ELSEVIER

Automation in Construction 12 (2003) 381–393

AUTOMATION IN CONSTRUCTION

www.elsevier.com/locate/autcon

A fuzzy quality function deployment system for buildable design decision-makings

Yi Qing Yang[a,*], Shou Qing Wang[b], Mohammad Dulaimi[c], Sui Pheng Low[a]

[a] *Department of Building, School of Design and Environment, 4 Architecture Drive, Singapore 117566, Singapore*
[b] *Department of Construction Management, Tsinghua University, Beijing 100084, China*
[c] *Faculty of the Built Environment, University of the West of England, Bristol, Coldharbour Lane, Bristol, BS16 1QY, UK*

Abstract

During the conceptual stage of a building design, major design decisions that have the greatest influence on buildability of a project are taken. Quality function deployment (QFD) is an integrated decision-making methodology that can assure and improve the alignment of elements of design and construction processes with the requirements of customers. On the basis of the enlarged customer concept, QFD has the potential to be developed as a quantitative approach for buildability evaluation. This paper presents the findings of a research effort to adapt House of Quality (HOQ) to meet the needs of buildable designs in the construction industry and to develop a fuzzy QFD system for buildability evaluation. In this system, the fuzzy set theory is integrated into HOQ to capture the inherent impreciseness and vagueness of design-relevant inputs and facilitate the analysis of design-relevant QFD information. An example is presented to illustrate the system, which provides a viable decision-making method for quantitative buildability evaluation at the early design phase.

Keywords: Quality function deployments; House of Quality; Fuzzy set theory

1. Introduction

Design-construction integration during the early stage of a project provides the potentials for designers to give their clients better value-for-money designs. Buildability (or constructability), which emphasizes the integration of design and construction to improve the chances of achieving a better-quality project, completed in a safe manner, on schedule, and for the least cost [1], has been regarded as an important concept to realize this integration in the construction industry. Previous research efforts into buildability have documented concepts; developed principles and ways to improve buildability; identified barriers; quantified costs/benefits; and provided project-level models, approaches and guide to implementation. All of these efforts focused on management systems and organizational commitment to the buildability concept and proposed to use them to overcome the technical and contractual barriers that limit the integration of design and construction.

When there is no direct organizational and managerial support for buildability implementation, the integration of design and construction heavily depends on the designers' prior construction experience [2]. However, the designers often are only partially knowledgeable about, and sometimes not aware of, the design-relevant construction inputs [3].

* Corresponding author. Tel.: +65-6-8743514; fax: +65-6-7755502.
E-mail address: sdep0178@nus.edu.sg (Y.Q. Yang).

0926-5805/03/$ - see front matter © 2003 Elsevier Science B.V. All rights reserved.
doi:10.1016/S0926-5805(03)00002-5

In addition, the decision-making process at early design stages tends to be ill structured and occurs in an unsystematic way. Quality function deployment (QFD) is an integrated decision-making methodology that can assure and improve the alignment of elements of design and construction processes with the overall requirements of a construction project. QFD has the potential to aid the development of a structured and systematic method to support the process of buildable-design decision making with suitable adoption and extension to facilitate its implementation.

The objective of this paper is to address the challenge of developing a fuzzy QFD system to support buildable design decision making. The research objectives are, first, to adapt House of Quality (HOQ) to provide a systematic and structured method to support the integrated decision-making process of buildable designs; second, to integrate fuzzy set theory into HOQ to facilitate the processing of design-relevant QFD information.

2. Quality function deployment

2.1. An overview of QFD

The basic rationale of QFD is to systematically take the customers' desires down to the level of detailed operations. The two QFD processes, the American Supplier Institute's (ASI) Four-Phase approach and the GOAL/QPC Matrix of Matrices approach, are widely accepted as effective processes to implement it [4]. The ASI's Four-Phase approach translates the customers' needs into technical requirements, and subsequently component characteristics, process steps and operational steps (Fig. 1). Each of the translations uses a matrix, called a House of Quality (HOQ) (Fig. 2). HOQ is a very complex matrix [5] that provides means for interfunctional planning and communications [6]. The fundamental rationale of HOQ is introduced in several publications (e.g. Refs. [5,6]).

2.2. Applications and developments of QFD

QFD is not only a technical tool, but also a managerial philosophy that can help enhance the organizational and managing effects. Technically, QFD can reduce the product development time, while simultaneously improving product quality and delivering the product at a lower cost, and consequently can increase the market share [7]. QFD can also facilitate continuous product improvement with emphasis on the impact of organization learning on innovation [8]. However, QFD also has some drawbacks; for instance, the amount of time to implement it [5], the difficulty in manually recording the QFD matrix in a paper form [9], and the qualitative and subjective decision-making process [10]. These drawbacks have promoted the need for new approaches to the application of the conventional QFD approach [10]. Various quantitative methods, such as analytic hierarchy process (e.g. Ref. [11]), artificial neural networks (e.g. Ref. [10]), and fuzzy

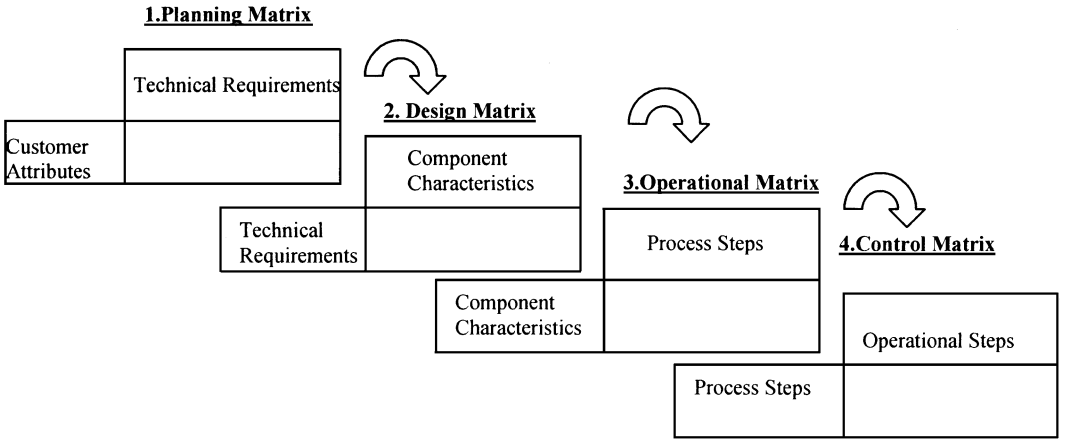

Fig. 1. The four-phase approach of QSD [8].