Cloud Accelerated Performance Based Seismic Design

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Abstract

Non-linear Time History Analysis (NLTHA) is a key enabler of Performance Based Seismic Design (PBSD). Arup Los Angeles office typically performs these simulations in LS-Dyna solver. In order to respond to the demands of concurrent design projects, the authors have adopted a cloud centric approach to accelerate our workflows and to enable the use of non-linear time history analysis as a design tool as opposed to a verification tool. This paper will present our custom workflow which enable a dramatic compression of the time required for these analysis. The workflow generates LS-Dyna models in parametric fashion via Rhino- Grasshopper. Since a single design iteration of analysis can result in 48 to 110 models from a range of ground motions and input parameters these models are typically executed on a compute cluster with a large number of compute cores. The resulting number of analyses generates a large amount of data (8-16TB) which we post process leveraging "Big Data" approaches typically used by other industries (financial or retail firms).

Keywords: Computational Methods, Information Technology, Seismic Design and Response, Performance Based Design, Cloud Computing

1 Introduction

Non Linear Time History Analysis (NLTHA) is a key component in Performance Based Seismic Design (PBSD). Such analysis seeks to explicitly determine the structural response and performance of a structure under various seismic events at different return periods of seismic excitation. The analysis considers material non-linearity (e.g. plastic hinging in moment frame beams, axial yielding in braces, etc…) and large geometric non-linearity. As such, the underlying analysis solver must be sufficiently sophisticated to consider those non-linear effects in a computational efficient manner.

Arup typically utilizes LS-Dyna for such analysis. LS-Dyna is mostly used for its explicit solver and has a long history in the automotive and aerospace industry. Together with Arup developed material models for seismic analysis and custom workflows, LS-Dyna has enabled us to perform these high fidelity analysis at the time scales comparable to Linear Static Analysis. This paper overviews our custom workflows leveraging various cloud environments to enable this workflow compression.

2 Performance Based Seismic Design (PBSD)

Structures are typically evaluated to different performance objectives at difference return periods. The performance objectives are typically quantified as "Life Safe", "Immediate Occupancy" and "Collapse Prevention". These performance targets can refer to measures such as plastic rotations in moment frame beams or peak strains in concrete or reinforcement. In order to measure these parameters, a relatively high level of detail within the Finite Element Model (FEA) is required. For example, concrete walls are modelled with 7 or more fibre layers to capture the distribution of strain across the concrete or reinforcement layers. Illustrated below are some of the current projects being designed in Arup's Los Angeles office.

2.1 Loma Linda University Medical Centre

This is a replacement hospital for the Loma Linda medical campus (Figure 1). Given that it is an essential facility and close proximity to a major fault in southern California, PBSD was critical in the

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