Optimization Methods: Dynamic Programming Applications – Optimum Geometric Layout of Truss

Module – 6 Lecture Notes – 2

Optimum Geometric Layout of Truss

Introduction

In this lecture, the optimal design of elastic trusses is discussed from a dynamic programming point of view. Emphasis is given on minimizing the cost of statically determinate trusses when the cross-sectional areas of the bars are available.

Optimum geometric layout of truss

Consider a planar, pin jointed cantilever multi bayed truss. Assume the length of the bays to be unity. The truss is symmetric to the x axis. The geometry or layout of the truss is defined by the y coordinates \(y_1, y_2, \ldots, y_n\). The truss is subjected to a unit load \(W_1\). The details are shown in the figure below.

Consider a particular bay \(i\). Assume the truss is statically determinate. Thus, the forces in the bars of bay \(i\) depend only on the coordinates \(y_{i-1}\) and \(y_i\) and not on any other coordinates. The
cross sectional area of a bar can be determined, once the length and force in it are known. Thus, the cost of the bar can in turn be determined.

The optimization problem is to find the geometry of the truss which will minimize the total cost from all the bars. For the three bay truss shown above, the relation between y coordinates can be expressed as

\[ y_{i+1} = y_i + d_i \quad \text{for } i = 1, 2, 3 \]

This is an initial value problem since the value \( y_1 \) is already known. Let the y coordinate of each node is limited to a finite number of values say 0.25, 0.5, 0.75 and 1. Then, as shown in the figure below, there will be 64 different possible ways to reach \( y_4 \) from \( y_1 \). This can be represented as a serial multistage initial value decision problem and can be solved using dynamic programming.