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Nonlinear Finite Element Method for Local Buckling in Plastic Greenhouse

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Abstract: As climate change escalates extreme weather events, the structural durability of plastic greenhouses, constituting 90% of Korea's facility agriculture, emerges as a critical issue. These greenhouses are pivotal for year-round crop cultivation and high-quality agricultural production. In 2021, collapses caused around US$2 million in damages, mainly due to heavy snowfall and strong winds, accounting for 97% of incidents. The Korean Ministry of Agriculture responded by disseminating disaster-resistant standardized designs, yet more robust standards are needed. Current designs rely on elastic analysis, but plastic greenhouses display nonlinear behavior due to factors like residual stress and local buckling. Our study employs a refined plastic hinge method and finite element analysis to analyze structures, considering progressive yielding. We conducted loading tests using scale down models of plastic greenhouses in accordance with similitude laws. Based on these tests, the deformation of models under different load conditions was measured and compared with the deformation of greenhouse using our nonlinear structural analysis. This study will contribute to the development of reliable design criteria for plastic greenhouses in response to climate extremes such as heavy snowfall and typhoons. In addition, by identifying the deformation characteristics of plastic greenhouses due to loads, it can contribute to establishing usability standards for greenhouses, and reinforcement measures for vulnerable areas which are easily deformed under load can be considered.

Key words: refined plastic hinge, progressive yield, nonlinear structural analysis, plastic greenhouse

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