Real Time Bi-objective Path Search Problem in a Capacitated Transportation Network

A Bhowmick[1] and B.Ashtakala[2]

Peak-period traffic congestion has been the subject of many research studies in transportation engineering for so many years. Path search problems in a wide and congested transportation network are one of the key issues in recent evolution of the Intelligent Transportation System (ITS). This research study aims to an efficient solution approach for finding optimum path through a network in real time that arises in dynamic transportation systems. The algorithm used in this study to find the time-dependent shortest path in the network is the incorporation of a well-known search technique, the best neighbour heuristic search with an existing bi-objective path search algorithm. Two important issues are addressed by this research in context of Dynamic route guidance systems. The first one is to direct the drivers towards their destination on the basis of real-time network condition and second one is to notify the improvement of path search problems due to the real-time dynamic traffic network. The study has been carried out through a visual simulation on a real traffic network of downtown Montreal area. Compared to existing literature of the path search problems and scope of implications, the findings of this research would definitely put a major contribution in the field of dynamic traffic management.

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Investigating the Relationship between Proximity to Subway Stations and Rates of Transit Use in Montreal and Toronto

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This paper investigates the effect of proximity to subway or metro stations on commute trips by transit the cities of Montreal and Toronto. To illustrate the relative importance of this contributing factor, socio-demographic variables were added to the analysis. Results derived from multiple regressions models estimated using zonal attributes reveal the following:

- In both Montreal and Toronto, variables such as race, gender, and income are more significant in explaining transit use rather than proximity to the subway station.

- For both Montreal and Toronto, the dummy variables used for distances from a metro station explained better the car use than the transit use. This means it is more significant to say “the further away a person lives from a metro station, the more likely they are to use their cars to go to work” rather than “ the further away one lives from a metro station, the less likely they are to use the metro to go to work”.

- In Toronto, people who live 500 m away from a station are more likely to use the subway than people who live in a zone that contains a metro station. This is not the case for Montreal.

- For both Montreal and Toronto, subway stations were located in the areas with highest densities; however the density of a zone is not strongly linked to transit use in that zone.

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Spectral Element of a Helix

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The helix is treated as straight, linear elastic element, exhibiting coupling of axial with torsional responses. The coupling is expressed by two constitutive equations

$$F = A_1\varepsilon + A_2\tau \qquad M = A_3\varepsilon + A_4\tau$$

where F is tensile force and M is torque, while ε is axial strain and τ is angle of twist per unit length. Furthermore, A_1, A_2, A_3, A_4 are constitutive constants dependent on both the rope material and construction. Determination of a spectral finite element of a helix is the focus of this paper. The equations governing coupled extensional-torsional oscillations of wire rope are

$$A_1\frac{\partial^2 u}{\partial z^2} + A_2\frac{\partial^2 \theta}{\partial z^2} = m\frac{\partial^2 u}{\partial t^2} \qquad A_3\frac{\partial^2 u}{\partial z^2} + A_4\frac{\partial^2 \theta}{\partial z^2} = J\frac{\partial^2 u}{\partial t^2}$$

Considering harmonic motions according to: $u(z,t) = \hat{u}(z,\omega)e^{i\omega t}$ $\theta(z,t) = \hat{\theta}(z,\omega)e^{i\omega t}$

where ω is the frequency, and the hat stands for a quantity in the frequency space. The solution for extensional-torsional oscillations of wire rope in terms of trigonometric functions becomes

$$\hat{u}(z,\omega) = U_1\sin(k_1 z) + U_2\sin(k_1(L-z)) + U_3\sin(k_2 z) + U_4\sin(k_2(L-z))$$

$$\hat{\theta}(z,\omega) = R_1\left[U_1\sin(k_1 z) + U_2\sin(k_1(L-z))\right] + R_2\left[U_3\sin(k_2 z) + U_4\sin(k_2(L-z))\right]$$

In the above U_1 through U_4 are arbitrary constants. Next, by taking the boundary conditions as

$$u(0) = \hat{u}_1 \qquad u(L) = \hat{u}_2 \qquad \theta(0) = \hat{\theta}_1 \qquad \theta(L) = \hat{\theta}_2$$

and using periodic boundary conditions we determine the four-by-four spectral stiffness matrix of a helix as follows:

$$K = \frac{1}{R_2 - R_1}\begin{bmatrix} k_1R_2E_1\cot(k_1L) - k_2R_1E_2\cot(k_2L) & -k_1R_2E_3\csc(k_1L) + k_2R_1E_4\csc(k_2L) \\ -k_1R_2E_1\csc(k_1L) + k_2R_1E_2\csc(k_2L) & k_1R_2E_1\cot(k_1L) - k_2R_1E_2\cot(k_2L) \\ k_1R_2E_3\cot(k_1L) - k_2R_1E_4\cot(k_2L) & -k_1R_2E_3\csc(k_1L) + k_2R_1E_4\csc(k_2L) \\ -k_1R_2E_3\csc(k_1L) + k_2R_1E_4\csc(k_2L) & k_1R_2E_3\cot(k_1L) - k_2R_1E_4\cot(k_2L) \end{bmatrix}$$

$$\begin{bmatrix} -k_1E_1\cot(k_1L) + k_2E_2\cot(k_2L) & k_1E_1\csc(k_1L) - k_2E_2\csc(k_2L) \\ k_1E_1\csc(k_1L) - k_2E_2\csc(k_2L) & -k_1E_1\cot(k_1L) + k_2E_2\cot(k_2L) \\ -k_1E_3\cot(k_1L) + k_2E_4\cot(k_2L) & -k_1R_2E_3\csc(k_1L) + k_2R_1E_4\csc(k_2L) \\ k_1E_3\csc(k_1L) - k_2E_4\csc(k_2L) & -k_1E_3\cot(k_1L) + k_2E_4\cot(k_2L) \end{bmatrix}$$

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Microzonation of the Island of Montreal

Ricardo Madriz[1] and Luc Chouinard[2]

Montreal is the third largest city of Canada according to the size of its population but ranked number two in terms of seismic vulnerability. In the past three decades many studies of the soil deposits of the Montreal Island have taken place without considering the influence of unconsolidated soils. There are records of earthquakes with magnitude 6 in the Richter scale, the last one in 1989 in the Saguenay area, around 300 km of Montreal. The study of the island is done considering the following statements:

1) By researching the history of the soft soil deposits and getting average values on the characteristics of the soft soils.
2) By developing a simple, inexpensive, but effective methodology to estimate the dynamic characteristics of the soft soils and estimate the amplification of the ground acceleration in all the island of Montreal.
3) By creating a database and update it as new data is available.

Nakamura's technique was used to find the predominant frequency of the site. It consists of recording microtremors, calculating the horizontal to vertical ratio of the components and plotting it versus the frequency. The amplification of the acceleration is done by the modeling of the soil. The analyses of the models are done in Shake91. Some average values of the properties of the soils are assumed and borehole records from the sites are needed. The final product will be a map identifying the critical zones of the island according to the resonance of the site and the amplification of the ground acceleration.

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Mechanical Behavior of PVC Geomembranes Subjected to Chemical Exposure

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Geomembranes are an important component of the multiple barrier system used in landfill application. Landfill generates large amount of leachate, which contains a complex mixture of chemicals and other hazardous materials that pose a threat to human health and environment. The question of the durability of a geomembrane in such an exposure is of concern to geoenvironmental engineers. The study of the behavior of geomembranes in such adverse chemical environments was therefore received attention over the past. Preliminary research has shown that geomembranes exhibit embrittlement after chemical exposure to chemicals such as ethanol and acetone. This research examines the alterations in the mechanical behavior of PVC geomembranes after periods of exposure to ethanol. The intact geomembrane exhibits a monotonic relationship between stress and strain. The exposed geomembrane exhibits greater stiffness than the unexposed material and the stress-strain response exhibits a characteristic yield. The geomembranes that are subjected to chemical exposure exhibit similar stiffness beyond the yield point pint in the stress-strain relation, which points to the unchanged rubber-like structure within the material. The yielding strain is about 4%, which is a critical constraint for certain landfill experiencing large differential settlement. The presence of yield point indicates the sudden large increase in the deformation beyond the value that could result from excessive deformation due to the failure of the slope. The paper discusses the experimental methodology and proposes constitutive models for both the intact geomembrane material and material subjected to chemical exposure.

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Moment Capacity of Pultruded FRP Composite Sheet Pile Panels

J. Shanmugam[1] and Y. Shao[2]

Fibre-reinforced polymer (FRP) composite materials offer potential performance advantages over traditional materials for use in waterfront retaining wall applications. The wood, concrete and steel pilings conventionally used in waterfront applications face durability problems and it is estimated that repair and restoration of these materials costs over $1 billion dollars annually in the United States alone. Design of FRP composite sheet piles currently draws upon strength-based methods used in steel design, thus assuming tensile failure of the material. However, due to the low modulus and thin walled nature of composite materials, they undergo large deformations and failure occurs predominantly due to local instabilities. The aim of the present research is to experimentally determine the moment capacity and failure mechanism of FRP composite sheet pile panels. A series of tests were conducted on 7ft long connected panels subjected to uniform load. The results of these tests show that buckling failure occurred when only about 30% of the tensile capacity had been reached, thus validating the fact that strength-based design methods would over-predict the structural capacity of these panels. This study allows us to conclude that current methods used to evaluate moment capacity for FRP composite sheet piles need to be revised in order to account for the mode of failure.

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Testing of Light Gauge Steel Frame/ Wood Panel Shear Walls

A.E. Branston[1] AND C.A. Rogers[2]

It is anticipated that the construction of homes and multiple storey buildings which incorporate light gauge steel frame / wood panel shear walls as primary lateral load resisting elements will increase across Canada in coming years due to the escalating construction costs of timber structures, the scarcity of adequate timber products, and, in addition, because of concerns such as pest resistance, fire resistance, and product quality. This includes sites that have a relatively high seismic risk, such as found along the West Coast of British Columbia and in the Ottawa and St. Lawrence River Valleys. With this rise in construction activity comes an accompanying increase in the probability that a light gauge steel frame structure will be subjected to the demands of a severe earthquake. Currently, guidelines for engineers with which the design of laterally loaded light gauge steel frame / wood panel shear walls can be carried out are not available in Canada. For this reason an extensive shear wall research program has been undertaken at McGill University. The long-term objective of this research is to develop guidelines for the seismic design of light gauge steel frame / wood panel shear walls for use with the 2005 National Building Code of Canada (NBCC) according to the Limit States Design Philosophy.

In order to study the performance of light gauge steel frame / wood panel shear walls subject to both monotonic and reversed cyclic loading protocols, a frame designed specifically for the testing of shear walls was installed in the structures laboratory at McGill University during the summer of 2002. This self-equilibrating structure can be used to displace the top of a test wall while measuring the wall resistance. A total of 106 steel frame / wood panel shear wall tests were carried out during the summer of 2003. In most cases, six specimens (3 monotonic and 3 reversed cyclic) were tested per wall configuration to provide a minimum level of validity/reliability for the test data. The test matrix included three wall specimen sizes: 2' × 8' (610 × 2440 mm), 4' × 8' (1220 × 2440 mm) and 8' × 8' (2440 × 2440 mm), as well as different combinations of materials and components. The scope of testing consisted of walls constructed of Canadian steel and wood products including: 1.12 mm 230 MPa nominal grade ASTM A653 steel studs and tracks; 12.5 mm Douglas Fir and Canadian Softwood plywood; 11 mm OSB; No. 8 wood sheathing to steel screws; and Simpson Strong Tie S/HD10 hold downs. All wall specimens contained back-to-back chord studs with the remaining interior studs spaced at 24", and were sheathed on one side with the wood panel positioned in the vertical direction. Three different sheathing screw patterns were investigated, that is 3" (76 mm), 4" (102 mm) and 6" (152 mm) c/c distance over the perimeter of each wood panel, with the field screws placed at a 12" (304 mm) spacing. The monotonic tests subjected the wall specimen to a static loading in one direction, while the reversed cyclic tests followed the CUREE protocol for ordinary ground motions.

The results of the testing program were analyzed using the EEEP data interpretation technique in hope to develop useful design capacities for a wide range of construction configurations. Research is ongoing in developing a resistance factor for use in design, as well as determining the effect of a combination of gravity load / lateral load on a light gauge steel frame / wood panel shear wall.

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Monitoring the Environmental Load Paths in Wooden Light-frame Structures

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The goal of the project is to devise and demonstrate methods of identifying load paths in light-frame wood buildings subjected to environmental loads. While several full-scale measurements of environmental loads on the building envelope have been made, the novelty of this study is to attempt to link these loads with the response of the structure (internal forces and displacements). This presentation will describe experiments in monitoring the structural response of two light-frame wooden structures. The structures are being monitored to determine the environmental forces applied and how those forces flow from surfaces over which they are applied to the foundation. Monitoring is synergistic with, and linked to, laboratory studies and whole-building finite element modelling. Long-term goals are improved wind load design code provisions, development and validation of design level methods for sizing components of wood structures.

The first structure is an industrial shed building located in Saint Foy, Québec City. It is a single-storey flat roof structure of rectangular plan with outside dimensions of 15.0 m by 8.0 m and height of 5.0 m. Walls are typical nailed stud and sheathing assemblies and the roof is made of wood I-joists sheathed with plywood. The monitoring of structural response is based on measurement of the deformations of a continuous strip (including three parallel elements - studs or I-joists) of the wall and roof, in the interior of the building. Displacements are correlated with real-time estimates of environmental loads, based on the climatic data collected. Artificial (controlled) loads were also applied to the structure. Simplified finite element analysis was conducted for the rib-stiffened roof sub-system and the overall assembly. The initial study confirmed expectations that composite action and load sharing are important mechanisms for light-frame buildings. It also proved the feasibility of real-time monitoring in natural load conditions.

The second structure is a single-storey wood house of typical platform construction specially built for this experimental project on the University of New Brunswick Campus. The structure is equipped with two series of 3-axis load cells, one series being placed at the roof-to-wall interface, and the other at the wall-to-foundation interface. Special load cells were designed for the wall-to-roof interface with a view to minimise load path disruption. Other instrumentation will be installed progressively as the architectural components (openings, partitions) are built. Application of artificial static and dynamic loads during construction will enable estimation of how various components contribute to the elastic stiffness of the system, and determination of load paths and how they are modified by addition of various structural and architectural components. Results from static load tests will provide a reference point for numerical modelling.

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Testing and performance of steel frame/ wood panel shear walls

Changyi Chen[1] and C.A. Rogers[2]

A literature review of analytical approaches on wood framed shear walls is presented. Analytical models of light gauge steel frame/wood panel shear walls are developed to predict the lateral loading capacity and deflection up to the design load level. Comparisons between test results and theoretical analyses are conducted to verify the accuracy of the analytical models.

There are three main methods used for predicting the racking performance of wood framed shear walls: Empirical equations, closed form models and finite element method (FEM) analysis. A simple closed form model is introduced, which can be used to predict the strength and deflection of a light gauge steel frame/wood panel shear wall. The model is derived using the minimum potential energy principle, and is based on assumptions which minimize the mathematical complexity required for design.

Results from a series of full-scale wall tests as well as connection tests are used in the development of the analytical model. Comparison between the test results and the wall properties as predicted using the analytical model show very good agreement in terms of shear strength, however the deflection predictions, which would be considered acceptable in engineering practice, do not accurately match the measured wall racking movement.

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Use of Fibres and Headed Bars in Dapped End Beams

Zhongchun Fu[1] and D. Mitchell[2]

The behaviour of dapped ends with high-performance concrete and headed bars, together with the effects of fibres added to the concrete was investigated. Two full-scale dapped end beams with four dapped ends were constructed in this experimental program. One half of each beam was cast without fibres while the other half was constructed with concrete containing either steel fibres or polypropylene fibres. The beams had a design concrete compressive strength of 60 MPa. Strut-and-tie models were used to predict the capacity of the dapped end beams. Headed bars were used as the horizontal tension ties, and closed stirrups provided the vertical tension ties.

From the comparisons between the testing results and the strut-and-tie model predictions, and the comparisons of the behaviour between the end regions with and without fibres, it was concluded that: the strut-and-tie models can be used as practical tools to predict the capacities of members with disturbed regions; the presence of fibres significantly increased the shear capacity and improved the ductility and crack control; the headed bars provided excellent anchorage and confinement of the nodal zones.

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Shear Lag in Steel Tension Connections

Georges Abi-Saad[1] and Dominique Bauer[2]

Shear lag can be described as a phenomenon that creates a loss in resistance in a tension member connected through only part of its cross-section. It is a complex problem which has been under study for many years by researchers. Parameters that influence the shear lag phenomenon are many and difficult to assess: type and size of cross-section, type of connection, length of welds, length of member, joint eccentricities, etc.

The speaker will present a research program on connections between double-angle web members and chords in trusses or open web steel joists, presently underway at the Department of Construction Engineering of the École de technologie supérieure.

A series of tests on simplified specimens, carried out at the Department of Civil and Applied Mechanics of McGill University, will be described including observed resistances and modes of failures, as well as comparisons between yield and ultimate loads and the values calculated using the design guidelines of the Canadian Standard S16-01 Limit States Design of Steel Structures.

The speaker will also present results of finite element analyses of the simplified test specimens done using ANSYS with solid elements and non linear material. Comparisons between calculated stresses and strain gauge readings show excellent agreement, both at the yield and ultimate load levels. The finite element models will be used for further study of the connections in order to establish the influence of several parameters.

Finally, the speaker will present a rational approach well suited for the design calculation of the reduced strength of steel tension connections due to shear lag, based on an assumed distribution of forces along inclined lines in the member ends, somewhat similar to the Whitmore's concept used with gusset plates for bracing members. The workings of the method will be established for both elastic and plastic stress distributions along a single weld in shear. The method will then be compared to the recommendations contained in S16-01 for elements connected by longitudinal welds along two parallel edges as well as elements connected by a single longitudinal weld. Comparisons with the test results will also be made. Application of the method to the calculation of tension members with various shapes and either welded or bolted connections will be proposed.

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Seismic Response of Operational and Functional Components Mounted on Building Rooftops

Rola Assi[1] and Ghyslaine McClure[2]

The research project is about the earthquake-resistant design of operational and functional components (OFCs) in common buildings. These components include architectural elements attached to the structural framework, electrical, telecommunication and mechanical equipments that ensure the functionality of buildings, and building contents. Post-earthquake damage assessment has confirmed that failure or malfunction of OFCs is often the direct cause of staggering losses in human lifes, injuries, and economic losses due to direct damage or lack of functionality. Provisions in Codes and standards regarding the prediction of acceleration profiles in buildings are very simplified and not necessarily realistic, sometimes overly conservative and sometimes not conservative.

An accurate prediction of peak floor absolute accelerations is a crucial step in defining simplified design procedures in the seismic design of (OFCs). A particular characteristic of accelerations is that they increase along the building height. The amount of this increase depends on many factors, such as the type of lateral load resisting system, the height of the structure and the input ground motion. The suggested linearly increasing height factor in the current design Codes is empirical and based on limited observation of recorded data. This factor needs revision in order to include the characteristics of the building and input ground motion.

As a part of a project sponsored by the Taiwan Strong Motion Instrument Program (TSMIP), available data from 15 extensively instrumented buildings in Taiwan during the 1999 Chi Chi earthquake will be analyzed and compared to modern code provisions. The studied buildings have different lateral load resisting systems and different heights. They did not suffer any structural damage and their response is assumed linear elastic. Numerical models of the buildings representing the important geometric, stiffness, inertial and damping characteristics will be developed. The recorded accelerations will allow calibrating the analytical models of the different buildings, and this will permit to study the effect of different variables on quite realistic models.

Based on the seismic records and models, trends relating the ground and roof accelerations will be identified. This will help to compare current suggested provisions in codes with these trends. If required, improvements will be proposed.
Once roof acceleration predictions are reasonably accurate, we will attempt to propose a simplified method to assess the seismic response of telecom towers on rooftops. The detailed model of the China Telecom facility (case study) will serve to verify/calibrate the eventual proposed method.

It is a five floor concrete building located in Taiwan. The building supports a 10-m high self-supporting lattice telecommunication tower on its rooftop. Monitoring data available includes 18 floor acceleration records at various levels from the basement to the roof, and three acceleration records at the tower mid height.

The combined building-tower structure was modelled using the commercial software SAP2000. Dynamic time history analyses were performed using basement acceleration records from the 1999 Chi Chi earthquake. The calculated floor and tower accelerations are compared to the recorded data. Of particular interest are the amplification of the floor accelerations along the building height, from the basement to the roof, and the dynamic amplification of the tower response with respect to the response at roof level.

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Seismic Analysis of Steel Frame/ Wood Panel Shear Walls

Felix A. Boudreault[1] and C.A. Rogers[2]

Light gauge steel frame/wood panel shear wall response can be influenced by various factors including size, wood type, screw spacing as well as the type of test protocol implemented, i.e. monotonic or reversed cyclic. Amongst these factors, the protocol selection is critical in order to replicate the possible seismic events that could occur and cause damage to the structure. Two different reversed cyclic testing protocols were evaluated using full-scale shear wall specimens. A protocol was selected, based on the most realistic energy demand and theoretical background, which was then incorporated in the testing of a series of 106 shear walls in the summer of 2003. In addition to the fifty-six walls tested monotonically, fifty shear wall specimens were tested under the CUREE cyclic protocol, and then analysed to assess design information.

As part of the analysis, key design values including ductility, shear strength and initial stiffness had to be evaluated for design purposes. Due to the highly non-linear behaviour of the shear-deformation curve of a steel frame/wood panel wall, a fitted model had to be used. The EEEP bilinear model (Equivalent Energy Elastic-Plastic) was chosen because it is independent of any cyclic loading protocol and because it has been commonly applied in the analysis of other non-linear types of structures.

Another important aspect of the research carried out was the modelling of shear walls with time-history analysis software. This task was executed with the help of specific software such as Ruaumoko, Drain or SAWS because standard structural analysis commercial software is not very efficient in modeling and predicting the behaviour of walls with non-linear inelastic properties. The hysteretic rule for woodframe members includes unique features such as: pinching, slackness, stiffness degradation, strength degradation, etc. The importance of proper modelling is to be able to predict the performance of a building constructed with these walls when subjected to earthquake ground motions. Full-scale testing is extremely expensive and labour intensive. Therefore, numerical methods and computer modelling are important to understand and predict the response of the system and to reinforce the confidence in the capacity of these structures to resist an earthquake.

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Seismic Water-Crack Interaction in Gravity Dams: Experimental Study and Numerical Simulations

F. Javanmardi[1], P. Léger[2] and R. Tinawi[2]

Oscillating crack wall opening and closing modes, with the crack mouth in contact with pressurized reservoir water, are going to modify the prevailing pre-seismic uplift pressure magnitude and spatial distributions in cracked concrete dams. Uplift pressures acting along cracks and joints creates external forces that favour crack propagation in the dam body and affects the dynamic stability of cracked concrete components. Seismic uplift pressure variations during earthquakes remains a major source of uncertainty in design and safety assessment of concrete dams. Review of dam safety guidelines indicates that the assumption regarding uplift pressure intensity in a crack during an earthquake may vary from full reservoir pressure to zero pressure. The state-of-the-practice illustrates the lack of knowledge in defining transient seismic uplift pressures in existing or new cracks in concrete dams. The objective of this study is thus to develop a rational seismic crack-water hydro-mechanical model to predict dynamic uplift pressure variations during earthquakes.

An experimental study to characterize the transient seismic uplift pressure response of small concrete specimens with either newly induced or existing 0.4m long seismic cracks was first performed. Cyclic crack wall frequency motions varying from 2 to 10 Hz were applied, with different magnitudes of crack mouth water pressures. A dynamic water-crack interaction model is then formulated to reproduce the experimental results, and extrapolate the computed uplift pressure variations to cracks of arbitrary lengths likely to develop in actual dams. The transient pressure gradients in a crack of specified length is modelled as a function of the crack mouth opening displacement (CMOD(t)) and crack mouth pressure (Pcrm(t)) time histories assuming: (i) 1D flow along the crack, (ii) continuity condition with an incompressible fluid of a constant viscosity, (iii) pressure-flow relations governed by the crack hydraulic conductivity accounting for the crack roughness, laminar or turbulent flow conditions according to Reynold's number, and cavitation, (iv) impervious crack walls, and (iv) residual crack aperture during cyclic motions (zero or larger). The dynamic water-crack interaction model is then implemented in a nonlinear finite element program with gap-friction elements to represent the crack and compute the related dynamic water pressure.

The interaction model is used to compute the dynamic pressure during typical crack opening and closing modes. It was found that for the opening mode, the key input parameters (CMOD(t) Pcrm(t) and crack length) could be estimated either (i) from FE analyses with gap-friction elements using commercial computer programs without modelling dynamic crack pressure variations, or (ii) from simplified formulation (Chopra's method, rigid body dynamics, Westergaard added pressure). Analytical formulas are derived to estimate the maximum dynamic uplift force and resultant position to use in seismic dam stability evaluation using simplified pseudo-dynamic methods. The experimental and computed uplift pressures indicate that, during crack opening mode, a nearly triangular water pressure develops near the crack mouth (0.2m to 2m in length depending on boundary conditions). During the closing mode, the pressurized crack length becomes longer and large dynamic pressure could be generated.

A rational model is proposed herein to compute the uplift pressure reduction in a pressurized pre-seismic crack in an opening mode, and the pressure build-up in a newly induced and propagating seismic crack. The model could be implemented in a fully coupled hydro-mechanical FE seismic analysis using gap elements. It could also be used in a simplified format using the developed analytical formulas and charts to quantify on a rational basis seismic uplift pressure variations thus improving existing dam safety guidelines.

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Data Analysis of a Concrete Dam in Quebec

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Because of several dam failures, which caused serious damage to the downstream area and loss of life and property, dam safety is paid highly attention in the world. In many countries, it is required to inspect and evaluate all the existed dams, especially those dams which have been constructed for several decades. One method to inspect dams is to install instruments in proper location of the dams, and collect data about geometric and physical properties, such as deformation, temperature, and reservoir level. By analyzing these data, e.g. explain the relationship of different variables, create statistical models, engineers can know the real status of the dam and predict its behaviour in the future.

The objective of this research is to analyze the observed data about the Daniel Johnson Dam, which is located in the north of Quebec. Since 1960s, instruments were placed to monitor the dam, so we have more than 30 years records about the dam, such as water level of reservoir, air temperature and displacements, crack width, flow content and other measures about the dam..

In this presentation, main research about the dam will be introduced. It includes: the Hydro-Seasonal-Time (HST) model, which describes the relation between displacement (deformation) and water level of reservoir, temperature, and time; Calculation of swell coefficients of the dam. Principal component analysis of the data with the software STATISTICA®, and a C++ program (***DASOD***) which was developed to calculate coefficients and draw graphs of HST model, as well as to prepare the necessary data for principal component analysis.

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Transient Post-Elastic Response of Transmission Towers

Xiao Hong Zhang[1] and Ghyslaine McClure[2]

Collapse of transmission towers can occur due to accidental loads such as conductor breakages, failures of insulators or other components, either under every day conditions (components with marginal strengths) or under extreme conditions such as ice storms, thunderstorms, tornadoes, fires, explosions, heavy mass impacts, etc.

The proposed research is aimed at evaluating the ultimate strength and transient dynamic behaviour of transmission towers under accidental loads with consideration of both the geometric nonlinearities and material nonlinearities.

The research is based on advanced (highly non-linear) finite element analysis and full-scale dynamic testing. The first step was to use USFOS to perform static progressive collapse analysis of transmission towers. Then dynamic modelling is introduced first on tower sections and finally on complete towers. Some full scale tests will be done at IREQ with the collaboration from Hydro-Quebec researchers in this year 2004

The expected original contributions are evaluation of post-elastic ultimate capacity of transmission towers vs. traditional limit state design, validated by full-scale testing, new knowledge on prediction of failure modes in dynamic regime (shock loads) vs. static regime, development of a reliable FEM modelling method for the highly nonlinear dynamic problem of Transmission Line Structures failing under shock loads through the simulation of component failures, and validation of the proposed method with results from full-scale dynamic tests.

Application of the method will allow to create now knowledge (quantitative instead of qualitative only) about the effects of complex shock load scenarios on the transmission towers.

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