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Stability study on structural systems assembled by system scaffolds

Jui-Lin Peng[a,*], Chung-Ming Ho[b], Siu-Lai Chan[c], Wai-Fah Chen[d]

[a] Department of Civil and Construction Engineering, National Yunlin University of Science and Technology, Yunlin, Taiwan, ROC
[b] Graduate School of Engineering Science and Technology, National Yunlin University of Science and Technology, Yunlin, Taiwan, ROC
[c] Department of Civil and Environmental Engineering, The Hong Kong Polytechnic University, Hong Kong, China
[d] Department of Civil Engineering, University of Hawaii at Manoa, HI, USA

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ABSTRACT

This study investigates the stability of the structural systems assembled by system scaffolds. Loading tests were conducted on the indoor single-bay system scaffolds and the outdoor full-scale structural system assembled by system scaffolds. Test results were compared with the second-order inelastic analysis with semi-rigid joints to determine the reliability of various analytical parameters. The study reveals that, while the failure model of the single-bay two-storey system scaffold without diagonal braces is overall buckling failure of the structure, the failure model of the same structure with diagonal braces is buckling failure of the vertical standards between the upper and lower storeys. The critical load of the configuration with diagonal braces is about double that of the same structure without diagonal braces. At the moment of buckling failure of the outdoor full-scale two-row, two-bay, six-storey structural system assembled by system scaffolds, the vertical standards at the four corners appeared to have large horizontal displacements owing to without diagonal braces. However, the vertical standard in the center did not exhibit obvious horizontal deformation because it was reinforced with diagonal braces on four sides. In addition, the use of diagonal braces can significantly increase the load capacity of vertical standards. This study recommends that all vertical standards be reinforced with diagonal braces to ensure the load capacity of the structural systems assembled by system scaffolds. A second-order inelastic analysis with semi-rigid joints and various notional lateral forces is recommended to determine the critical loads of full-scale structural systems assembled by system scaffolds.

1. Introduction

In recent years, the system scaffold has been frequently used as a temporary structure in the process of construction, as shown in Fig. 1. However, presently, in engineering practice, references for the design of system scaffolds are limited, so the collapses of system scaffolds often occur on construction sites. Fig. 2 displays the scene following the collapse of system scaffolds during the construction of a subway station in Kaohsiung, Taiwan.

The system scaffold consists of such components as vertical standards, ledgers, diagonal braces, jack bases, and others. Most of these structural components are standardized and can be easily used to assemble various structural systems as required on the construction sites. Features of system scaffolds include easy and quick assembly, easy setup to cope with the headroom of structures, and no need for assembly with different types of shoring members. The system scaffold has a higher load capacity than the frame-type steel scaffold and has gradually come to be widely used in various engineering constructions.

Most studies of falsework have given undue emphasis to the frame-type steel scaffold. For example, Peng et al. [7] provides a simplified analysis on the door-type steel scaffold and confirmed the load capacities and failure models of the single-bay, single-row, multi-storey "door-type steel scaffold system" and the "door-type steel scaffold with wooden shores system". Subsequently, Peng et al. [8] explored the load capacities and failure models of the multi-bay, multi-row, multi-storey "door-type steel scaffold system" and the "door-type steel scaffold with wooden shores system" and proposed design guidelines on steel scaffolds for engineers.

Godley and Beale [4] developed a model for analyzing the frame-type steel scaffold and used it in their studies. Huang et al. [5] conducted loading tests on the indoor three-storey and outdoor five-storey door-type steel scaffolds using the numerical software ANSYS. Weesner and Jones [12] performed numerical analyses and loading tests on four setups of the frame-type steel scaffold. Yu [14] examined the structural behaviors of frame-type steel scaffolds with different boundary conditions by performing loading tests and nonlinear analyses.

Zhang et al. [15] applied the Monte Carlo method to multi-storey steel scaffold systems and used the results to evaluate the reliability of

* Corresponding author at: 123, Section 3, University Road, Douliu, Yunlin 64002, Taiwan, ROC.
E-mail addresses: peng.jl@msa.hinet.net, pengjl@yuntech.edu.tw (J.-L. Peng).

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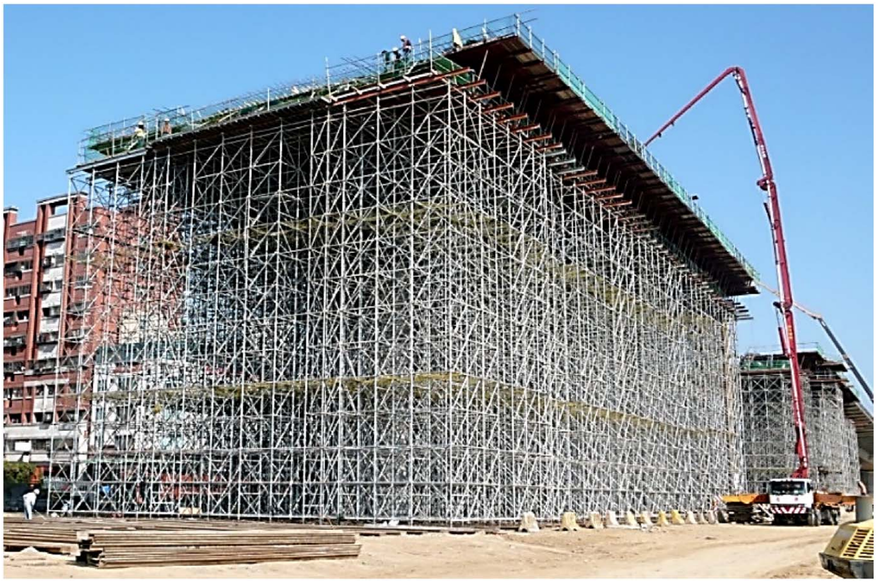

Fig. 1. System scaffolds used as falsework on construction sites.

scaffold strength. Zhang et al. [16] explored the failure model of steel scaffolds and the reliability of steel scaffold systems with different random variables, and, based on that model, established a probabilistic model of the supporting tube strengths. Peng et al. [6] examined the critical loads and failure models of isolated heavy-duty scaffolds using various loading tests. Beale [1] collected and comprehensively reviewed international studies of steel scaffolds from the last four decades, providing information that can be very helpful to scholars who are interested in steel scaffold research.

With respect to research on system scaffolds, Peng et al. [10,11] and Wu [13] performed loading tests on single-bay system scaffolds in a structural testing lab and verified their load capacities by numerical analyses. These three studies emphasized the structural behaviors of the single-bay system scaffold and the joint parameters of various scaffolding members, without probing the mechanical behaviors of the entire structural system in each case.

The load capacities and failure models of system scaffolds are different from those of frame-type steel scaffolds whose setup is installed by scaffold-units and cross-braces. The installation of frame-type steel scaffolds has the strong and weak axes obviously. On the contrary, the installation of system scaffolds does not have apparently the strong and weak axes. Therefore, the study results of frame-type steel scaffolds can serve only as a reference but cannot be directly used for system scaffolds. Most studies of system scaffolds have focused on “single-bay” system scaffolds, without exploring the mechanical behavior of the “structural system” assembled by the system scaffolds. Therefore, the mechanical behavior of the “structural system” assembled by system scaffolds must be studied to determine the load capacities and failure models of actual assembled system scaffolds on construction sites.

2. Significance

The purpose of this study is to explore the load capacities and failure models of different structural systems assembled by system scaffolds based on the structural stability. This investigation involves loading tests and numerical analyses not only on the single-bay two-storey system scaffolds with and without diagonal braces, but also on the outdoor full-scale “structural system assembled by system scaffolds” (abbreviated as “structural system of scaffolds” below) to confirm their load capacities and failure models.

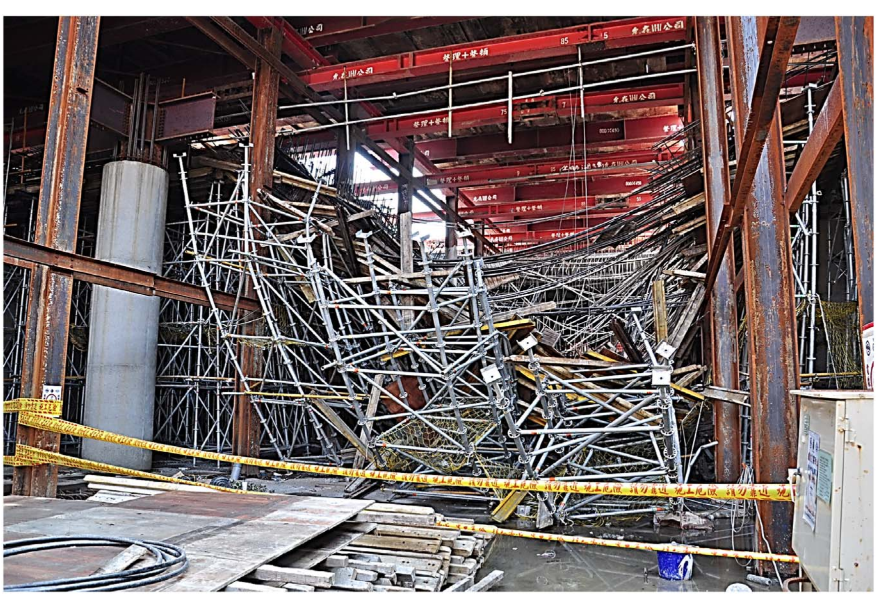

Fig. 2. Collapse of system scaffold falsework during construction of a subway station in Kaohsiung, Taiwan.