DEPLOYMENT OF VALIDATED CAE METHODS AND AUTOMATED PROCESSES ON ICONIC DESIGN PROJECTS

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KEYWORDS

Nonlinear analysis, Oasys/LS-DYNA, Performance-based assessment, seismic isolation, model validation, process automation.

ABSTRACT

For complex nonlinear time-history analysis and performance-based assessments, LS-DYNA has been the software of choice for Arup since 1985 and Arup has worked in conjunction with LSTC to develop a number of specific features for seismic and crashworthiness analyses. Typical in-house applications include soil-foundation interaction, the response of reinforced concrete structural components to seismic loading and the optimization of vehicle structures.

On recent high-profile projects, validated performance-based approaches combined with advanced simulation have been instrumental to enable safe, economic and sustainable new designs:

As a first illustration, advanced CAE simulations have been at the center of the engineering process of the Raffles City Chongqing development (RCCQ). Since 2012, Arup has been providing structural engineering services for all design stages of RCCQ. This mega-complex has been designed by the internationally acclaimed architect Moshe Safdie for the developers CapitalLand and Singbridge Holdings.

Various structural schemes for the 300m-long sky deck atop the four 250m-high interior towers have been assessed using LS-DYNA. Extensive nonlinear time-history analyses have been performed to simulate the behavior of several conservatory articulations and isolation solutions under extreme seismic conditions. Arup has also been investigating innovative fuse/concrete outrigger solutions to meet the wind/seismic demands on the 350+m North Towers (T3N and T4N). A hybrid steel diagonal and concrete wall outrigger system (Hybrid OT

wall) proved particularly promising. Compared with traditional steel designs, a Hybrid OT wall would simplify the design of the wall-to-mega-column connection while being significantly cheaper in cost. The development of these elements also required extensive Finite Element analyses and physical testing.

Secondly, robust modelling techniques have contributed to the validation of innovative design solutions for the Gerald Desmond Bridge Replacement (GDB) in the Port of Long Beach. Since 2011, Arup has been SFI's (Schimmick / FCC / Impregilo) joint-venture's lead designer for the replacement of the deteriorating GDB, providing structural and geotechnical engineering, traffic operations analysis, lighting design and civil engineering services. Arup designed an elegant mono-pole stayed-cable solution that met all the project requirements while providing dramatic cost-savings to the Client. The deployment of advanced CAE analysis capabilities was also critical to assess the structural options against the stringent project requirements. The extreme seismic demands of the 1000-year Safety Evaluation Event (SEE) could be addressed by isolating, by means of viscous dampers, the Main Bridge deck from the Towers and by introducing a ground-breaking approach for the design of the ductile hollow-section columns. These innovative solutions, among other particular features of the bridge, required detailed Finite Element modelling and validation through explicit nonlinear time-history analysis.

As a final example, automated simulation and optimisation processes are routinely used on our vehicle crashworthiness projects. Expert tools, developed in the Oasys/LS-DYNA environment, capture engineering best practices. In particular, recent applications in pedestrian safety have allowed significant productivity gains.

This paper presents the validation process, some analysis results and the design solutions that could achieve the ambitious objectives of these complex, iconic projects.