Automation in Construction 62 (2016) 124–132

Contents lists available at ScienceDirect

Automation in Construction

journal homepage: www.elsevier.com/locate/autcon

Inclined construction hoist for efficient resource transportation in irregularly shaped tall buildings

Taehoon Kim [a,1], Hyunsu Lim [b,2], Seung Woo Kim [c,3], Hunhee Cho [b,*], Kyung-In Kang [b,2]

[a] School of Architecture, Chosun University, Seosuk-Dong, Dong-Gu, Gwangju 501-759, Republic of Korea
[b] School of Civil, Environmental and Architectural Engineering, Korea University, Anam-Dong, Seongbuk-gu, Seoul 136-713, Republic of Korea
[c] Liftec Corp., 248-8, Siheung-Dong, Sujeong-Gu, Seongnam-Si, Gyeonggi-Do 461-370, Republic of Korea

ARTICLE INFO

Article history:
Received 13 April 2015
Received in revised form 14 October 2015
Accepted 15 November 2015
Available online 3 December 2015

Keywords:
Inclined construction hoist
Irregularity
Tall buildings

ABSTRACT

Construction hoists are essential equipment in tall building construction for the vertical transportation of construction resources. Recent increases in the construction of irregularly shaped tall buildings have created demand for a more efficient hoist operation system. This study proposes a new inclined construction hoist for efficient transportation of resources in the construction of irregularly shaped tall buildings. Tilted masts and inclination and speed control systems enable the transportation of resources without needing temporary structures to access the building, which require large cost and time inputs. In a case study, the proposed system remarkably reduced total operation costs by 26.0%, total resource transportation time by 28.8%, and time taken to the highest floor by direct transportation by 11.0% over existing systems. The proposed system will contribute to successful project completion with reduced costs in response to the current trend in tall building construction.

1. Introduction

In tall building construction, an effective vertical transportation of construction resources is a key factor for successful project completion. Tall building construction demands much larger amounts and longer moving distances of vertical transportation of resources than low- or medium-height buildings. In particular, construction hoists are essential equipment for vertical transportation of construction resources in finishing works and comprise approximately 80% of these resources [1]. Thus, there have been many efforts to support adequate hoist planning and to enhance the lifting efficiency by adopting simulation techniques, optimization algorithms, and intelligent control systems [2–8].

Nevertheless, the increase in the construction of irregularly shaped tall buildings has created a demand for more efficient hoist operation methods. From an engineering perspective, tall buildings generally have a tapered and setback structure in elevation to distribute their vertical loads more stably and reduce the effect of wind loads [9]. In addition, supported by developments in computing technology and structural engineering, complexity and irregularity in building shapes have become more common for emphasizing the symbolic aspects of tall buildings [10,11]. Over the past decades, the technical performance of construction hoists has improved in terms of lifting speed, payload capacity, and cage size. However, there have been a few efforts to improve the equipment and its operation for coping with irregularity in tall buildings. Most existing construction hoists move up and down along vertically installed masts. Thus, a very large number of temporary structures are required to provide access to buildings with a tapered or tilted structure in elevation. This leads not only to substantial cost and time increases for installation and disassembly of the temporary structure but also to a reduction in lifting efficiency because of the increase in the distance that the resources need to be transported. Meanwhile, several hoist manufacturers have developed construction hoists to deal with the inclination of structures [12–14]. However, their application to tall building construction is limited, i.e., there is difficulty in dealing with various angles and operation speeds.

The objective of this study was to introduce a new inclined construction hoist for more efficient transportation of resources in irregularly shaped tall building construction. In the proposed hoist, the capacity was designed to suit supertall buildings of over 300 m in height. The masts can be tilted to cope with various inclination angles in building elevation, and electronic and mechanical control systems keep the hoist cage horizontal as well as adjusting the operation speed for safe inclination changes. The hoist enables the transportation of resources in an efficient and safe way without the support of temporary structures, which require large cost and time inputs. The proposed hoist would be useful for tall building projects with tapered or tilted structures.

* Corresponding author. Tel.: +82 2 921 5920; fax: +82 2 923 4229.
E-mail addresses: thoonkim@chosun.ac.kr (T. Kim), iroze00@korea.ac.kr (H. Lim), ksw@liftec.co.kr (S.W. Kim), hhcho@korea.ac.kr (H. Cho), kikang@korea.ac.kr (K.-I. Kang).
[1] Tel.: +82 62 230 7145; fax: +82 62 230 7155.
[2] Tel.: +82 2 921 5920; fax: +82 2 923 4229.
[3] Tel.: +82 31 322 3000; fax: +82 31 322 3010.

http://dx.doi.org/10.1016/j.autcon.2015.11.008
0926-5805/

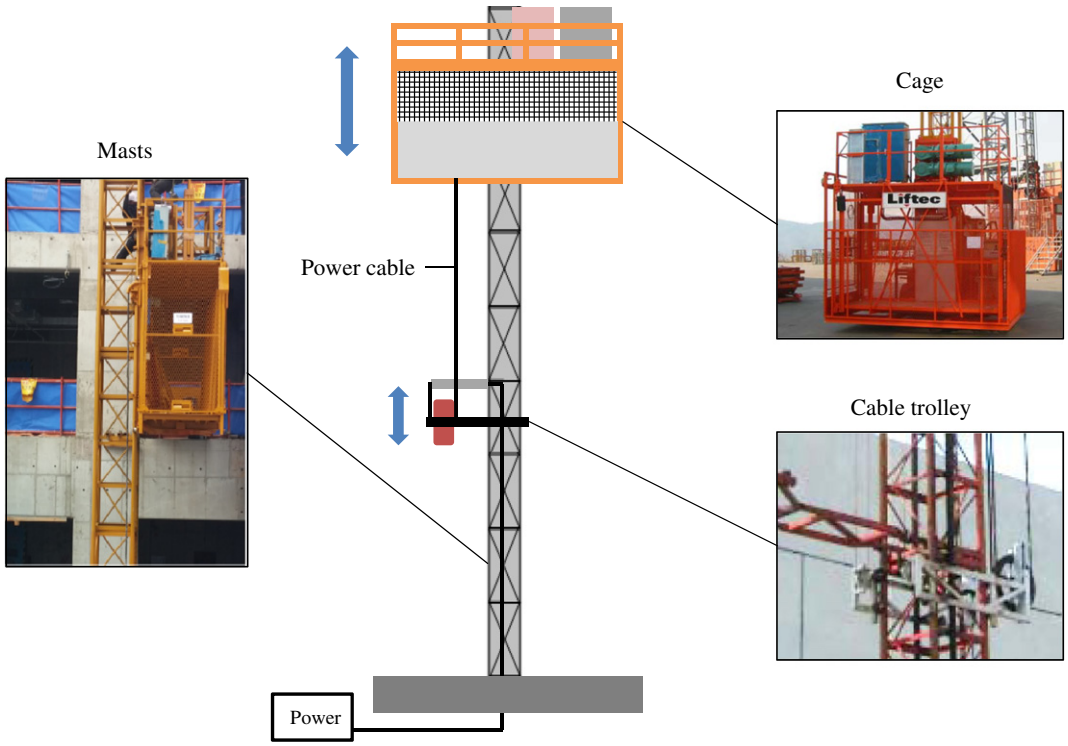

Fig. 1. Components and general operation of conventional hoists for building construction.

2. Construction hoists for irregularly shaped tall buildings

The current trend in tall building construction is a continuous increase in building height and in the irregularity of building shapes. The average height of the ten tallest buildings completed each year in the world has increased from about 150 m in 1960 to about 420 m in 2009 [15]. In addition, 36 supertall buildings of over 300 m were built between 2010 and 2013, which comprises nearly half the total number of supertall buildings [16]. Lim et al. [11] analyzed trends in exterior design of tall buildings from 170 construction projects that were higher than 50 stories or 150 m. They found that construction of irregularly shaped buildings has been steadily increasing and represents over 40% of total projects since 2011. In particular, tapered building shapes are continuously increasing while setback types are decreasing since the 1990s.

Conventional construction hoists have limitations for dealing with this environment in tall building construction. Fig. 1 shows the components and general operation of conventional hoists for building construction. First, the masts are installed vertically from the ground or the floor. Next, one or two cages are connected with the masts and move along the masts using electrical power supplied by power cables. Half of the power cable is fixed to the mast, and the remaining half is unfixed. A cable trolley is attached to the mast for the safe movement of the unfixed cable. The trolley moves along the mast to prevent

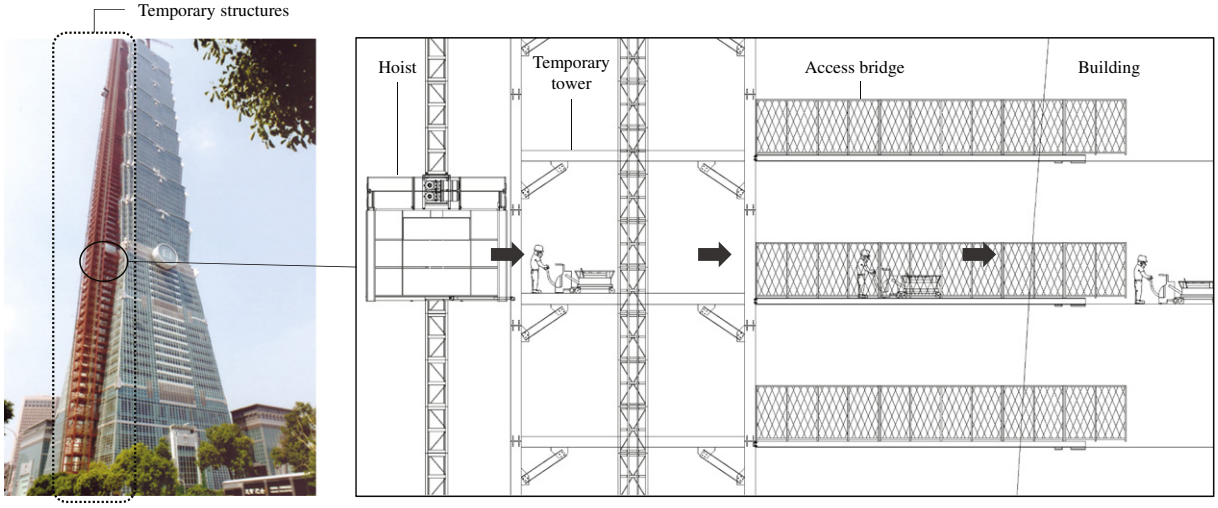

Fig. 2. Temporary structures for the access into the building on Taipei 101 tower construction.