstructure. The fixed-base and base-isolated systems are subjected to an ensemble of spectrum-compatible ground motions and winds of increasing return periods. The wind histories considered in the study are generated from wind tunnel data, available at the Tokyo Polytechnic Database. Nonlinear wind and earthquake history analyses provide measures of the inelastic structural response in terms of floor accelerations, inter-story drifts and isolator displacement demands. The fixed-base structure dissipates the energy input by the earthquake through controlled yielding of ductile members, but remains elastic under the design-level winds. Base isolation decouples the structure from ground shaking and reduces the earthquake and wind demands in the structural members. Mitigation of the forces exerted to the superstructure is achieved through period elongation. The input energy is absorbed through hysteresis in the bearing elements - the latter sustain several cycles of lateral loading without significant loss of integrity. At the design level, the base-isolated superstructure remains in the linear range, ensuring the continuous operation of the structure and minimizing losses. The base-isolated structure responds following the first mode (isolation mode), minimizing this way the relative to the base superstructure response. The findings demonstrate the effectiveness of base isolation to improve the seismic and wind performance of long period structures. They moreover show that the multi-hazard design of important structures could benefit by the use of a limited reduction factor (R=1.5), without any loss of performance at the design level.

Keywords: inelastic superstructure, ductile design, base isolation, nonlinear analysis, earthquake, wind

CHARACTERIZATION OF THE CONCRETE CRACKING LIMIT STATE FOR THE SEISMIC ANALYSIS OF GRAVITY DAMS

A. Santos[(1)] and P. Paultre[(2)]

[(1)] *PhD candidate, Université de Sherbrooke, Sherbrooke, Canada, anderssen.barbosa.dos.santos@usherbrooke.ca*

[(2)] *Professor, Université de Sherbrooke, Sherbrooke, Canada, patrick.paultre@usherbrooke.ca*

Abstract

Concrete dam structures are often subjected to dynamic loads, such as earthquake loads. Under such loads, distinct changes may occur in the dynamic and damage behavior of concrete. At the seismic strain rates, the tensile strength of concrete increase significantly. The guidelines for concrete dams consider this amplification by the dynamic increase factor (DIF), i.e. the ratio of the dynamic to static strength, is normally reported as function of strain rate. Despite of the scarce number of studies, is notable that the DIF at different strain rates can be amplified by the water content and loading history, indicating the need for research focused on these factors. Furthermore, the dynamic tensile strength of concrete may be affected by the curing process, aggregate size and the concrete strength. The mass concrete for dams characterized by the presence of large aggregates (up to 150 mm) in diameter, presents tensile strength lower than standard concrete. Although, low strength concrete tends to be more sensitive to the train rate in relation to structural concrete. Currently, the method recommended in dam guidelines to account for the concrete dynamic properties is through an amplification factor determined as function of the static properties. However, this simplified and deterministic approach does not represent the high strain rate sensitivity on the mechanical properties of the concrete, nor the conditions rarely documented in the literature as water content and the loading histories. This study aims to conduct an experimental and numerical study the concrete dynamic tensile resistance to rigorously characterize the cracking limit state for gravity dams in the presence of seismic loads. Exploring the influence of ambient and the initial load conditions to which hydraulic structures are exposed during their lifetime. This research project will allow to determine the dynamic tensile strength, by providing an extensive data from the experimental test, which will allow to develop strain rate dependent model to asses concrete cracking under seismic loads. The compilation of these results will allow the establishment of more reliable cracking limit state criteria to improve the seismic assessment of dam structures. Influencing parameters in different levels will thus be defined, which will constitute the basis to enhance the decision-making process. The analysis and compilation of these data together with the judgment of experts will allow to modify the existing limit states and to reduce their uncertainty.

Keywords: Dam concrete, Strain rate, Water content, Loading history, Cyclic load, Mesoscale Model

CFD MODELLING FOR THE STUDY OF STRUCTURAL STABILITY OF DAMS AND SPILLWAYS SUBJECT TO OVERTOPPING

M. Freitas[(1)], E. Favre, P. Léger[(2)] and L.J. Pedroso

[(1)] *PhD candidate, Polytechnique de Montréal, Montréal, Canada, mario-raul.freitas@polymtl.ca*

[(2)] *Professor, Polytechnique de Montréal, Montréal, Canada, pierre.leger@polymtl.ca*

Abstract

A particularly challenging aspect in gravity dam stability assessment is the estimation of the induced hydrodynamic water pressure when water with significant velocity is overtopping gravity dams and flowing in or over spillway components. The water flow conditions, including the related pressure fields and resultant forces, are difficult to quantify accurately. Computational fluid dynamics (CFD) is an attractive alternative to physical models to quantify the hydrodynamic forces acting on overtopped gravity structures and spillways to assess their structural stability. Herein, existing dam safety guidelines to estimate the weight of the overflowing water nappe on gravity dams with rectangular crests are first reviewed. Then, validation and verification models are run to ensure that the computational models are suitable for the case studies that are analyzed later. After that, CFD is used to develop an improvement to the simplified estimation of hydrodynamic pressure fields acting on the rectangular crests of submerged gravity dams. The CFD pressures are used as input data to classical structural stability analyses based on the gravity method to more adequately quantify the dam sliding stability during overtopping. Applications are then presented on an existing 7.6 m high gravity dam comparing existing dam safety guidelines with proposed improvements based on CFD. A back analysis is also performed on the stability of an existing gated spillway with a bridge that was overtopped during the 1996 Saguenay flood in Québec. The complex flow conditions across the spillway are investigated, including the incidence of accumulated floating debris producing additional thrusts on the structure.

SEISMIC RESILIENCE ASSESSMENT OF REINFORCED MASONRY SHEAR WALL SYSTEMS

S. Hosseinzadeh[(1)] and K. Galal[(2)]

[(1)] *PhD candidate, Concordia University, Montréal, Canada, shadman.hosseinzadeh@concordia.ca*

[(2)] *Professor, Concordia University, Montréal, Canada, galal@bcee.concordia.ca*

Abstract

The resilience concept is known as the capacity of the structure to resist and maintain a certain level of functionality during and after an unexpected event such as an earthquake. In this research work, the impact of utilizing masonry boundary elements is highlighted through a developed framework to assess the seismic collapse capacity of Reinforced Masonry Shear Wall buildings. The findings of this study prepare comprehensive and useful information for earthquake mitigation measures and disaster risk reduction programs.

Keywords: earthquake mitigation, masonry shear wall, seismic collapse capacity.