Adaptable High-Rise Buildings

Thomas VON BORSTEL
PhD candidate
Hamburg University
of Technology
Hamburg, Germany
thomas.vonborstel@tuhh.de

Thomas von Borstel (1980) received his civil engineering degree from TUHH, Germany; since 2008 he is a research associate at TUHH.

Viktor SIGRIST
Professor
Hamburg University
of Technology
Hamburg, Germany
sigrist@tuhh.de

Viktor Sigrist (1960) worked as a structural engineer for several years and is a Professor and Head of the Institute of Concrete Structures since 2002 at TUHH.

Summary

This paper presents an innovative concept that allows a flexible use of high-rise buildings by incorporating adaptable structural components, thus contributing to a sustainable development by extending the building's service life. The focus lies on vertical adaptability which implies a structural conception for different floor heights and for adding and removing temporary floor slabs, respectively. Contrary to conventional buildings, dead loads originating from floor slabs might be variable in an adaptable high-rise. Attention is drawn to this characteristic and its impact on the structural design. Typically, adaptable structures resist lateral loads by using a reinforced concrete core located in the centre of the floor plan and a diagrid placed along the perimeter surface. It is shown that this type of lateral-load-resisting system is not only attractive from an architectural point of view but also economical if used to enable vertical adaptations.

Keywords: high-rise buildings, adaptable buildings, diagrids

1. Introduction

In recent years, sustainable principles have become an essential component for almost every business, marketing or manufacturing strategy. Sustainability has penetrated public attitudes because the effects of global warming and its environmental consequences have reached almost everyone’s consciousness. Since scientific predictions expect a dramatic increase of people living in cities, high-rise buildings are likely to play a major role in the future; possibilities of vertical floor stacking allow for an efficient urban density which decelerates urban sprawl [1].
However, due to the large amount of natural resources used for their construction and operation, high-rise buildings are scarcely regarded as a sustainable building type. At present, the embodied energy required for the construction of a new building represents a multiple of its lifetime energy consumption. A great part of this embodied energy is enclosed in the structural frame [2].
In fact, the limited flexibility for future occupancies is a major reason why the durability of its structural components exceeds the overall life expectancy of a building by far. For that reason, traditional structures are taken out of service or are even removed after a short period of time. In the UK the average life of a building is only 50 years, whereas the average period of occupancy is 7 years [3].
Short life performances of high-rise buildings are counterproductive, if a sustainable development is aspired. Adaptable high-rises provide an opportunity to extend the building's service life, allowing for flexible floor heights and for adding or removing temporary floor slabs, respectively.
A precondition to a sustainable performance of a high-rise building is a minimized material demand. Thus, it is necessary to provide an efficient lateral-load resisting system, which counteracts the forces induced by wind and contributes to a reduction of the premium for height.
Diagrids offer a material efficient lateral-load-resisting system as well as aesthetic qualities, which has already been proven by buildings like the *30 St. Mary Axe* in London and the *Hearst Tower* in New York. Consisting of numerous triangles composed of diagonals between nodal levels, diagrids are determinant for the façade. Because of their diagonal members, vertical flexibility of floor slabs is enabled from an architectural point of view; between nodal levels, floor slabs can be removed or vertically adjusted without conflicting with the façade (see Figure 1).

https://doi.org/10.2749/222137810796024088
Distributed by structurae