Keywords: site layout planning, ant colony optimization

Construction site layout is among the most challenging tasks of the construction planning process that consists of identifying temporary facilities to support construction activities, defining their shapes, sizes and allocating them into available spaces within the site boundaries. A good site layout can minimize the travel time between facilities, improve site safety, increase productivity, and, thus, decrease construction cost and time. Although site layout has such a major role in planning, it has received relatively little attention due to the complex nature of the problem, which is formulated as a combinatorial optimization problem. Recently, many researchers have focused their attention on site layout planning, and various models have been proposed in prior studies using neural networks, genetic algorithms (GA), expert systems, computer aided design (CAD), simulation, hybrid systems, and the like. (Yeh, 1995; Li and Love, 1998; Mawdesley et al., 2002; Zhang et al., 2002; Sadeghpour et al., 2004, 2006; Ma et al., 2005; Zhou et al., 2009).

A construction site layout problem is the allocation of a number of predetermined facilities to a number of predetermined locations. The problem can be modeled as quadratic assignment problems, where there are equal numbers of facilities and locations. In this study, it is assumed that there are equal numbers of facilities and locations and each of the predetermined location is available for accommodating the largest facility. The predetermined locations are represented as rectangles. The objective of construction site layout is to minimize the total traveling distance of personnel trips between facilities. The total distance is defined as in (1)

\[
\sum_{\varphi \in S(n)} \sum_{i=1}^{n} \sum_{j=1}^{n} \delta_{x} f_{x} d_{ij} \]

(1)

Subject to \( \sum_{x=1}^{n} \delta_{x} = 1 \), \( \{i=1,2,\ldots,n\} \) (2)

where \( TD \) is the total traveling distance; \( n \) is the number of facilities; \( \delta_{x} \) is the permutation matrix variable (=1 if the facilities is assigned to site \( i \)); \( f_{x} \) is the frequencies of trips made by construction personnel or material flow between facilities \( i \) and \( j \); and \( d_{ij} \) is the distance between locations \( m \) and \( n \).

ACO algorithms are population-based techniques that are derived from the observation of real ants’ behavior, and in particular, their ability to find the shortest path between their nest and a food source. The main idea of ACO algorithms is the cooperation of a colony of artificial ants in finding an optimal solution to optimization problems. In this study, the Ant Colony Optimization (ACO) algorithm is proposed for site layout problems. The framework for the developed ACO algorithm is established as follows with referring to Stützle and Dorigo (1999):
**Step 1:** Define the heuristic information

**Step 2:** Select assignment sequence for the facilities

**Step 3:** Assign facilities to a location

**Step 4:** Pheromone update

**Step 5:** Local search

A Quick Basic program Ant Colony Optimization with Local Analysis (ACO-LA) is developed on a personal computer to implement the ACO algorithm. Parameters were set to $\alpha=0.1$, $\beta=2$ and $\rho=0.1$ where $\alpha$, and $\beta$ are the parameters that show relative influence of pheromone trail and heuristic information, respectively, and $\rho$ is the pheromone trail evaporation rate. Number of ants were set to 10 and $Q$ is taken as 1. These parameter settings were taken from the study of Dorigo and Gambardella (1997a, 1997b). A numerical example is taken from Li and Love (2000) where there are two permanent buildings to be constructed and 11 facilities to be positioned. After 1000 runs the objective function values and optimal layouts are obtained as in Table 1.

<table>
<thead>
<tr>
<th>Location</th>
<th>Facility</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>Objective function value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Li and Love (2000)</td>
<td></td>
<td>11</td>
<td>5</td>
<td>9</td>
<td>7</td>
<td>2</td>
<td>8</td>
<td>3</td>
<td>1</td>
<td>6</td>
<td>4</td>
<td>10</td>
<td>15 160</td>
</tr>
<tr>
<td>ACO-LA</td>
<td></td>
<td>11</td>
<td>9</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>10</td>
<td>12628</td>
</tr>
</tbody>
</table>

Li and Love came up with an objective function of 15160 by using genetic algorithm with 100 population size and 90 generations. Developed ACO-LA algorithm produced a better result, and obtained an objective function of 12628. Total travel distance was found to be reduced by 16.7%. This result indicates that ACO-LA is an efficient model to solve the site layout problem.

**References**


