Optimizing Material-Related Costs Using Dynamic Site Layout and Supply Chain Planning

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Introduction

Space in a Construction Site

Temporary facilities

Material storage areas

Ongoing construction works

Often Considered LIMITED

(Said & El-Rayes, 2013), (Mossman, 2007)
Introduction

Seven groups of resource flow needed to complete a certain task:

- Construction Design
- Components and Materials
- Workers
- Equipment
- Space
- Connecting Works
- Addition to External Conditions

(Koskela, 2000), (Lange & Schilling, 2015)
When Are Material-Related Costs Incurred on Site?

Material movement into the site from laydown areas or storage facilities

Material transportation to installation area

Push nature of activities

Introduction

(Tommelein, 1994), (Alves, Tommelein, & Ballard, 2006)
Introduction

Why Dynamic Site Layouts?

(Said & El-Rayes, 2013)
Gap Statement

Different methods and models in the academic literature addressing material handling in a construction site have focused on:

- On-site congestion
- Logistics cost
- Project schedule
- Material flow to the site
- Dynamic site layout planning

The impact of how all those individual factors act and interact with one another in a single production system to incur material moving costs has been understudied.
Research Objective

How can we decrease material-related costs on site through the use of dynamic site layout and supply chain strategies?

What’s the Main Problem?
Methodology

1. Gathering Intel
2. Case Study
3. Conceptual Model
4. Base Case Scenario
5. Improved Scenario
Case Study

GRC units Held on Rack

GRC Installation Zones
## Case Study

<table>
<thead>
<tr>
<th>Zone number</th>
<th>Number of GRC units ($Q_{z_i}$, $i = 1:8$)</th>
<th>Total GRC area per zone ($m^2$)</th>
<th>Installation period (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zones 1,3,5</td>
<td>350</td>
<td>4550</td>
<td>8</td>
</tr>
<tr>
<td>Zones 2,4,6</td>
<td>700</td>
<td>9100</td>
<td>8</td>
</tr>
<tr>
<td>Zones 7,8</td>
<td>175</td>
<td>4550</td>
<td>6</td>
</tr>
</tbody>
</table>

### GRC Quantities and Equivalent Areas per Zone

### GRC Installation Schedule

![GRC Installation Schedule Diagram]

*Note: Diagram shows installation periods from May 1 to November 30.*
Case Study

Available storage area for GRC units equivalent to 100 units

Site Layout Plan

- Tower Crane
- Site Entrance
- Total Area Available: 800 m²
- Motor and Equipment Room
One delivery = ¼ of the quantity per zone
Conceptual Model

On Site
Conceptual Model
Conceptual Model
Base Model Concerns

- Trucks Accumulating on Site
- No Space for Other Material
- Labor Overutilization
- Storage Costs
- Material Deterioration Costs
- Hindering Movement
Improved Model

- **Pull System**
  Decrease Lead Time of Trucks on Site

- **Merging Activities**
  Combine the activities “Clean GRC” and “Install GRC” into one

- Decrease the # of trucks from 4 to 2
- Make deliveries weekly instead of biweekly

- Crane moves a GRC rack (10 units) instead of moving one unit
- Labors of both activities should work at the same time
- Requires less time than if the activities were separated (less movement)
Improved Model
Developed Models

Model A
- Reduced L.T. = 1 Week (pull system)

Model B
- Merging activities
- Longer L.T. = 2 Weeks

Model AB
- Merging activities
- Reduced L.T. = 1 Week
## Assessment Criteria

### Total hours
- Model simulation time

### The Truck Delay Cost ($)
- Cost incurred by trucks waiting to be unloaded instead of performing another delivery

### Deterioration Cost ($)
- Cost of the total time a GRC unit spends on site before its final installation

### Turnover Rate (hours/occurrence)
- Time needed for the storage space on site to be replenished by a new GRC rack.

### Total Cost ($)
- Cost of the trucks, labour, crane, the GRC units’ deterioration cost, and truck delay cost.
Simulation Results & Analysis

Percent of Cost Improvement for the Models

<table>
<thead>
<tr>
<th>Category</th>
<th>A</th>
<th>B</th>
<th>A+B</th>
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</thead>
<tbody>
<tr>
<td>Total Cost</td>
<td>1%</td>
<td>15%</td>
<td>16%</td>
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<tr>
<td>Truck Delay Cost</td>
<td>56%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Deterioration Cost</td>
<td>0%</td>
<td>16%</td>
<td>16%</td>
</tr>
<tr>
<td>GRC Turnover</td>
<td>0%</td>
<td>15%</td>
<td>15%</td>
</tr>
</tbody>
</table>
Simulation Results & Analysis

Percent Improvement for Total Hours

<table>
<thead>
<tr>
<th>Case Scenario</th>
<th>Percentage Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0%</td>
</tr>
<tr>
<td>B</td>
<td>15%</td>
</tr>
<tr>
<td>AB</td>
<td>10%</td>
</tr>
</tbody>
</table>
Simulation Results & Analysis

Reducing Lead Time Effect
- Decreased transportation delay cost
- Satisfy site and schedule demand
- Reduced site congestion

Combining Activity Effect
- Decrease unneeded movement
- Decreased total material handling cost
- Increased space utilization
Conclusions & Future Work

Incorporating lean tools along with the proper supply chain

---> Reduced the material related costs on site by 15-16%
---> Reduced the process time by 15%

Future work aims at improving the existing model to better reflect the actual site conditions regarding labour productivity and truck capacity of the site.
Thank you for your time!