Moveable Facade Elements for Sustainable High-rise Buildings

Yangwen Zhang*, Wulf Wulff, Achim Bleicher

Brandenburg University of Technology Cottbus–Senftenberg, Chair of Hybrid Structures - Structural Concrete, Cottbus, Germany

Laurenz Wernicke, Thomas Schauer

Technische Universität Berlin, Control Systems Group, Berlin, Germany

Michael Engelmann

Josef Gartner GmbH, Gundelfingen, Germany

***Contact:** yangwen.zhang@b-tu.de

Abstract

This paper presents a sustainable semi-active distributed-Multiple Tuned Facade Damping (d-MTFD) system that utilizes the existing mass of the Double-Skin Facade's outer skin as damping mass to mitigate structural vibrations caused by wind excitation. Based on this concept, a prototype with one full-scale parallel moveable facade element has been developed, built, and validated. A stepper motor working together with its connected energy harvesting circuit is innovatively applied as an adjustable electrical damper and simultaneously as an energy harvester. Its feasibility has been proven through experiments using Hardware-in-the-Loop (HiL) simulations. An energy harvesting efficiency of 75% was achieved by using a two-stage power converter as the energy harvesting circuit. The self-sufficiency of the semi-active d-MTFD system was achieved.

Keywords: distributed-Multiple Tuned Facade Damping (d-MTFD) system; Double-Skin Facade (DSF); parallel moveable facade; electrical damper; grey-box system identification; Hardware-in-the-Loop (HiL) simulation; energy harvesting; semi-active control; wind-induced vibration; high-rise buildings; sustainability.

1 Introduction

Various types of damping systems have been developed to ensure the serviceability of high-rise buildings [1]. In addition to the widely used traditional single Tuned Mass Damper (TMD) system, different types of Multiple Tuned Mass Dampers (MTMD) systems have also been proposed and proven to be more efficient and robust than the single TMD. Based on the location of the multiple damping mass, the MTMD system can be categorized into series MTMD [2], parallel MTMD [3], and distributed MTMD systems [4].

Many high-rise buildings are installed with a Double-Skin Facade (DSF). The authors have intensively studied different approaches by using moveable DSF to reduce wind-induced structural vibrations of high-rise buildings [5-8]. The

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