# A Framework for Determining Contractor's Cash Outflow Based on Building Information Modeling (BIM)

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## ABSTRACT

Accurate determination of project cash flow is vital for contractors in construction projects. Among cash flows, the contractor's cash outflow is particularly important, and neglecting it can lead to liquidity shortages during the project. With the advancement of modern computational tools, especially Building Information Modeling (BIM) in the construction industry, the contractor's cash outflow can be calculated at any moment of the project easily and within minutes. This paper presents a framework based on contractors' payment models for labor, equipment, and materials, which was implemented in a real construction project. The model is designed with an emphasis on the time lag between resource utilization and cost payment, and the actual cash flow is compared with the total cost curve. The results indicate that the primary source of discrepancy between the total cost curve and the outflow cash flow is the time difference between recording costs and actual payments. This delay creates liquidity peaks in capital-intensive and discrete costs such as materials, while continuous costs, such as labor, only cause minor temporal variations. Using the total cost curve to estimate profitability introduces a limited error of approximately 0.3 to 2.1%. However, the contractor's actual cash requirement due to delays in material payments can be overestimated by up to 64%, whereas labor payments mainly cause only minor shifts in cash flow. Therefore, active management of material payments and negotiation with suppliers can reduce liquidity risk and improve financial decision-making.

## KEYWORDS

BIM, Contractor's cash outflow, Project Resources cost, Payment models, Profitability.

## Introduction

Cash flow is critically important for construction companies, as it indicates future financial needs and allows time to find solutions before liquidity problems arise [1]. Cash outflow, which represents payments for labor, machinery, and materials, is particularly important for contractors; however, it is generally calculated manually, making the process time-consuming and prone to errors.

Previous research has attempted to predict cash flow using various methods. Mohagheghi et al. [2] proposed a type-2 fuzzy model for cash flow prediction, while Tabei et al. [3] used fuzzy methods to determine upper and lower bounds of cash flow considering project risks. Kuchta and Zabor [4] developed a reliable model using the full spectrum of fuzzy computations. With the advancement of Building Information Modeling (BIM), 5D BIM has become prevalent due to its ability to integrate time and cost [5]. Kim and Grobler [6] presented an initial framework for generating cash flow diagrams using BIM. More recently, Tavakolan and Nikoukar [7] proposed a BIM and simulation-based method for financial scheduling.

However, most existing models are static and, critically, do not adequately incorporate the "time lag" between resource usage and actual payment. Therefore, this research develops a BIM-based model that emphasizes time lags between resource utilization and cost payment to determine contractor cash outflow.

## Methodology

This section presents a BIM-based model for estimating contractor cash outflows. A BIM model with a minimum LOD 300 is employed, as it delivers precise location, geometry, and physical attributes (length, width, height, area, volume, and materials), offering adequate reliability for financial computations. BIM tools are utilized to derive accurate quantities and volumes based on standard unit prices. Once component quantities are established, resources are allocated to determine the required machinery, labor, and materials for each activity.

Integrating BIM-extracted quantities with the project schedule database enables determination of resource demands over time. Linking these with unit cost data for labor, machinery, materials, and overhead then reveals temporal trends in direct and indirect costs.

However, this integrated model only displays daily costs without considering time lags, because contractors do not pay for resources at the same time they are used. Therefore, payment models must be specified:

- Machinery & Equipment: cash outflow from machinery used in each activity is calculated based on required quantities and unit price. The payment time equals the end time of usage plus a specified lag.
- Labor: The number of payments is calculated by dividing the duration of labor usage in an activity by the payment interval. For each payment, the contractor's cash outflow is based on the work completed by that labor during the specific payment period, and the payment time is calculated as the start time of usage plus the payment interval multiplied by the payment number.
- Materials: At the time of order, the contractor pays a percentage of the material cost. The remaining balance is paid after a specified lag. There is typically a lag between order and delivery, and between delivery and usage. Payment times are calculated accordingly.

Finally, after determining daily cash outflow from machinery, labor, materials, and overhead, the discounted cumulative cash outflow is calculated using the discount rate.

## Results and Discussion

The proposed framework was implemented in a real 4-story office building project with steel structure and approximately 5000 sq.m. floor area (project duration: 343 days, total cost: 44,929,506,188 IRR, see Table 1).

**Table 1. General Specifications of the Case Study Project**

| Parameter | Value |
|---|---|
| Project duration | 343 days |
| Total project cost | 44,929,506,188 IRR |
| Discount rate | 18% |
| Floor coefficient | 1.02 |
| Overhead coefficient | 1.30 |
| Insurance deductions | 5% of each progress payment |
| Retention | 10% of each progress payment |

3.1. Comparison of Cash Outflow and Total Cost

As expected, the total cost curve cannot accurately display real contractor costs at the time they occur. Although this curve estimates project profitability only about 0.9% less than the real amount, it estimates the contractor's required liquidity about 41% more than the real value. This significant overestimation may lead the contractor to secure financing beyond actual needs.

3.2. Scenarios Related to Material Cost Payment

Two scenarios were analyzed. In the first scenario, all material amounts are paid one month after use with no advance payment (fully credit-based). In the second scenario, 50% of material costs are paid at order and 50% one month after use. With fixed cash inflow, profitability using real cash outflow is about 0.3% and 0.7% higher than using the total cost curve for the first and second scenarios, respectively. However, not considering real payment models causes the maximum contractor liquidity to be overestimated by about 64% for the first scenario and 32% for the second scenario. The difference between cash outflow and total cost curves is negative for 93% and 92% of project duration for the first and second scenarios, indicating daily cost overestimation by the total cost curve.

3.3. Scenarios Related to Labor Cost Payment

To examine the effect of changing labor payment methods, third and fourth scenarios were analyzed. From a profitability perspective, the difference between total cost and cash outflow in the third and fourth scenarios is about 1% and 2.1%, respectively. From a liquidity perspective, this difference increases to about 3% and 6% in the third and fourth scenarios. However, these values still indicate limited temporal shifts in cash outflow and do not suggest a structural or significant change in project liquidity needs. In other words, changing labor payment methods mainly leads to minor temporal shifts in the cash outflow diagram.

3.4. Causal Analysis and Discussion

The fundamental cause of the divergence between the total cost curve and actual cash outflow lies in the delay between incurring a cost and settling the corresponding payment. The total cost curve presumes that financial obligations occur simultaneously with resource usage, whereas real-world cash disbursements adhere to contractually defined payment terms. This temporal mismatch leads the total cost curve to persistently overstate the contractor's liquidity requirements over the majority of the project duration.

As reported in Table 2, non-continuous, capital-heavy expenditures—such as construction materials—tend to concentrate within brief time windows, thereby creating sharp liquidity spikes. By contrast, recurring costs like labor, which are dispersed evenly across time and feature shorter settlement periods, produce only modest temporal displacements. Accordingly, revisions to material payment schedules affect the project's liquidity profile far more significantly than do equivalent revisions to labor payment schedules. Hence, proactive negotiation and management of material supply agreements represent a powerful strategy for mitigating liquidity risk, whereas adjustments to labor payment mechanisms serve only a subordinate and constrained function.

**Table 2. Comparison of Payment Scenarios**

| Scenario | Profitability Error | Liquidity Error |
|---|---|---|
| First (Material - Full Credit) | 0.31% | 63.65% |
| Second (Material - 50% Advance) | 0.71% | 31.83% |
| Third (Labor - Periodic) | 0.99% | 3.08% |
| Fourth (Labor - Delayed) | 2.09% | 5.96% |

## Conclusion

This research developed a dynamic BIM-based model for determining contractor's real-time cash outflow by incorporating time lags between resource consumption and payment. Using the total cost curve, although having less than 2.1% error in profitability, can overestimate contractor liquidity needs by 32-64%, especially for material costs. Changing labor payment methods causes only 3-6% shifts.

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