Dynamic Energy Based Method for Progressive Collapse Analysis

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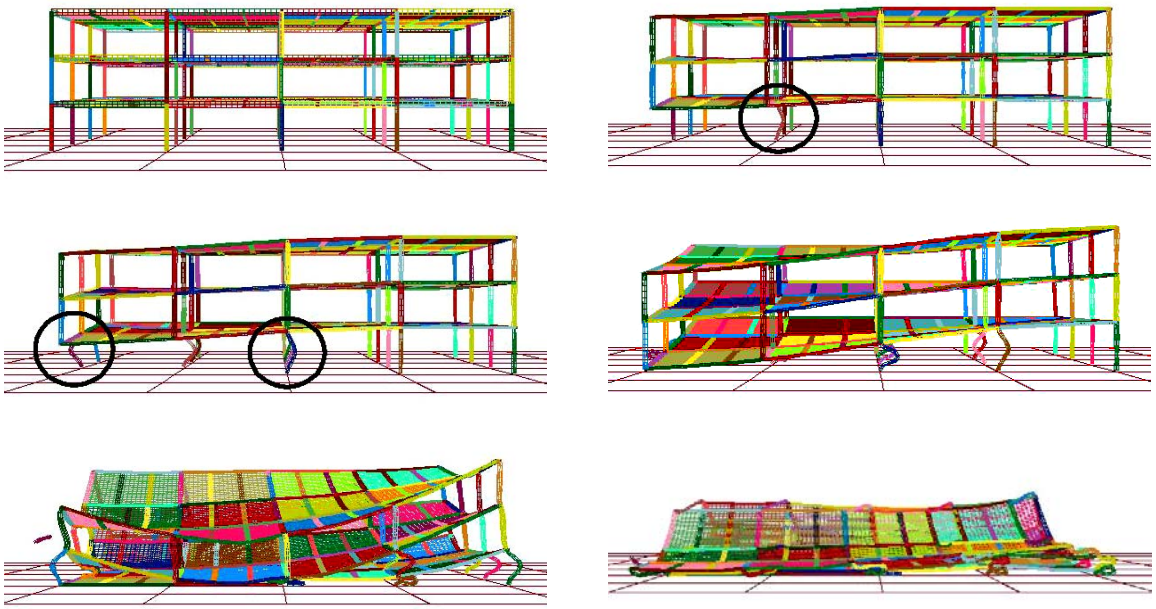
SUMMARY

Physics based collapse simulations of moment resisting steel frame buildings are presented with an emphasis on the development of energy flow relationships. It is proposed that energy flow during progressive collapse can be used in evaluation of moment resisting, steel frame building behavior, and specifically, localized failure. If a collapsing structure is capable of attaining a stable energy state before total failure, through absorption of gravitational energy, then collapse will be arrested. Otherwise, if a deficit in energy dissipation develops, the unabsorbed portion of released gravitational energy is converted into kinetic energy and collapse propagates from unstable state to unstable state until total failure occurs. Accurate quantification of energy flow necessitates dynamic time-history analysis. This is demonstrated by comparing energy propagation during dynamic analysis and traditional static push-over analysis. Energy absorption of individual members is very stable in comparison to oscillating internal dynamic forces in structural members. Therefore critical energy absorption capacity is proposed as a stable failure criterion in progressive collapse analysis. Energy flow quantification is shown to be readily available from the dynamic finite element simulations. It has become apparent that vast majority of designers may not be able to perform dynamic analysis in time domain to assess structural resistance to collapse propagation. Therefore, a correlation between dynamic energy flow and static push-over energy propagation is developed. The proposed dynamic, energy based, approach to progressive collapse provides insight and a simple yet robust analysis for producing structures capable of resisting abnormal loadings and/or unexpected hazards.

Keywords: Progressive collapse, energy flow, steel frame, numerical simulation, finite element method, Ls-Dyna, collapse analysis



Collapse sequence of 3-D model with slabs