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Progressive Collapse Analysis of Heavily Loaded Pallet Rack Systems Subjected under Impact Loads

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Pallet rack systems used in warehouse are generally constructed with light weight uprights and beams, and are frequently subjected to accidental impact by forklift trucks [1]. When heavily loaded, those impact may cause partial or progressive collapse of rack systems which will mostly lead to catastrophic loss of goods and sometimes of human lives [2].

In this study, numerical investigation was conducted on progressive collapse behavior of rack systems using the Adaptively Shifted Integration (ASI) - Gauss code [3], which can supply highly accurate elasto-plastic solutions with minimum subdivision of finite elements and can stably simulate nonlinear phenomena such as member fracture and contact. Push-down and push-over analyses with and without upright removal were carried out on a two-bay rack system to observe the standard strength and effects of plan bracings installed at different levels. Furthermore, dynamic analyses with impact load in cross-aisle and down-aisle directions under fully- and over-loaded conditions were conducted and the effects of plan bracings were investigated.

According to the numerical results, plan bracings installed at first level affect greatly against lateral impact at lower levels, and those installed at top level affect greatly in preventing downward collapse making the most of its catenary action. Progressive collapse analysis of a large-scale pallet rack system was also conducted and the effect of optimal installation of plan bracings was confirmed.

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