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Delivery Reliability as Operational Value in Affordable Housing: A Critical Path Analysis of a Type 36 House Project in Samarinda

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Abstract

Affordable housing competes not only on price but also on dependable handover performance. However, many Critical Path Method (CPM) studies on small housing projects remain framed as technical scheduling exercises and do not clearly show the precedence logic needed for replication. This study examines a Type 36 house project in Samarinda as a case of project-based housing delivery. Using field observation, interviews with the project manager, and project schedule records, the study reconstructs a package-level CPM network with explicit predecessors, forward and backward pass results, slack values, and an accelerated scenario. The documented managerial schedule shows a normal completion horizon of 180 days. Under the accelerated scenario, the elapsed project time can be reduced to 123 days, generating a saving of 57 days or 31.7 percent. The revised CPM presentation shows that the critical structure is concentrated in preparatory work, earthworks, concrete work, wall work, the roof-ceiling sequence, sanitation coordination, and final electrical work, while floor work, frame installation, and locking activities carry limited float. The contribution of the study is threefold. First, it positions schedule control as a delivery-reliability issue in affordable housing operations. Second, it provides a more transparent CPM presentation than many local housing case studies. Third, it offers practical guidance for managers in prioritizing supervision and resource coordination. The study does not measure customer satisfaction directly; therefore, its claim is limited to time-efficiency analysis and delivery-reliability support.

Keywords: Affordable Housing, Critical Path Method, Project Scheduling, Delivery Reliability, Project Control

1. Introduction

Affordable housing delivery is increasingly pressured by urban growth, buyer expectations, and the need to coordinate construction resources efficiently. In project-based housing, completion time is not merely a technical indicator; it also determines the dependability of the handover promise and the coordination of labor, materials, and downstream activities. Evidence from recent construction research shows that schedule delays remain a persistent performance problem and are associated with planning, materials, communication, financial, and coordination constraints (Gómez-Cabrera et al., 2024; Masoetsa et al., 2022; Tariq & Shujaa Safdar Gardezi, 2023). In the Samarinda context, housing development also needs to be understood against local demographic and urban-development conditions as in data from the Central Statistics Agency of Samarinda City in 2025.

From an operations perspective, speed and dependability connect internal project execution with the value experienced by customers. Effective project control requires planning, monitoring, analysis, and reporting so that deviations can be identified before they affect the final completion date (Tukundane & Yang, 2024). Recent studies likewise emphasize that reliable planning and schedule control are important because changes in activity timing can propagate to subsequent work packages and increase the likelihood of delay (Kim et al., 2021; Zhang & Wang, 2023). Thus, for affordable housing, schedule reliability should be treated as an operational concern rather than only a technical scheduling outcome. Recent evidence on schedule and cost risk likewise shows that construction projects require explicit management of risks that can affect schedule performance (Abdul Nabi & El-adaway, 2021).

Previous housing-project studies using CPM in Indonesia have demonstrated its usefulness for identifying critical activities and optimizing completion time (Aprillia et al., 2023; Perdana & Sari, 2022; Rakasyiwi et al., 2022). Recent case studies in Samarinda and other Indonesian housing projects also report that CPM can make critical paths and available float more visible (Ningsih et al., 2025; Sigit et al., 2024). Nevertheless, much of this work remains centered on technical schedule optimization. A further issue is analytical transparency: project scheduling studies need to show activity precedence, network logic, forward and backward calculations, and float information clearly enough for readers to understand and reproduce the analysis (Bhatt, 2022; Ezzeddine et al., 2022).

The present study addresses these limitations through a revised analysis of a Type 36 house project in Samarinda. Type 36 housing provides a relevant case because it represents a practical form of relatively affordable housing and involves repeated coordination among structural, architectural, roof, sanitation, and electrical work packages. Recent literature on affordable housing also highlights the need to improve the efficiency and reliability of housing production while maintaining the required quality and affordability (Reid, 2023; Styhre & Brorström, 2023). The present study therefore retains CPM as the analytical method but strengthens its interpretation from a project-delivery and operations perspective.

The study makes three specific contributions. First, it interprets schedule control in a Type 36 housing project as an operational mechanism that can support delivery reliability rather than treating CPM solely as a calculation tool. Second, it provides a transparent package-level representation by reporting immediate predecessors, network logic, forward and backward schedule windows, and slack values. Third, it translates the critical-path results into managerial priorities for supervision and resource coordination. This positioning is consistent with recent research showing that project-control practices and reliable scheduling are associated with stronger construction performance (Ezzeddine et al., 2022; Tukundane & Yang, 2024).

On that basis, the objective of this study is to analyze the planning and control of a Type 36 house project in Samarinda using CPM and to interpret the result in terms of delivery reliability. The study does not claim that CPM is a new method, nor does it measure customer satisfaction or market response. Its contribution is limited to the transparent analysis of time efficiency, critical activities, float, and an accelerated managerial scenario, while linking these findings cautiously to the operational conditions that support more dependable handover.

2. Literature Review

Project management provides the structure needed to organize resources, coordinate work, and control progress in time-bound activities. Within this domain, the Critical Path Method (CPM) is a deterministic scheduling technique used to identify activities that determine the minimum project duration and to reveal activities with available float. Its practical value remains evident in recent construction studies, including residential and specialized construction cases (Asrul et al., 2025; Ningsih et al., 2025; Zakia & Febrianti, 2021). The underlying logic is also consistent with project-management guidance that emphasizes systematic planning and control of project activities. This operational foundation is also in line with the operations research literature that places scheduling as a tool to systematically determine the sequence of activities and resource use. CPM is also grounded in deterministic network scheduling logic for identifying the minimum completion horizon and critical activities (Mazlum & Güneri, 2015; Zakia & Febrianti, 2021).

From an operations-strategy perspective, schedule control matters because speed and dependability are important performance objectives. Speed reduces elapsed completion time, whereas dependability concerns the ability to deliver according to the promised or planned time. Recent construction research reinforces the importance of planning and control for project performance and shows that project-control practices are associated with improved organizational performance (Tukundane & Yang, 2024). Similarly, research on planning reliability demonstrates that uncertainty in construction schedules can affect downstream production and delivery decisions (Kim et al., 2021). This view is consistent with operations-strategy research linking operations strategy to service-delivery performance (Arias-Aranda, 2003) and with the operations-strategy treatment of speed and dependability as performance priorities (Slack & Lewis, 2017).

Delivery reliability also has an external dimension. Jalili Marand et al., (2019) position delivery time and delivery reliability as important dimensions of delivery performance, while Anwer AL-Shboul, (2022) links delivery reliability with responsiveness in supply-chain settings. More recent construction research extends this concern by showing that schedule delays can emerge from interconnected planning, material, communication, and coordination problems (Gomes et al., 2023; Tariq & Shujaa Safdar Gardezi, 2023). These studies are not specific to Type 36 housing, but they provide a conceptual bridge for interpreting tighter schedule control as a condition that can support more dependable project delivery. In an operations perspective, the findings of Jalili Marand et al., (2019) show that delivery time and delivery reliability both affect service value, while Anwer AL-Shboul, (2022) shows the role of delivery reliability in supply chain responsiveness.

This bridge is also relevant to process innovation. The present paper does not claim radical innovation or new product development. Its innovation angle is modest and process-oriented: a better-structured scheduling process can improve how work is sequenced, monitored, and coordinated. This interpretation is compatible with the earlier service-delivery innovation perspective of (Chen et al., 2009), while recent studies show that digital and analytical approaches are increasingly being used to improve schedule visibility and control (Guo et al., 2022; Lee et al., 2022). The present study deliberately retains a conventional CPM approach because the contribution lies in the transparency and managerial interpretation of the case rather than in introducing a new algorithm.

Prior CPM studies on residential construction have demonstrated the practical importance of planning quality, time optimization, and acceleration scenarios. Indonesian studies report critical-path identification and potential time savings in housing projects (Aprillia et al., 2023; Perdana & Sari, 2022; Rakasyiwi et al., 2022), while more recent studies in Samarinda report similar benefits for residential construction (Ningsih et al., 2025). Research on CPM and crashing in subsidized housing further illustrates the managerial interest in shortening project duration . Yet many studies remain tool-centered and report durations or savings without fully exposing the network logic. Accordingly, the present study combines a transparent package-level CPM presentation with an operational interpretation grounded in delivery reliability. Temuan tersebut melanjutkan bukti dari studi perumahan sebelumnya yang menggunakan PERT/CPM untuk optimasi waktu dan biaya (Wardani et al., 2018) serta studi yang membahas keterbatasan implementasi CPM.

3. Research Methodology

This study uses a descriptive case-study design. The empirical case is a Type 36 house project in Samarinda, Indonesia. The case was selected because it represents a practical affordable-housing project with a clearly defined scope, identifiable work packages, and accessible schedule information. The research focuses on time analysis rather than on cost, financing, or customer-satisfaction measurement.

The data are project-based primary data. They were obtained from direct field observation, interviews with the project manager, and project schedule records used in implementation planning. The project manager provided the normal-duration and accelerated-duration estimates for the main work packages. The owner had already secured the core building materials, which is relevant because material readiness affects the feasibility of acceleration.

To address the reviewer concern about replicability, the revised article expresses the case as a package-level CPM network. The original project records grouped activities into broad work packages and allowed partial overlap in site execution. Therefore, the duration values shown in the work-package table are managerial package durations and are not directly additive as simple finish-to-start chains. For transparency, the revised analysis reports the immediate predecessors, package-level network logic, elapsed-day schedule windows, forward and backward pass results, and slack values used to interpret the critical structure.

The accelerated scenario was derived from project-manager estimates under the assumption that the scope and quality target remained unchanged, material availability remained secured, and tighter coordination, earlier task hand-offs, and limited overtime were feasible. Thus, the accelerated scenario should be interpreted as a managerial compression scenario rather than as a formal crash-cost optimization model. The analytical steps were as follows: identification of work packages, specification of package-level predecessors, construction of the CPM network, estimation of earliest and latest schedule windows, identification of slack, and comparison of the normal and accelerated elapsed-time schedules.

The study is subject to three boundaries. First, it is a single-case analysis, so the result is analytically informative rather than statistically generalizable. Second, the paper focuses on time efficiency and delivery reliability, not cost trade-offs. Third, the operational interpretation remains indirect because customer perceptions were not collected. These limits are acknowledged in order to keep the claims consistent with the available evidence.

4. Result And Discussion

4.1 Result

The project consisted of eleven major work packages, from preparatory work to electrical finishing. Table 1 reports the normal and accelerated package durations collected from the project manager. These values represent managerial package durations. Because some packages overlap in field execution, the total elapsed project duration is shorter than the simple arithmetic sum of all package durations. For that reason, the elapsed-day CPM schedule is presented separately in Tables 3 and 4.

The pattern in Table 1 shows that the largest nominal time reductions occur in concrete work, wall work, ceiling installation, and door-window installation. This suggests that schedule compression is not distributed evenly across all activities. Instead, acceleration depends on selected work packages where coordination, crew deployment, and earlier hand-offs are feasible.

Table 2 presents the immediate predecessor structure used in the revised package-level network. The logic is intentionally transparent and conservative. Concrete work branches into floor work and wall work. Wall work then becomes the main point from which frame installation, roof work, and sanitation coordination are organized. Final electrical work is positioned after the key completion packages are ready. Figure 1 visualizes this network and highlights the critical structure used in the revised analysis.

Table 1. Work-package durations used in the case analysis

Code	Work Package	Normal Duration (days)	Accelerated Duration (days)
A	Preparatory work	14	10
B	Earthworks, backfill, and foundations	41	30
C	Concrete work	62	40
D	Floor work	58	48
E	Wall work	48	37
F	Door and window frames and leaves	32	22
G	Locking work and accessories	13	10
H	Ceiling installation work	36	25
I	Roof work	17	14
J	Sanitation work	23	18
K	Electrical work	16	12

Note: The duration values are project-manager package estimates. They are not directly additive because several work packages partially overlap in field execution. The elapsed-day CPM schedules are therefore reported separately in Tables 3 and 4.

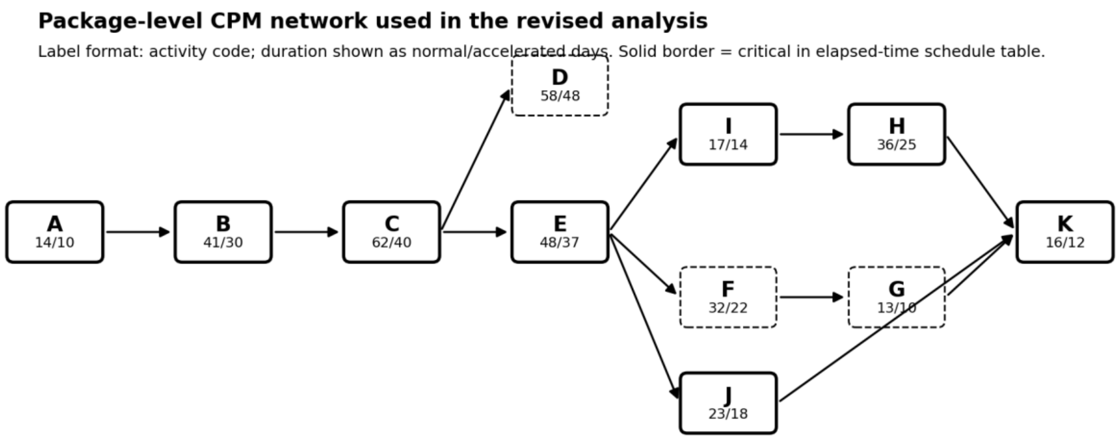
Table 2. Immediate predecessors used in the revised package-level CPM network

Code	Work Package	Immediate Predecessor(s)	Interpretive Logic
A	Preparatory work	-	Project start
B	Earthworks, backfill, and foundations	A	Starts after site preparation
C	Concrete work	B	Begins when the foundation stage is sufficiently ready
D	Floor work	C	Can proceed after concrete readiness
E	Wall work	C	Starts after the main structural concrete stage
F	Door and window frames and leaves	E	Installed after wall progress allows framing
G	Locking work and accessories	F	Follows frame installation
I	Roof work	E	Starts once wall progress allows roof installation

H	Ceiling installation work	I	Follows roof-readiness sequence
J	Sanitation work	E	Coordinated after wall progress and service access
K	Electrical work	G, H, J	Final electrical completion after key finishing packages

Note: The predecessor table represents the package-level network used for analytical transparency. It simplifies detailed daily site logs into a CPM structure that can be reproduced and discussed in a journal setting.

Figure 1. Revised package-level CPM network



The normal schedule results are shown in Table 3. The package-level CPM table indicates a project completion horizon of 180 days. The critical structure is concentrated in A-B-C-E-I-H-K, while the E-J-K branch also reaches the same project finish and therefore behaves as a parallel critical branch. By contrast, floor work (D), frame installation (F), and locking work (G) have positive float and can absorb limited delay without immediately extending the final completion date.

Table 3. Forward-backward schedule results for the normal scenario (elapsed days from project start)

Code	ES	EF	LS	LF	Slack	Critical?
A	0	14	0	14	0	Yes
B	14	55	14	55	0	Yes
C	35	97	35	97	0	Yes
D	85	143	97	155	12	No
E	97	145	97	145	0	Yes
F	118	150	132	164	14	No
G	150	163	151	164	1	No
I	111	128	111	128	0	Yes
H	128	164	128	164	0	Yes
J	141	164	141	164	0	Yes
K	164	180	164	180	0	Yes

Note: Day 0 marks the documented start of the project. The normal scenario yields an elapsed completion horizon of 180 days. Activities D, F, and G retain positive float, while the E-I-H-K and E-J-K branches both reach the final completion date and therefore form the critical structure at the package level.

The accelerated schedule results are shown in Table 4. Under the compressed scenario, the project duration decreases to 123 days. The same managerial logic is preserved, but earlier hand-offs and shorter package durations reduce the elapsed schedule significantly. The critical structure remains concentrated around the preparatory, structural, wall, roof-ceiling, sanitation, and electrical packages, while noncritical activities still retain limited float.

Table 4. Forward-backward schedule results for the accelerated scenario (elapsed days from project start)

Code	ES	EF	LS	LF	Slack	Critical?
A	0	10	0	10	0	Yes
B	10	40	10	40	0	Yes
C	20	60	20	60	0	Yes
D	52	100	55	103	3	No
E	60	97	60	97	0	Yes
F	75	97	79	101	4	No
G	99	109	101	111	2	No
I	72	86	72	86	0	Yes
H	86	111	86	111	0	Yes
J	93	111	93	111	0	Yes
K	111	123	111	123	0	Yes

Note: The accelerated scenario combines shorter package durations with tighter managerial coordination and earlier hand-offs under unchanged project scope. The elapsed completion horizon is reduced to 123 days.

Table 5 summarizes the difference between the two scenarios. The reduction from 180 days to 123 days yields a saving of 57 days, equivalent to 31.7 percent. For a small housing project, that saving is operationally meaningful because it improves schedule visibility, allows tighter supervision of high-risk packages, and can support more dependable handover performance.

Table 5. Comparison of the normal and accelerated schedules

Indicator	Normal Scenario	Accelerated Scenario	Change
Project completion horizon	180 days	123 days	57 days faster
Percentage reduction	-	-	31.7%
Dominant critical structure	A-B-C-E-I-H-K and E-J-K	A-B-C-E-I-H-K and E-J-K	Maintained
Activities with positive float	D, F, G	D, F, G	Still noncritical

4.2 Discussion

The first implication of the findings is that critical-path control matters specifically in affordable housing because such projects operate within tight coordination margins. A delayed completion date can affect resource redeployment, financing or installment timing, and the credibility of promised handover dates. Recent evidence shows that delays are associated with multiple interacting causes, including planning and scheduling, materials, financial issues, change orders, and communication (Gómez-Cabrera et al., 2024; Tariq & Shujaa Safdar Gardezi, 2023). In this setting, CPM is useful not simply because it calculates time, but because it helps managers distinguish work packages that require continuous protection from activities that retain limited slack.

The second implication concerns internal coordination. Once the critical structure is visible, managerial decisions become more focused. In the present case, supervision can be concentrated on preparatory work, earthworks and foundations, concrete work, wall work, roof-ceiling sequencing, sanitation coordination, and final electrical completion. Material arrival can be timed more carefully for critical packages, and crew allocation can be adjusted so that noncritical delays do not migrate into the critical structure. This interpretation is consistent with recent evidence that planning is a central project-control activity and that effective control practices are associated with better construction performance (Tukundane & Yang, 2024). Research on construction constraints likewise shows that constraints can directly impede progress toward project goals (Masoetsa et al., 2022).

The third implication is conceptual. Existing housing CPM studies commonly present schedule results as technical outputs. The present study shows that the same evidence can also be interpreted through an operations lens: better schedule control supports the operational conditions required for more reliable delivery. This interpretation is consistent with research demonstrating the importance of schedule reliability and planning reliability in construction production systems (Kim et al., 2021; Zhang & Wang, 2023). The claim remains deliberately conservative because customer perceptions, satisfaction, and market outcomes were not measured in this case. Hasil ini juga dapat dibaca bersama penelitian lokal mengenai pengendalian waktu dan biaya proyek menggunakan CPM (Ekowati et al., 2024) (Saputra et al., 2024) dan studi perencanaan proyek rumah kecil di Samarinda oleh Surahman et al., (2024) The house construction project was carried out in a span of 120 days involving 6 people. Data processing is carried out to ensure the smooth implementation of the project in accordance with the predetermined plan. By using the literature study method and secondary data processing, this study aims to develop an effective and efficient house construction project management plan, the method used in this project planning is the CPM critical path method (Critical path method). The project is carried out by 6 people, all materials such as sand, stone, cement and wood have been prepared in advance by the project owner. The information used in this analysis is based on direct interviews between the project owner and the researcher. Thus, the main conclusion is that effective and efficient project management, including careful budget planning and good control, is very important in ensuring the success of house construction. By maintaining a balance between time, budget, and quality, and applying the latest management techniques, the house construction project can be completed well in accordance with the set plan. The house construction project was carried out in a span of 120 days involving 6 people, with Mr. Ardiansyah in charge of project management. All materials such as sand, stone, cement, and wood have been prepared in advance by the project owner, ensuring the availability of construction materials during implementation. Normal and quick duration work network analysis is used to understand the sequence of construction activities, fastest duration, and normal duration of each project activity. By utilizing the CPM method, the critical path of the shophouse construction project can be identified to calculate the estimated project completion time and the minimum duration required (Surahman et al., 2024).

The discussion also clarifies the novelty of the study. The novelty does not lie in inventing a new CPM model. Rather, it lies in making a standard CPM case more transparent and analytically useful for business and operations audiences. Compared with prior local housing papers that mainly report durations and final savings, this article explicitly presents package predecessors, network logic, forward and backward schedule windows, and float information. Recent CPM studies demonstrate continuing practical use of the method in housing and other construction settings (Asrul et al., 2025; Ningsih et al., 2025). The contribution of the present case is therefore the combination of transparent schedule reconstruction and a delivery-reliability interpretation.

At the same time, the implication of the paper should not be overstated. The study shows that CPM improves time-efficiency analysis and provides a basis for supporting delivery reliability. It does not demonstrate customer satisfaction, service-quality perception, or marketing outcomes. Nor does the accelerated scenario constitute a formal crash-cost optimization model. Future research should therefore integrate cost acceleration, cash-flow consequences, schedule-risk analysis, and customer-facing measures such as perceived handover reliability or trust in the developer. Recent work on schedule-delay risk and alternative schedule-control approaches indicates useful directions for extending deterministic CPM analysis (Anastasiu et al., 2023; Zhang & Wang, 2023).

5. Conclusion

This study analyzed a Type 36 house project in Samarinda through a revised and more transparent CPM presentation. The package-level analysis shows that the normal schedule horizon of 180 days can be reduced to 123 days under an accelerated managerial scenario, producing a time saving of 57 days or 31.7 percent. The revised presentation also shows where the critical structure is concentrated and which activities retain limited float.

The practical contribution is that affordable-housing providers can use CPM not only to calculate project time but also to strengthen delivery reliability through better supervision and coordination of critical packages. The study therefore supports a conservative but useful claim: schedule discipline improves time-efficiency analysis, and better schedule control supports more reliable delivery in housing provision. Further research is needed to integrate crash-cost analysis and customer-facing outcomes so that the operational benefits of schedule reliability can be evaluated more comprehensively.

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