



SISTEM DC90

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VI INOVACIONA KOLONIJA HISTEREZIS 2017

Poštovani,

U okviru programa šeste Inovacione kolonije **HISTEREZIS 2017**, pozivamo vas da prisustvujete predavanju Prof. dr Vladimira Gocevskog, na temu rešavanja kompleksnih inženjerskih problema primenom naprednih numeričkih analiza.

Predavanje će se održati u četvrtak 12. oktobra 2017. u prostoru Sistema DC90 sa početkom u 15,00 časova. Broj mesta je limitiran a iznos kotizacije je 10.000,00 dinara.

Za detaljnije informacije možete se obratiti preko e-maila dc90@eunet.rs ili na tel 064114537.

Očekujemo vaše interesovanje.

Srdačan pozdrav i do skorog viđenja.

Zoran Petrašković

Predavanje br.1.

Prof. dr Vladimir Gocevski, dipl.ing.građ., Hydroquebek, Montreal-Kanada (vreme trajnja 45 minuta)

SOLUTION TO COMPLEX STRUCTURAL PROBLEMS THROUGH ADVANCED NUMERICAL METHODS

Abstract: The presentation presents advanced numerical models capable to simulate complex structural behavior. A brief development and implementation of a constitutive models for swelling of AAR affected concrete, crack propagation in reinforced concrete and behaviour of jointed rock masses is presented. The non-linear constitutive models address both the pre- and post-localized deformation of the material. The NSTAR modules have been developed and incorporated in COSMOS/M finite element software. The performance of the modules have been tested by solving some boundary-value problems involving a AAR affected lock, airplane impact on a nuclear power plant reactor building and a gravity concrete dam founded on a jointed rock mass. The results of the numerical simulations, including the evolution of fracture pattern, deformation profile and global load-displacement response are presented. Realistic trends of the structural behaviour of analysed complex structural behaviours are captured.

Emphasis will be placed also on: **MODELLING THE RESPONSE OF UNREINFORCED STRUCTURAL MASONRY**

The latest development in the dynamic nonlinear analysis of unreinforced brick masonry walls incorporates a continuum formulation in which the anisotropic properties of the masonry are described using the critical plane approach. An appropriate specification of material functions/parameters is addressed. The approach involves numerical simulations which accounts for the onset and propagation of localized deformation. The results are compared with the available experimental data. In the second part of this paper a series of dynamic analyses have been conducted that include a study of the impact of seismic retrofit of the masonry walls on their overall stability

RESENJE KOMPLEXNIH STRUKTURALNIH PROBLEMA UPOTREBOM ELABORIRANIH NUMERICKIH METODA

Rezime: Ova prezentacija ukratko objašnjava razvoj i praktičnu primenu elaboriranih numeričkih modela koji su u mogućnosti da simuliraju kompleksno ponašanje konstrukcija. Bubrenje betona usled alkaline reakcije, propagacija pukotina u armiranom betonu i ponašanje ispucanih stenovitih fundamenta je isto tako predstavljeno. Nelinearne relacije naprezanje-deformacije pre i nakon pojave pukotina materijala su predstavljene. NSTAR numeričke modele su developirane i inkorporirane u komercijalnom computerskom programu konačnih elemenata COSMOS/M. Ponašanje developiranih modela je testirano resavajući realne probleme kao AAR afektirane konstrukcije, impact nakon havarije komercijalnog aviona u nuklearnu reaktorsku zgradu i ponašanje ispucanih stenskih fundamenata ispod betonske gravitacione brane. Realistično ponašanje analiziranih objekata je adekvatno simulirano.

Posebnu pažnju posvetit će se na: **MODELIRANJE PONAŠANJA KONSTRUKCIJE OD NEARMIRANE OPEKE**

Bice prezentiran novi pristup nelinearne dinamičke analize u kojoj je uzeto u obzir anizotropno ponašanje zidanih konstrukcija od nearmirane opeke aplicirajući metodu kritične ramnine. Adekvatni pristup određivanja analitičkih parametara koji karakterisu građevinske materijale zidarije isto tako su opisane. Pristup uključuje numeričke si

mulacije koje određuju početak i propagiranje lokaliziranih deformacija. Analitički dobijeni rezultati upoređeni su sa eksperimentalnim rezultatima. U drugom delu rada serijom dinamičkih analiza evaluiran je impact seizmickog pojanja zidova od nearmirane zidarije.

INTRODUCTION

SOLUTION TO COMPLEX STRUCTURAL PROBLEMS THROUGH ADVANCED NUMERICAL METHODS

The analysis and design of new structures is regulated by many building codes and guidelines hence, the practicing engineers already have clear instructions of how to proceed to insure their safety and durability. Under the majority of loading cases linear elastic behaviour of the structure is mandatory; therefore, the structural components are designed to satisfy this requirement. The exception is the seismic design for which during a seismic loading the national standards, with some exceptions, permit occurrence of cracking without possibility of collapse.

The approach is different for the evaluation of existing structures or in search for solution in analysis of complex structural problems. Due to large variety of degradation mechanisms encountered, the requirements of the latest codes and standards for the older buildings are usually not uniformly applicable or well defined. The degradation of the mechanical properties or the aging of the structural materials used in the construction often requires particular analytical and experimental approaches in order to determine the effects of the deterioration on the local or overall structural stability. There are many aging mechanisms that may occur during the lifespan of any structure. The analysis of these mechanisms in order to evaluate the safety of, for example, an existing building, a bridge or a concrete dam which do not satisfy the latest code requirements may be difficult if not impossible task with the analytical tools commercially available. The degradation phenomena such as: (a) swelling due to the Alkali-Aggregate Reaction (AAR), the creep, and the shrinkage in the concrete, (b) the cracking propagation of already cracked reinforced concrete to ensure air tightness in Nuclear Power Plants, (c) the safety of concrete element following a major fire, (d) impact of airplane crash into a important concrete structures, (e) the seismic evaluation of unreinforced masonry buildings monuments tunnels and bridges, (f) the effect on the dynamic behaviour of jointed rock masses from the expansion of the concrete dam affected by AAR; are some of the examples who requires special attention. In this paper due to space limitation only few of the advanced analytical models developed and applied in the evaluation of Hydro-Quebec's structures will be briefly outlined. The short description of the

developed constitutive relations and their application in solving real structural problems (after their implementation into a commercial finite element code and the experimental validation) are presented. The application in solving some structural problems is presented for each numerical model.

MODELLING THE RESPONSE OF UNREINFORCED STRUCTURAL MASONRY

An earthquake can have a devastating effect on older unreinforced masonry structures. It is therefore desirable to design an adequate reinforcement to enhance their seismic resistance. Unfortunately, the refurbishment methods proposed by structural engineers are often based on simplistic standards which cannot realistically address the seismic response of existing masonry structures. This is primarily due to the fact that masonry is a complex composite material, which is anisotropic on the macroscale and has a large number of possible modes of failure. The mechanical response is further complicated due to variability in the mechanical properties of its constituents (i.e. bricks and mortar) as well as in the quality of workmanship. Thus, a rational approach to the problem should incorporate advanced nonlinear formulations that account for the diversity of mechanical characteristics.

The first numerical model incorporating the notion of microstructure tensor was formulated and used for evaluation of the seismic behavior of Beauharnois power plant (Gocevski and Pietruszczak 2001). In this case, the masonry is described as a continuum whose average properties are identified at the level of constituents taking into account their geometric arrangement. Over the last decade, a number of different approximations have been developed for assessing the homogenized properties of structural masonry. Those include, among others, the micropolar Cosserat continuum models (e.g. Sulem & Muhlhaus, 1997; Masiani & Trovalusci, 1996) and theory of homogenization for periodic media (e.g. Anthoine, 1997; Luciano & Sacco, 1998; Cluni & Gusella, 2003).

At the macro-level, a significant work has been undertaken with regards to the development of phenomenologically-based failure criteria for structural masonry. Examples include the studies of Lourenço et al.(1998), Raffard et al.(2001), Ushaksaraei et al.(2002) and Pietruszczak et al.(2009).

The first part of the paper deals with the meso-scale approach and its application in studying the mechanical characteristics of structural masonry. The objective is to derive the macro-scale characteristics of masonry from the properties of their constituents. Various methodologies are reviewed which include predictions based on strain-hardening plasticity that address both pre- and post-localization behavior, elasto-perfect plasticity as well as limit analysis. In part two, this methodology is applied to identify the material functions/parameters of a continuum formulation using the properties representative of Beauharnois masonry structures. The objective is to examine the stability of the walls and to evaluate the proposed refurbishing strategy.

DESCRIPTION OF THE ADVANCED MODELS AND THEIR APPLICATION

The following models will be briefly described:

- Numerical model capable to simulate the nonlinear static and dynamic behaviour of structures affected by the concrete swelling due to Alkali-Aggregate Reaction in the concrete;
- Numerical model for simulation of cracks propagation in plane, reinforced and pre-stressed concrete in nonlinear static and dynamic analysis of structures;
- Numerical model for simulation of the nonlinear static and dynamic behaviour of fractured rock under concrete dams;
- Meso-Scale approach of modeling masonry
- Macroscale approach of modeling masonry

2. Uvodno saopštenje

Obraćanje organizatora, uvodna reč i kratak prikaz

dr Zran Petrašković, dipl.ing.građ., Sistem DC90, Beograd, Srbija, (vreme trajanja 10 minuta)

KONSTRUKCIJSKI SISTEMI POVIŠENE SIGURNOSTI KORIŠĆENJEM SPECIALNIH UREĐAJA A POSEBNO Uređaja DC90

1. Uvod (o Istraživačkom Centru Sistem DC90, www.dc90.co.rs, stanje u svetu u ovoj oblasti uređaja i istema za kontrolu i povećanje sigurnosti konstrukcija)

2. Masivni zidani sistemi (istorijski objekti i novi masivni zidani sistemi povišene energetske efikasnosti) u seizičkim regijama, povećane sigurnosti, (opšte o osnovnim elementima sistema)

3. Skeletni sistemi povećane sigurnosti primenom amortizera DC0, opšte o sistemu

4. Visoke zgrade i dimnjaci (kontrola vibracija i dejsta, vortex i sl.), opšte o sistemima aktivne i pasivne dinamičke kontrole.

5. Ruski kinematički sistem KUZANOV, kontrolisan uređajima DC90, opšte o sistemu, stanje razvoja i primene

6. Jedan specifičan pristup automatizaciji projektovanja (primer hala sistema DRIMS), opšte o iskustvima sa prikazom programa.

7. Uređaji i histerezijsni metalni amortizeri DC90 za kontrolu konstrukcija, (dizajn po meri korisnika, asortiman, testovi, zamor u polju velikih dilatacija, akumulacija energije), objašnjenje karakteristike uređaja saglasno EN 15129-2008.

8. Metodologija i postupak transfera tehnologije, znanja i veština ustupanjem prava korišćenja autorskih i patentom zaštićenih rešenja, osnovni pojmovi u toj oblasti

