



ELSEVIER

Advances in Engineering Software 35 (2004) 27–33

ADVANCES IN  
ENGINEERING  
SOFTWARE

[www.elsevier.com/locate/advengsoft](http://www.elsevier.com/locate/advengsoft)

# Optimal deployment of construction equipment using linear programming with fuzzy coefficients

K. Eshwar, Vellanki S.S. Kumar\*

*Department of Civil Engineering, University College of Engineering, Osmania University, Hyderabad 500 007, India*

Received 6 December 2001; accepted 22 July 2003

## Abstract

Decisions made by the experts in the construction industry are usually approximate and contain some sort of imprecision. Classical linear programming (LP) model optimize the decision making situation in a crisp environment. It is difficult to get an optimum decision with imprecise information of the project environment using LP. In the construction industry, identifying optimum number of construction pieces of equipment require experts' knowledge. When certain degree of flexibility needs to be incorporated in the given model to get more realistic results, fuzzy LP is used. But when the parameters on constraints and objective function are in a state of ambiguity then the extension principle is best suited, which is based on personal opinions and subjective judgments. The objective of this paper is to identify the optimum number of pieces of equipment required to complete the project in the targeted period with fuzzy data. A realistic case study has been considered for optimization and LINGO6 has been used to solve the various non-linear equations.

© 2003 Elsevier Ltd. All rights reserved.

*Keywords:* Fuzzy sets; Fuzzy numbers; Fuzzy linear programming; Extension principle; Flexibility; Membership function

## 1. Introduction

Decision making in construction industry is very complex and requires deep knowledge of various construction management techniques. Operations Research (OR) techniques are widely used under such circumstances through appropriate mathematical models. Of all the models of OR Linear Programming (LP) is widely used in the construction industry. In LP models, all the information pertaining to the problem is expressed in terms of linear constraints on the decision variables where the data is precise. Many project managers arrive at feasible decisions using this model.

The construction industry is clearly affected by market conditions, i.e. by ups and downs in construction activity and by the size and the type of the construction projects undertaken. It is also affected by technological innovation in fields such as materials, metallurgy, mechanical systems, electronic sensing and hydraulic controls. The industry focuses on the continuous improvement of its products by

introducing advanced technology [1]. In addition, the success of any construction project depends on the efficiency and economy achieved in the construction phase of the project. The economy of the project is dependent on accurate and elaborate analysis in early stages of construction. But in real project, activities must be scheduled under limited resources, such as limited crew sizes, limited equipment amounts, and limited materials [2]. The presence of large number of interacting variables creates a problem for optimization. Decisions are mainly based on the conceptual understanding of the project by the experts and are usually vague. Therefore, consideration of imprecise and vague information becomes an important aspect in the decision making process. In view of uncertain environment prevailing in the construction industry, the ability to arrive at an optimal decision is most important for its success. Hence, decisions in the construction industry are to be taken only after evaluating the feasibility of an alternative with respect to various criteria affecting its outcome.

The traditional quantitative methods of assessing the feasibility of an alternative such as payback period, rate of return, and benefit cost analysis evaluate the project from the aspect of monetary costs and benefits. But many

\* Corresponding author.

*E-mail addresses:* [vsskumar@hd2.dot.net.in](mailto:vsskumar@hd2.dot.net.in) (V.S.S. Kumar), [eshwar\\_konkati@rediffmail.com](mailto:eshwar_konkati@rediffmail.com) (K. Eshwar).

non-quantitative factors and approximate numbers such as availability of labor, weather conditions, and number of equipments also influence the construction project. The above methods fail to incorporate the necessary qualitative parameters and uncertainty in decision making and thus it is difficult to get an optimum decision in construction industry for optimal deployment of machinery.

These uncertainties can be accommodated into the analysis using Artificial Intelligence techniques such as fuzzy sets, neural networks, and expert systems. The successful application of fuzzy logic reflects the true situation of the real world, where human thinking is dominated by approximate reasoning. Hence to obtain optimality, hybrid optimization techniques are used for incorporating flexibility in decision making. Fuzzy LP makes it possible to accommodate these intangible factors in a most systematic way. The objective function is characterized by its membership value and so are the constraints. In fuzzy LP, the decision maker establishes a satisfaction criterion rather than just maximizing or minimizing the objective function. Here, each of the constraints is modeled as a fuzzy set with their respective membership values.

The aim of this paper is to introduce the approximate numbers into the analysis for optimal decisions. This is done by incorporating flexibilities in the coefficients of the objective function and constraints for an optimal value. The approach described in this paper is intended to illustrate the practicability of applying fuzzy LP with fuzzy parameters to civil engineering problems and the potential advantages of the resultant information.

## 2. Construction equipment

Construction industry comprises of broad range of equipment which include scrapers, graders, hydraulic excavators, trenchers, pipe layers, etc. Depending upon the type and nature of the construction jobs, various equipments and tools are required at different point of time during the execution period. These equipments can be accommodated by hiring, buying or by transferring from other sites. It is important to estimate exactly, the number of equipments to be bought, hired and number of equipments that can be adjusted from the other sites. Normally, experts' qualitatively judge the number of equipments required and hence there is every possibility that the estimated numbers may increase or decrease at the site. Optimally deploying these equipments, preparing an equipment schedule or equipment calendar is an important task of the project manager, such that the construction manager may have no difficulty in arranging the equipments for the purpose at the right time and the work will not be held up because of lack of any equipment. It must be remembered that non-availability of the appropriate equipment or extra idle equipments/tools on the site may lead to financial loss and delays. Hence, the knowledge of various

equipments and their usage on the site is necessary and proper planning of them will always fetch good results. The number and the capacity of the equipment is entirely dependent on the nature and the size of the project.

## 3. Literature review

In construction industry, optimal deployment of machinery plays a significant role. Even though conventional quantitative techniques are efficient enough for getting optimal decisions, they have their own drawbacks. Fuzzy set theory was developed by Zadeh in 1965 for analyzing the decision problems involving fuzzy information. Since then, more than 5000 publications have highlighted the concept and diversified the use of fuzzy set theory.

Bellman and Zadeh [3] developed a decision theory based on fuzzy goals and constraints. In their opinion decision is the confluence of fuzzy goals and Constraints. Zadeh [4] outlined the rules of fuzzy set interpretation of linguistic hedges. He presented systematic conversion of qualitative factors into membership grades for decision analysis. Sasikumar and Mujumdar [5] stated that the imprecisely defined goals and constraints are represented as fuzzy sets in the space of alternatives. Ayyub and Haldar [6] developed a method for estimating the duration of construction activities based on fuzzy set models, and the factors affecting the activity duration. In subsequent years, decision methodologies are developed for selecting and designing construction strategies using approximate reasoning. Wang et al. [7] have evaluated a competitive tendering methodology using fuzzy set theory. Lorterapong [13] proposed the fuzzy network scheduling (FNET) model in which a fuzzy heuristic method was developed to solve the resource constraint project-scheduling problem under uncertainty. Kumar et al. [8] applied fuzzy set theory to working capital requirement. Skibniewski and Armijos [9] adopted LP approach to construction equipments and labor assignments. Mohan [10] used fuzzy LP for optimal crop planning for irrigation system dealing with the uncertainty and randomness for the various factors affecting the model.

Tanaka and Asai [11] have formulated a fuzzy LP problem and considered the ambiguity of parameters. Cross and Cabello [12] applied fuzzy set theory to optimization problems, where multiple goals exist. They have solved a multi-objective LP problem with fuzzy parameters for borrowing/lending problem. It is found that several methods have been suggested for including non-quantitative variables into the decision making process. But very few people have incorporated the complete fuzziness in to the problem. A civil engineering problem comprise mostly of complete fuzzy data, which have to be incorporated to arrive at optimal decisions.

In this paper, the scope has been expanded to include applications in civil engineering projects where optimal

متن کامل مقاله

دریافت فوری ←

**ISI**Articles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات