Available online at www.sciencedirect.com

ScienceDirect

Materials Today: Proceedings 5 (2018) 4669–4677

materialstoday: PROCEEDINGS

www.materialstoday.com/proceedings

ICMPC 2017

Dynamic Cost Optimization Method of Concrete Mix Design

Amin Ziaei-Nia[a], Gholam-Reza Tadayonfar[a]*, Hamid Eskandari-Naddaf[a]

[a]*Department of Civil Engineering, Hakim Sabzevari University (HSU), Iran*

Abstract

As in the most practical problems, decisions have to be made sequentially at different points in time, place, and levels, dynamic programming as a mathematical technique is well suited for the optimization of these problems. Concrete mix design includes various parameters choosing each will have many direct effects on the others. Therefore, performing dynamic optimization in design process is essential to achieve the desired conditions. Cost optimization, is one of the most important aspects in the optimization problems especially in engineering ones. Cost optimization via dynamic programming is performed in the present study due to the effects of various parameters such as cement strength grade, water-cement ratio, maximum size of aggregate, amount of cement, concrete workability and other factors as decision variables. In this regard, a nonlinear dynamic model is used to study the behavior of variables; the model is validated using data presented in literature of this study. Since, the dynamic optimization method works as a decomposition technique, it requires the separability and monotonicity of the objective function. So, the objective function has been represented as the composition of the individual stage returns. The procedure then found the optimal profile modification that reduces the cost over a wide range of operating conditions. Dynamic optimization shows a good performance for the computational efficiency as well as the reliability of results. Finally, an application to air-entrained concrete curb is presented and an extremely good performance is obtained by optimization procedures and concrete properties.

Selection and/or Peer-review under responsibility of 7th International Conference of Materials Processing and Characterization.

Keywords: Cost optimization, concrete curb, dynamic optimization, mix design ;

1. Introduction

Optimization is the process of attaining the optimum result under the existing conditions. Engineers have to make some managerial and technological decisions in several stages during the construction, repairing and maintenance of a structure or engineering systems. Minimizing the required efforts or maximizing the intended interests are the

* Gholam-Reza Tadayonfar. Tel.: +985144012771; fax: +985144012773.
E-mail address: r.tadayon@hsu.ac.ir

Selection and/or Peer-review under responsibility of 7th International Conference of Materials Processing and Characterization.

ultimate purpose of those decisions. Generally, there is more than one acceptable solution or design, so optimization purposes achieved in comparing different designs and selecting one of them as the optimum one [1] . The dynamic optimization problem is solved for any possible transition to determine the operational conditions, which provide the recipe data for the scheduling problem. These recipe data are treated as fixed parameters when the production schedule is optimized. However, it has been recently demonstrated that a collaborative optimization approach which solves the integrated scheduling and dynamic optimization problem simultaneously can significantly improve the overall performance of the entire process system because the operational conditions can be optimized along with the production sequence and assignments [2-4].

The mix design of concrete depends on different parameters that all play critical role in the level of performance [5, 6] and also the cost of concrete. In this regard, dynamic optimization can be a suitable solution. An appropriate method for timely solution of large-scale practical problems is the dynamic optimization [7, 8]. One of the characteristics of this method is that the procedures and negative and positive items are mutually dependent [9]. Moreover, this method has been used in various cases, such as optimization of energy consumption; optimal selection of routes and material transportation, products, and also it is consumables in industries [10, 11]. The objective functions for optimization should be based on decision variables, limitations of decision, and resources (concrete constituent materials) [12, 13].

This study tries to show the application of dynamic optimization on concrete mix design with high durability and minimum cost for the first time. To this, all variables such as air entraining, maximum size of aggregate, slump, cement type, water to cement ratio, and also the costs of them are formulated to obtained a better mix design with minimum cost and in very hard environmental conditions, which needs air entraining into the concrete around 4 and 7 percent.

2. Dynamic Optimization and Proposed Model

Dynamic optimization can be efficient in multi-functional issues which need step-by-step decision making, when each step effects on the next one. A decision making process can be described with specific input parameters, S (or data), specific decision variables (X), and specific output parameters (T) showing the output obtained as a result of making a decision. The input parameters are called input state variables, and the output parameters are called output state variables. Then, a return function or an objective function R measures the effect of the decisions and the output that is the result of these decisions. Fig. 1 shows an example of a single-stage process.

The output (efficiency) is associated with the input through the single-stage conversion function shown in

$$T=t(X, S) \quad (1)$$

As the input state of the system affects the decisions, the return function can be presented as follows:

$$R = r(X, S) \quad (2)$$

A sequence of a multistage process can be presented briefly as shown in Fig. 2.

Therefore, the parameters of the decision such as strength of cement, water-cement ratio, the contents of cement, maximum aggregate's size, workability, and etc. are high and the results will have an impact on the other parameters, to achieve minimum costs of optimization. The dynamic method can also be very effective. The aim of this study is to provide an optimal mix design to precast the concrete under the extreme environmental conditions, with minimum cost. The flowchart of dynamic optimization method for concrete mix design is shown in Fig. 3. The cost of aggregates,

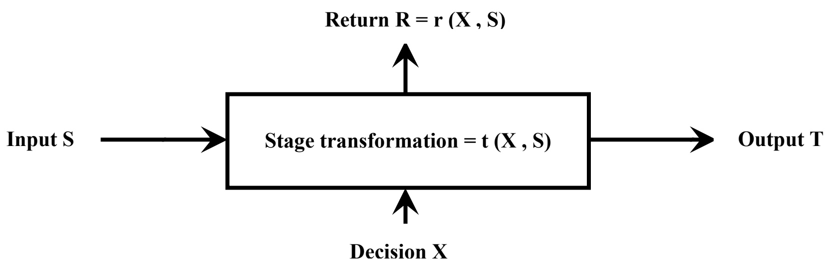

Fig. 1: Processing of dynamic optimization for one step.