Abstract

This project will make use of ALICE’s powerful parametric scheduling capability in order to find the optimal combination of work crews, workflow, and work hours for a given project. The project includes modeling a construction project in ALICE and experimenting with the different parameters in order to understand the effect of each on the project’s duration and cost. The outcome of this exercise will be a better understanding of the project and an optimized plan and schedule.

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I. Introduction

ALICE is an artificial intelligence construction scheduler that aims to revolutionize the way construction managers plan and schedule their projects. It introduced parameters that were previously impossible to iterate on while planning a construction project. This includes BIM, recipes, and resource constraints. ALICE is able to vary the project's basic parameters, analyze the variation's impact on the schedule's basic metrics, and produce an optimized schedule with detailed statistics that can suggest further changes to the input parameters. ALICE gives construction managers the ability to understand the effects of changes in inputs that were hard to understand previously.

Our project is a 10-storey high-rise in Tokyo. We will be using ALICE to produce a number of possible schedules and to find the most effective and efficient way to complete the project.

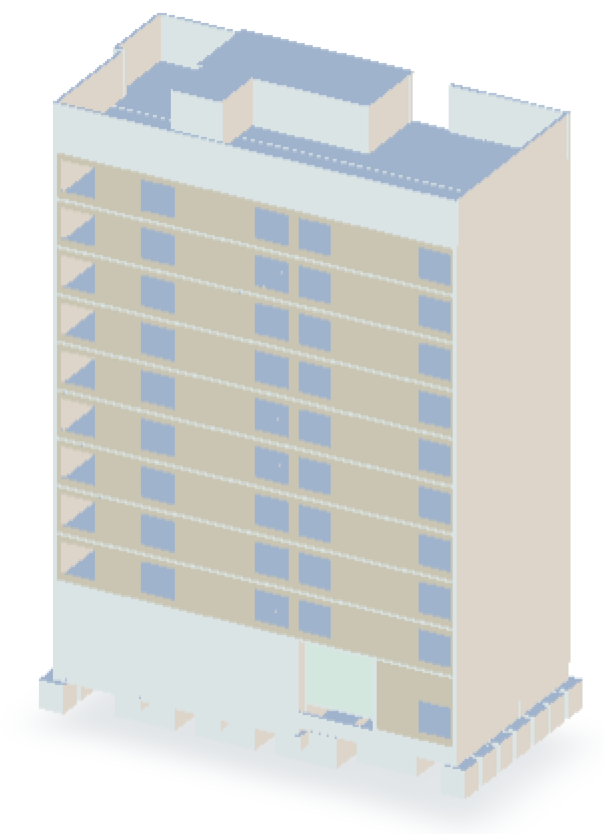

Figure 1: Our Project

II. Zoning

A. Two-zone Workflow

As a construction manager in charge of scheduling, Mary approached us for solutions to make the schedule shorter and more cost-effective. There are several questions to answer, starting with how the workflow affects cost and duration. In our project, we analyzed two workflows; in the first one, we grouped the basement together, the roof together, and divided each floor into two zones (left and right) that were built sequentially. In each zone, we grouped the walls into two sets that were built consecutively on top of one slab. The variable cost here is 64 percent, i.e. more than half of our project cost is idle costs! This is clearly inefficient. Our available days worked is at 77% which shows that a substantial amount of days, excluding weekends, are being lost with no work done in them. Finally, our average crew utilization is at 35%, demonstrating even more that our crews aren't being employed efficiently. This is primarily due to our workflow that is not economical as a lot of time and resources are being wasted as crews work on each zone completely, when they could be utilized more effectively if the other zone was started simultaneously versus successively.

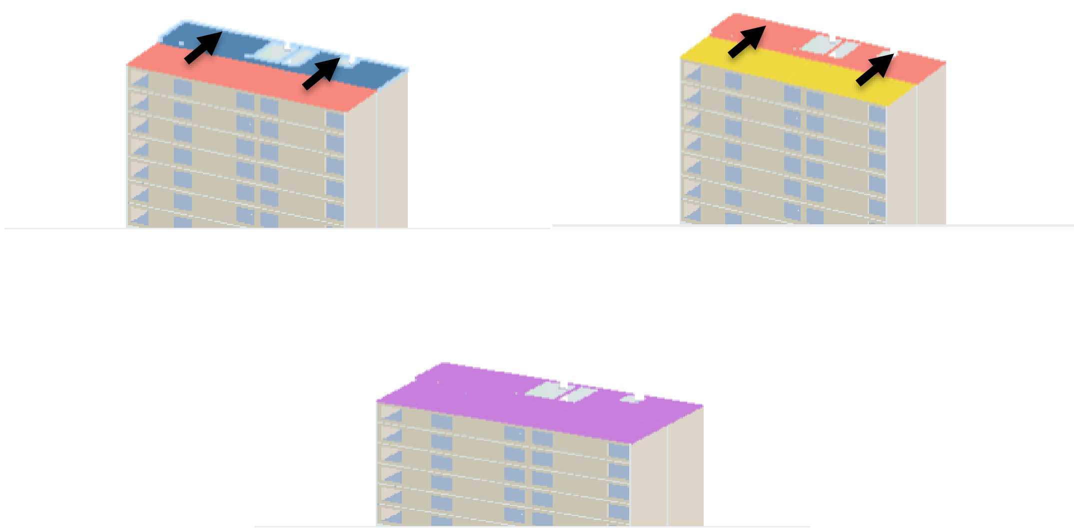

Figure 2: Two-Zone Workflow, Crews Alternate Between Two Zones

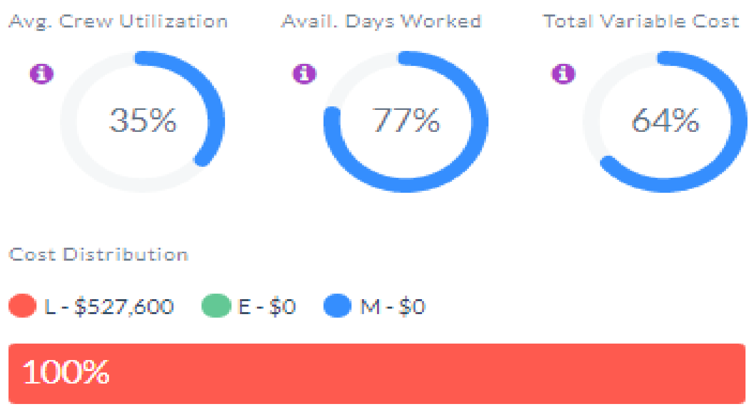

Figure 3: Crew Behavior for Two-zone workflow

B. Four-Zone Workflow

Our second workflow consisted of grouping the basement and roof into two clusters and divided each floor into four zones of walls that were built sequentially on one slab. In this case, the total variable cost is at 19% which is much lower than the value in our initial workflow. Here, our idle cost is 78888$ which is a small sum compared to our direct cost of 344,400$. This indicates that crews are being employed more efficiently and aren't waiting a lot of time to perform their job. Our available days worked is 100%, meaning that available days are fully occupied by work. Lastly, our average crew utilization is at 64%, which is comparatively higher than our previous workflow.

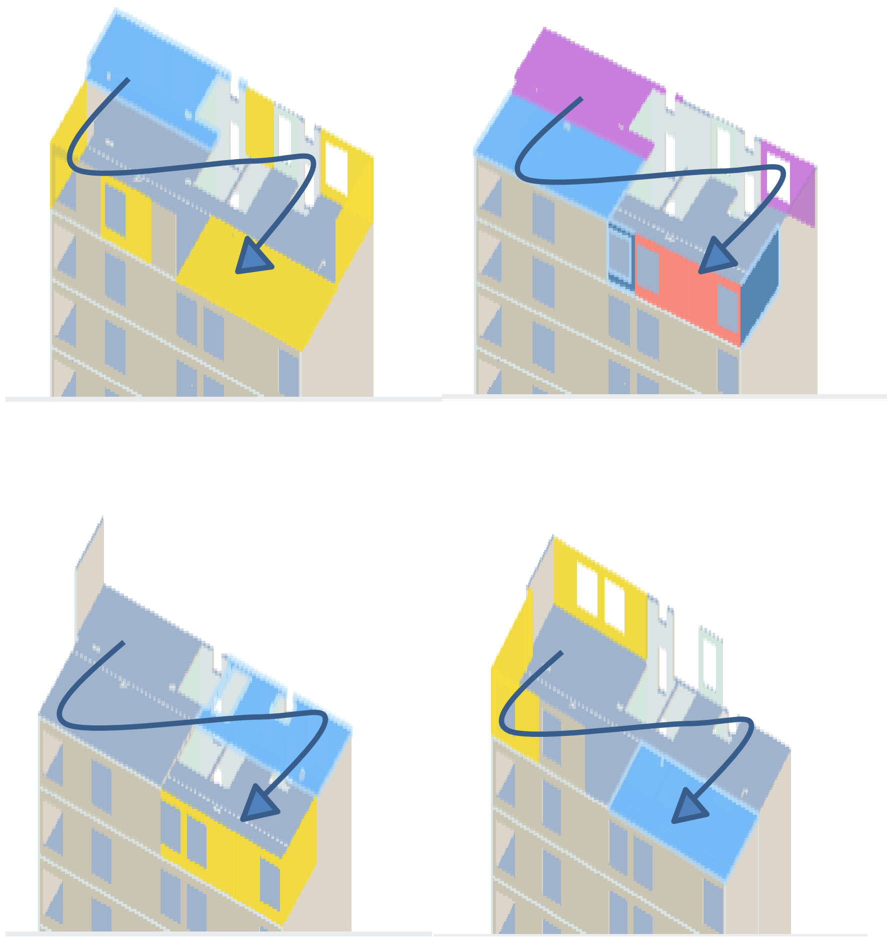

Figure 4: Four-Zone Workflow, Each Zone is an Independent Entity

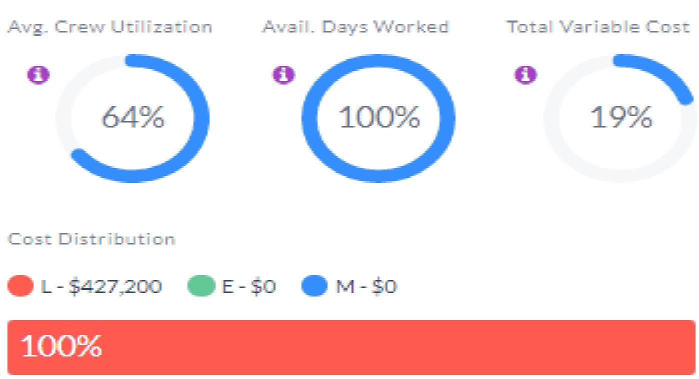

Figure 5: Crew behaviour for Four-zone workflow

There is a clear improvement in project budget (1,005,657 $ vs. 843,200$), with some increase in project duration which may be attributed to the additional need for crews a 4-zone workflow incurs due to its dynamic nature.

Figure 6: Cost-time curve: 4 zones vs. 2 zones

III. Crew Mixes

Table 1: Different Scenarios Results

Scenario	# Carpenters	# Steel Workers	# Concrete	Best Duration	Best Cost
1	2	2	2	287	762,684
2	2	1	2	446	982,450
3	2	2	1	441	1,067,202
4	1	2	2	443	1,076,050
5	3	3	3	266	893,903
6	4	4	4	251	1,082,050

The chosen workflow was run using different crew mixes in order to identify the effect of varying key schedule parameters on the total outcome of the project in regards to duration and cost. From the results shown in the table, it is clear that the number of crews used of each type has a major effect on the project outcome. However, it is important to keep in mind that the “best option" to choose depends on the end goal of the owner. Does the owner prioritize time or money?

For our project, we have chosen scenario 1 as the optimum crew mix because it optimizes duration and cost. Scenarios 2, 3, 4 were generated by alternating decreasing each crew type to 1. It is noted that the three crews are approximately equally critical on the project duration and cost. The three scenarios exhibited a bug jump in both duration and cost. Therefore, it can be inferred that decreasing the crew number of each type resulted in resource scarcity. Scenario 5 was generated by appointing 3 crews to each activity type. As expected, this mix marginally decreased the total duration while considerably increasing project cost. As for scenario 6, were we have 4 crews for each activity, the duration was again decreased but the cost jumped considerably.

Therefore, scenario 1 represents the best crew mix.

IV. Effect of Overtime

Table 2: Results of Different Runs

Run	Min. Duration	Max. Duration	Variance	Min. Cost	Max. Cost	Variance
Run 1	287	312	25	$762,684	$821,020	$58,336
Run 2	446	473	27	$982,450	$1,054,337	$71,887
Run 3	441	469	28	$1,067,202	$1,113,946	$46,744
Run 4	443	478	35	$1,076,050	$1,477,022	$400,972
Run 5	266	298	32	$893,903	$994,783	$100,880
Run 6	251	275	24	$1,082,050	$1,112,500	$30,450

We have increased the work hours to include overtime on Saturday (8 workhours). We ran the schedule on two different crew combinations. Overtime work hours cost 50 % more than the base hourly wage. The first run was made using 1 crew member of each trade. Without the overtime, the original duration was approximately 287-300 days, and the cost ranged between $762,684 and $800,000. With the overtime schedule, the project duration ranged between 235 and 236 days, whereas the cost ranged between $888,725 and $997,300. The overtime improved the project duration by around 50 days; however, there was a notable increase in the project cost. The second run showed similar results where there was a slight improvement in duration (from 251-275 to 225-233 days), but a great increase in project cost (from $1,082,050-$1,112,500 to $1,415,588-$1,484,900). The increase in project cost outweighs the improvement in duration. Therefore, it is preferable not to resort to overtime. Increasing the work hours of laborers beyond reason does not necessarily improve production rate. Beyond a certain time, increasing labor work hours stops yielding benefits.

V. Conclusion

After finishing the project, we got better ideas for resource management and grouping processes. Choosing the best grouping process is the primary and main step before discussing any result. In our project, we get to group the basement and roof into two clusters while dividing each floor into four zones. This grouping gave us better average crew utilization, available working days and low variable cost. And after that, we can start managing our resources and picking up the best scenario. As we see in the results of different runs for resources management, beyond a certain time, increasing labor hour stops yielding benefits; in project management, the manager should count for the effect of increasing cost on the duration of the project (and vice versa) and figure out which one will exceed the improvement of the other. Using ALICE, and running our chosen scenario, we get different runs and figure out that even without overtime, the project will proceeds much better introducing overtime.