Hybrid testing for non linear analysis of reinforced structures

G. Lebon, F. Ragueneau & R. Desmorat
LMT-Cachan, ENS Cachan/CNRS/Université Paris 6/PRES Universud Paris, 61 avenue du Président Wilson, 94235 Cachan Cedex, lebon@lmt.ens-cachan.fr, ragueneau@lmt.ens-cachan.fr, desmorat@lmt.ens-cachan.fr

KEY WORDS: Hybrid testing, anisotropic damage, substructuring, concrete

Seismic loading generates severe damage on civil engineering structures: yielding, buckling, collapse, loss of concrete... These pathologies are difficult to model accurately and influence greatly the whole structure. A complex numerical model often needs expensive calculation time to obtain only approximate results. To avoid hazardous modelling, laboratory tests provide a good alternative. The behaviour can then be observed for laboratory structures under severe loading, but not for real (large) civil engineering structures as bridges, multi-framed buildings ...
Quick observations of damaged structures are enough to note that severe damage is often localized in a small part of the structure, the others ones remaining virgin or lowly damaged. Consequently, a domain decomposition approach [1,2] using numerical modelling and laboratory tests appears the best approach. The critical parts can be physically tested (in pseudodynamics or in real time, [3-4]) while the remaining part is simulated by Finite Element. Such hybrid tests are currently used with linear elastic subdomains for the simulated parts. However the global behaviour of the structure strongly depends on the numerical model used for these simulated subdomains [5] and even more when they are damaging [6] . Consequently, an accurate model for reinforced concrete must be used. The anisotropic damage model [7-8] is such a suitable model for quasi brittle material as concrete, with the dissymmetry tension/compression due to induced damage anisotropy and with unilateral effect (microcracks closure). Written in the thermodynamics frame, this model is quite robust to perform simulation until ultimate behaviour. The 3D model implementation can be costly and for real time performance a multifiber finite element adaptation reduces much the computational time required.

REFERENCES

[1] Dermitzakis, S.N., and Mahin, S.A., Development of substructuring techniques for on-line computer controlled seismic performance testing, *Report No. UCB/EERC-85/04, Earthquake Engeneering Research center, University of California*, Berkley, CA, USA, 1985.

[2] Buchet, P., Pegon, P., PSD Testing with Substructuring: Implementation and Use, *JRC-Special Publication N0.I.94.25*, Ispra, Italy, 1994.

[3] Wei, Z., Fast hybrid test system for substructure evaluation, *Ph.D. Thesis University of Colorado*, 2005.

[4] Saouma, V.E., Sivaselvan, M., Hybrid Simulations Theory: Implementations and Implications, Ed. M.V., Taylor and Francis, 2008.

[5] Magonette, G., and Pegon, P., Continuous psd testing with non-linear substructuring; Presentation of a stable parallel inter-field procedure. *European Commission*, 29, December 2002.

[6] Souid, A., Sous-structuration combinée expérimentale/numérique pour chargements pseudo-dynamiques endommageants, *Phd Thesis LMT-Cachan*, 2008.

[7] Lemaitre, J., Desmorat, R., Engineering Damage Mechanics: Ductile, creep, fatigue and brittle failures, Springer, 2005.

[8] Ragueneau, F., Gatuingt, F., and Desmorat, R., Finite element computations of rupture with induced anisotropic damage, *Computational modelling of concrete structures*, 345-352, 2006.