JOURNAL OF MARKETING INNOVATION AND BUSINESS RESEARCH
E-ISSN: 3163-5474
Volume: 01, (2), 2026
Homepage: https://ojs.polnes.ac.id/index.php/jmibr
Research Article
JOURNAL OF MARKETING, INNOVATION, AND BUSINESS RESEARCH
Page: 244-260

Implementation of the Critical Path Method (CPM) for the Schedule of a Type 63 Residential House Construction Project in Samarinda

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Article History

Received:
29 July 2026

Accepted:
27 August 2026

Published:
31 August 2026

Abstract

Small residential contractors in Indonesia often use manual bar charts that indicate planned work periods but do not identify activities controlling project completion. This study applies the Critical Path Method (CPM), operationalised in Microsoft Project, to construct and verify a baseline schedule for a Type 63 single-storey residential house in Samarinda, East Kalimantan. A single-case quantitative design was used, with secondary data from the Cost Budget Plan (RAB), working drawings, bill of quantities, and the original bar-chart schedule, supported by field observation and a semi-structured interview with the project manager. The project was decomposed into 13 work packages and 79 activities. Durations were estimated from work volumes and labour-productivity coefficients, while activity dependencies were validated against technical drawings and confirmed by the project manager. Forward and backward pass calculations were performed manually and verified in Microsoft Project using Earliest Start, Earliest Finish, Latest Start, Latest Finish, Total Float, critical path, and total duration. The verified baseline duration is 105 days, with a critical path comprising 28 activities from site clearing and bouwplank installation through foundation, structural, roofing, ceiling, and finishing works to key handover. Critical activities have zero total float; therefore, a three-day delay extends the project to 108 days, while a seven-day delay extends it to 112 days. Non-critical activities, such as the septic-tank and door and window frame packages, have sufficient float for rescheduling without affecting completion. The study also reconciles the original planning documents, where a 90-day headline figure conflicted with the detailed 105-day schedule. The contribution is an auditable and reproducible scheduling procedure that enables small residential contractors to identify activities requiring the closest supervision.

Keywords: *Critical Path Method, Baseline Schedule, Total Float, Microsoft Project, Residential Construction, Samarinda*

1. Introduction

Residential construction is one of the most active segments of the Indonesian construction industry, and a substantial share of it is delivered by small contractors and owner-builders who operate with limited managerial infrastructure. Demand for landed housing in growing regional cities such as Samarinda continues to be driven by population growth, migration linked to resource and administrative activity, and the ongoing development of East Kalimantan. In this segment the technical quality of the building is usually acceptable, because the trades involved are traditional and well understood, but the management of time is frequently weak. Projects are planned with a bar chart drawn from experience, progress is tracked informally, and the reasons for a delay are usually identified only after the delay has already occurred (Alicia et al., 2023; Rafiqa Fijra, Anindita Rahmalia Putri, Fahrurrozi Mawasandi, 2025; Sa & Rijanto, 2021).

The consequence of weak time management is not merely inconvenience. For an owner-builder, a delay postpones occupation and prolongs the payment of rent elsewhere. For a small contractor, a delay ties up crews and working capital that were committed to the next project, and it damages the reputation on which future work depends. Studies of construction delay in Indonesia consistently identify planning weakness, material-supply interruption, and labour-allocation problems as leading causes, and they note that these causes are frequently interrelated: an unrealistic plan produces late material orders, which in turn produce idle crews (Annisa Nur Khofifah, 2025); (Lestari et al., 2022). What the bar chart cannot do is tell the site supervisor which of the many concurrent activities actually determines the finish date, and therefore which one deserves attention first when resources are scarce.

The Critical Path Method addresses exactly this gap. Developed by (JAMES E. KELLEY, 1959) for industrial maintenance planning, CPM models a project as a network of activities connected by dependency relationships, then computes for every activity an Earliest Start (ES), an Earliest Finish (EF), a Latest Start (LS), and a Latest Finish (LF). The difference between the latest and earliest dates is the total float, which measures how long an activity may be delayed without delaying the project. Activities with zero total float form the critical path: the longest sequence through the network, and the sequence that fixes the project duration. The method converts an opaque schedule into an explicit statement about where delay risk is concentrated.

CPM has been applied widely in Indonesian construction research. (Venn Y. I. Ilwaru, Dorteus L. Rahakbauw, 2018) used it to schedule a housing development, (Alicia et al., 2023) evaluated time scheduling for a house construction project in Karawang, and (Rafiqa Fijra, Anindita Rahmalia Putri, Fahrurrozi Mawasandi, 2025) applied it to a housing project to improve project-management efficiency. Others have combined CPM with PERT to handle duration uncertainty (Abdul et al., 2020); (M. S. A. Perdana & Sari, 2022) or with crashing analysis to evaluate acceleration (Sa & Rijanto, 2021). Collectively this literature demonstrates that network scheduling identifies a critical path and, in many cases, a duration shorter than the original manual plan.

Two limitations recur in this body of work, and they motivate the present study. First, many published applications report an aggregate result, a total duration and a list of critical activity codes, without publishing the underlying activity register in a form that allows the computation to be reproduced or audited. A reader cannot verify a critical path that is asserted rather than shown. Second, several studies report internally inconsistent figures, in which a headline duration in the abstract or conclusion does not match the schedule computed in the results, and the discrepancy is left unexplained. Both problems reduce the practical value of the analysis for the contractor who is expected to act on it.

The case examined here exhibits precisely the second problem in its original planning documents. The project is a Type 63 single-storey residential house in Samarinda. Its original documentation carried a headline duration of 90 days, while the detailed activity schedule prepared in Microsoft Project computes to a longer duration once the dependency network is followed through to the handover milestone. The same documentation reported the preparatory work package as 89 days, a figure that is implausible for physical preparatory work on a house of this size and that invited the reasonable objection that a data-entry error had occurred. Rather than discard these figures, this study treats them as the object of analysis: the reconciliation of the reported numbers is itself a contribution, because the same confusion is common in small-project schedules and is rarely explained in the literature.

Accordingly, the objective of this study is to construct and verify a reproducible CPM baseline schedule for the case project, to identify its critical path and float profile, and to reconcile the contradictory durations in the original documentation. The research questions are: (1) what is the verified baseline duration of the Type 63 house when the full activity network is computed and checked in Microsoft Project; (2) which activities constitute the critical path and therefore control delivery; (3) how sensitive is the completion date to delay on those activities; and (4) how can the reported 90-day and 89-day figures be reconciled with the computed schedule?

The scope of the study is deliberately restricted to baseline time scheduling. Verified daily-wage records, a cost baseline, and actual expenditure data were not available for this owner-built case, so no claim is made regarding cost saving, cost control, earned-value performance, or schedule crashing. The contribution is methodological and managerial: a transparent scheduling procedure, published together with its complete activity register, and an interpretation that tells a small contractor which activities to supervise most closely.

2. Literature Review

Project scheduling theory distinguishes between representations that show intent and representations that show logic. A bar chart, sometimes called a Gantt chart, places activities against a calendar and communicates intent effectively, which explains its persistence in practice. What it does not encode is the dependency structure between activities. Two bars that overlap on a bar chart may be genuinely independent, or one may be strictly required before the other; the chart is silent on the difference. Network-based methods encode that structure explicitly and can therefore compute consequences, which is why they remain the foundation of modern scheduling practice (PMI, 2021; (Kerzner, 2017).

CPM represents the project as an activity network in which each node is an activity with a deterministic duration and each arc is a precedence relationship, most commonly finish-to-start (Abdul et al., 2020; Fijra et al., 2025; M. S. A. Perdana & Sari, 2022; Surahman et al., 2024). The forward pass propagates earliest dates from project start to project finish, and the backward pass propagates latest dates from finish back to start. Total float is the difference between the two, and the set of activities with zero total float forms the critical path.

It is important to distinguish the several float measures, because they support different decisions (Abdul Nabi & El-adaway, 2021; Alhady et al., 2025; Gómez-Cabrera et al., 2024). Total float measures the delay an activity can absorb without delaying project completion. Free float measures the delay it can absorb without delaying its immediate successor. An activity may have substantial total float but no free float, in which case using that float will immediately disturb the next trade even though the finish date is unaffected. For a small residential site where the same crew moves between activities, this distinction determines whether float can actually be used in practice or exists only on paper.

CPM is deterministic, which is both its strength and its principal limitation (Ningsih et al., 2025; M. A. Perdana & Sari, 2022; Wardani et al., 2018). Each activity is assigned a single duration, so the computation is transparent and reproducible, but the method cannot express uncertainty in that duration. PERT addresses this by combining optimistic, most likely, and pessimistic estimates into an expected duration and a variance, allowing probabilistic statements about the completion date. (Abdul et al., 2020) and (M. S. A. Perdana & Sari, 2022) demonstrate the combination on Indonesian projects and report that PERT widens the picture without displacing CPM, since the critical path itself is still identified by network logic. A second limitation is that classical CPM assumes unlimited resources: it computes what the technological sequence permits, not what the available crews can actually deliver. When one crew must perform two activities that the network shows as concurrent, the computed schedule is optimistic, and resource levelling is required to correct it. A third limitation is that CPM as applied here models only finish-to-start relationships without leads or lags, which is a simplification of site practice where trades often overlap partially. These limitations bound the claims that can legitimately be made from a CPM result, and they are stated here so that the findings of this study are read with the appropriate qualification.

Empirical applications in the Indonesian residential and building context are numerous. (Venn Y. I. Ilwaru, Dorteus L. Rahakbauw, 2018) scheduled a housing development project and identified the critical sequence through the structural trades. (Alicia et al., 2023) evaluated time scheduling for a house construction project at Perumnas Karawang and found that network analysis produced a shorter and better justified duration than the contractor original plan. Analysed construction time control with CPM and emphasised the role of the method in monitoring rather than only in planning. (Mulia & Candra, 2023) applied CPM to a public-works gate project, and (Sinurat & Misdalena, 2024) and (Saputra et al., 2024) applied it to building projects with an explicit focus on control. (Zareei, 2018) provides an international comparison outside the building sector, scheduling a biogas plant and reporting a substantial reduction against the original plan. (Rafiqa Fijra, Anindita Rahmalia Putri, Fahrurrozi Mawasandi, 2025) is the most directly comparable recent work, applying CPM to a housing project and framing the outcome as an efficiency improvement in project management.

A related strand examines why projects are late in the first place. (Lestari et al., 2022) analysed delay factors in a school building project and grouped them into planning, resource, and external categories. (Annisa Nur Khofifah, 2025) reviewed causes of construction delay and their mitigation, noting that mitigation is only possible when the schedule identifies where slippage matters. (Hoon & Sang, 2026) quantify the schedule impact of design changes in finishing work, which is relevant here because finishing activities occupy the closing segment of the critical path in many residential projects. (Qi et al., 2024) provide a systematic review of construction labour-productivity research, which is the empirical basis for converting work volumes into durations and therefore underpins the duration-estimation step of any CPM study.

Baseline scheduling and progress control of residential projects in Microsoft Project and argue that the software contributes reliability rather than insight: it removes arithmetic error from the forward and backward pass and it maintains consistency when the network is revised, but the quality of the result still depends on the correctness of the durations and the dependency logic entered by the planner.

It is sometimes suggested in the applied literature that adopting network scheduling confers a competitive advantage on a small contractor. That proposition is plausible as a theoretical argument, since a contractor able to commit to a defensible delivery date can price and bid more confidently, and it is treated in this paper strictly as literature context. It is not a finding of the present study. No competitive, financial, or market-performance variable was measured here, and no causal claim linking scheduling practice to firm performance is made or implied.

Table 1 positions the present study against representative prior work on the dimensions that matter for reproducibility: the case object, the method applied, the software used, the duration outcome reported, and whether the critical path and the underlying activity register were published in a form a reader can audit.

Table 1. Positioning of the present study against representative prior CPM research

No	Study (Year)	Case Object	Method	Software	Duration Result	Critical Path Reported	Gap / Contribution
1	Ilwaru et al. (2018)	Housing development	CPM	Manual	Shorter than plan	Yes	Full register not published
2	Abdul et al. (2020)	General project	CPM + PERT	Manual	Expected duration	Yes	Probabilistic, no residential case
3	Sa & Rijanto (2021)	Hospital building	CPM + crashing	MS Project	Accelerated	Yes	Crashing needs cost data
4	Perdana & Sari (2022)	Residential project	CPM + PERT	Manual	Reduced duration	Yes	No float profile reported
5	Alicia et al. (2023)	House, Perumnas Karawang	CPM	Manual	Shorter than plan	Yes	Single aggregate figure only
6	Rafiqa Fijra et al. (2025)	XYZ housing project	CPM	MS Project	Efficiency gain	Yes	Register not reproducible
7	This study	Type 63 house, Samarinda	CPM, manual + software check	MS Project	105 days (verified)	Yes	Full 79-activity register published; 90 vs 105 day contradiction reconciled

Source: Processed Data (2026)

Two observations follow from Table 1. First, almost every prior study reports a duration and a critical path, but few publish the activity register that would allow the computation to be repeated; the reader is asked to accept the result. Second, none of the reviewed studies addresses the situation in which the source documents themselves carry contradictory durations, even though this is a common condition in small-project practice. The research gap addressed here is therefore twofold. Methodologically, the gap is reproducibility: this study publishes the complete activity register with durations, predecessors, and all four schedule dates, so that any reader can reconstruct the forward and backward pass independently and arrive at the same critical path. Substantively, the gap is reconciliation: this study explains, rather than silently corrects, why the original documentation reported 90 days and an 89-day preparatory package, and it shows that the second figure is a summary span produced by a level-of-effort activity rather than an error of data entry. Addressing both gaps is what allows the resulting baseline to be defended to an owner, a lender, or a reviewer.

3. Research Methodology

This study uses a quantitative approach with a single-case study design. The object of the research is the construction schedule of a Type 63 single-storey residential house located in Samarinda, East Kalimantan. The unit of analysis is the individual project activity, characterised by its duration, its predecessor relationships, and its computed schedule parameters. A single-case design is appropriate because the objective is a deep and verifiable reconstruction of one project network, together with the reconciliation of the contradictions in its planning documents, rather than a statistical generalisation across a population of projects.

The research was carried out in seven sequential stages: data collection; construction of the Work Breakdown Structure; duration estimation; dependency validation; CPM calculation; verification in Microsoft Project; and validation of the result with the project manager. The complete research flow is presented in Figure 1.

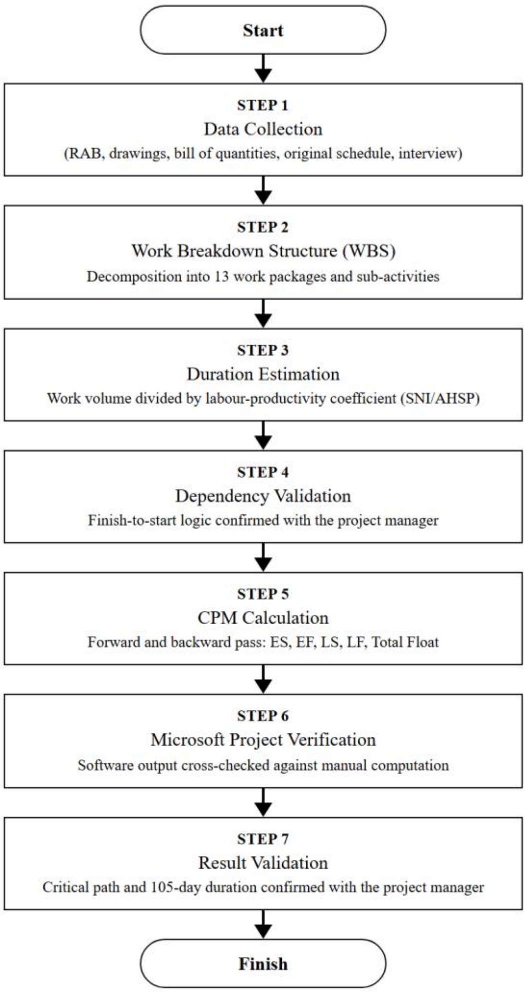

Figure 1. Research flow of the study, from data collection through CPM calculation and Microsoft Project verification to result validation.

Data collection combined secondary and primary sources. The secondary documents comprised the Cost Budget Plan (Rencana Anggaran Biaya, RAB), the working drawings and structural details, the bill of quantities, and the owner original bar-chart schedule. The primary data were obtained through direct field observation during the construction window and one semi-structured interview with the project manager, who has more than ten years of experience in residential construction in Samarinda. The interview covered four topics: the realistic duration of each activity given the crew actually assigned, the technological sequence that governs the order of the work, the crew composition for each trade, and the operational constraints most frequently encountered on site, particularly material delivery and the availability of skilled workers.

The Work Breakdown Structure decomposes the project into 13 work packages: preparatory work (A); excavation and landfill (B); masonry and plastering (C); concrete work (D), itself subdivided into sloof, practical columns, ring beam, and front terrace; roofing and ceiling (E); door and window frames (F); flooring and ceramics (G); hanging and locking hardware (H); electrical and water installation (I); finishing (J); septic tank and infiltration (K); other jobs (L); and the key-handover milestone (M). These packages are further decomposed into 79 scheduled activities, the complete list of which is published in Appendix A.

Activity durations were estimated by dividing the work volume recorded in the bill of quantities by the standard labour-productivity coefficient for the crew assigned to that activity, following the Indonesian analysis-of-unit-price framework. The coefficients used are those published in SNI 7394:2008 for concrete and related structural work and in the Analisa Harga Satuan Pekerjaan (AHSP) schedules issued under Permen PUPR No. 1/PRT/M/2022 for the remaining trades (Badan Standardisasi Nasional, 2008; (Pekerjaan et al., 2022). The general form of the estimate is that the duration in days equals the work volume divided by the product of the daily output coefficient and the number of workers assigned. Each resulting duration was then cross-checked in two ways: against the duration recorded for the same activity in the owner original schedule, and against the project manager field estimate obtained in the interview. Where the three sources disagreed, the project manager estimate was adopted, because it reflects the crew actually deployed on this site, and the difference was noted. This triangulation is consistent with the productivity literature reviewed by (Qi et al., 2024), which stresses that published coefficients are population averages and require local calibration.

Dependency validation determined the predecessor of every activity. The procedure had three steps and drew on specific reference documents. First, a provisional predecessor list was derived from the technological logic evident in the structural drawings and the sequence implied by the bill-of-quantities ordering: no element may be constructed before the element that physically supports it, so the sloof follows the foundation, the practical columns follow the sloof, the brick masonry follows the columns, the ring beam follows the masonry, and the roof structure follows the ring beam. Second, the provisional list was reviewed activity by activity with the project manager against the architectural and mechanical drawings, which resolved the cases where the drawings alone are ambiguous, in particular the point at which electrical conduit is installed relative to the ceiling frame, and the point at which door and window frames are set relative to the masonry. Third, the resulting network was checked for terminal branches. In the original data, several packages, including electrical and water installation, septic-tank work, and hanging and locking hardware, terminated without reconnecting to the handover milestone, which would have permitted the project to be reported as complete while essential works were still unfinished. Each of these branches was reconnected as a predecessor of the final cleaning and handover activities, so that the network correctly represents a habitable and fully serviced house at the point of handover. Only finish-to-start relationships were used, with no leads or lags.

The CPM calculation uses inclusive day numbering, in which Day 1 is the first working day and an activity occupies whole days from its Earliest Start to its Earliest Finish. The forward pass computes ES equal to the latest EF among the predecessors plus one, and EF equal to ES plus the duration minus one. The backward pass computes LF equal to the earliest LS among the successors minus one, and LS equal to LF minus the duration plus one. Total float is TF equal to LS minus ES, which is identically equal to LF minus EF, and an activity is critical when its total float equals zero. As a worked example, activity B.1, foundation soil excavation, has a duration of two days and follows A.3; since A.3 finishes on day 3, B.1 has ES equal to 4 and EF equal to 4 + 2 - 1 = 5.

The network was then entered into Microsoft Project and the software output was compared against the manual computation. The verification was not limited to the total duration. Seven parameters were checked explicitly for every activity on the critical chain and for a sample of float-bearing activities: Earliest Start, Earliest Finish, Latest Start, Latest Finish, Total Float, membership of the critical path, and the total project duration. Agreement on all seven was required before the schedule was accepted. Microsoft Project was configured with a continuous seven-day project calendar reflecting the small-crew owner-built operation, eight working hours per day, no artificial constraints, and no public-holiday exclusions within the observation window; because the calendar contains no non-working days, working days and calendar days coincide for this project. Finally, the computed critical path and the 105-day duration were presented to the project manager for confirmation that the sequence and the result correspond to the way the work was actually executed on site.

4. Result And Discussion

The reconstructed network contains 79 scheduled activities distributed across 13 work packages and converges on a single key-handover milestone. The forward and backward pass produces a verified baseline duration of 105 days, and the manual computation agreed with the Microsoft Project output on all seven verification parameters. Table 2 summarises the result at work-package level.

Table 2. Work-package summary of the verified baseline schedule (durations in days)

ID	Work Package	No. of Act.	Package Start (day)	Package Finish (day)	Package Span (days)	Critical Activities	Status
A	Preparatory Work	4	1	89	89	3	On critical path
B	Excavation & Landfill	4	4	30	27	1	On critical path
C	Masonry & Plastering	5	6	82	77	3	On critical path
D	Concrete Work	12	20	80	61	9	On critical path
E	Roofing & Ceiling	6	74	97	24	6	On critical path
F	Door & Window Frames	4	43	51	9	0	Float (min TF = 50)
G	Flooring & Ceramics	2	83	88	6	0	Float (min TF = 11)
H	Hanging & Locking	7	50	53	4	0	Float (min TF = 50)
I	Electrical & Water Installation	13	87	95	9	0	Float (min TF = 8)

J	Finishing	4	98	103	6	4	On critical path
K	Septic Tank & Infiltration	16	4	23	20	0	Float (min TF = 80)
L	Other Jobs	1	104	104	1	1	On critical path
M	Key Handover (Milestone)	1	105	105	0	1	Milestone

Source: Processed Data (2026)

An important clarification follows directly from Table 2. The figures in the package-span column are spans, measured from the earliest start of the first member activity to the latest finish of the last one, and they are not the sum of the member durations. This distinction explains the 89-day preparatory package that appeared in the original documentation and that a reader could reasonably have taken for a data-entry error. Preparatory work contains three short physical activities, namely site clearing, bouwplank installation, and work-water provision, each of one day, together with a fourth activity, administration and documentation, that runs for 88 days alongside the physical work. Administration is a level-of-effort activity: it is not a construction task that must be completed before the next trade can begin, but a continuous supervisory obligation that spans most of the project. Because Microsoft Project reports a summary bar as the span of its members, the preparatory package is displayed as 89 days even though the physical preparatory work occupies only the first three days. The same mechanism explains the 77-day span of the masonry package and the 61-day span of the concrete package, both of which contain activities separated by long intervals during which other trades are working.

The verified critical path comprises 28 activities, all with total float equal to zero. In sequence it runs: site clearing (A.1), bouwplank installation (A.2), and work-water provision (A.3) in the preparatory package; foundation soil excavation (B.1); aanstamping (C.1) and the mountain-stone foundation (C.2); the sloof reinforcement, formwork, and casting sequence (D.1.a to D.1.c); the practical-column reinforcement, formwork, and casting sequence (D.2.a to D.2.c); brick masonry (C.3); the ring-beam reinforcement, formwork, and casting sequence (D.3.a to D.3.c); the roof and ceiling sequence comprising the light-steel truss (E.1), listplank (E.2), metal roof sheeting (E.3), hollow-iron ceiling frame (E.4), gypsum ceiling board (E.5), and ceiling profile list (E.6); the finishing sequence of wall paint (J.1), ceiling paint (J.2), wood primer (J.3), and wood paint (J.4); final cleaning (L.1); and the key-handover milestone (M) on day 105. Table 3 reports the computed schedule parameters for the critical chain together with representative float-bearing activities.

The complete network is presented in Figure 2, which shows the critical spine together with the float-bearing branches and makes visible that every terminal branch reconnects before the handover milestone. Figure 3 isolates the critical path itself, so that the continuous chain from site clearing to key handover can be read directly; in that figure the earliest and latest start of every node are identical, which is the graphical expression of zero total float. Figure 4 presents the corresponding baseline Gantt chart at work-package level, in which the grey bar is the package span and the black segments are the critical activities inside it.

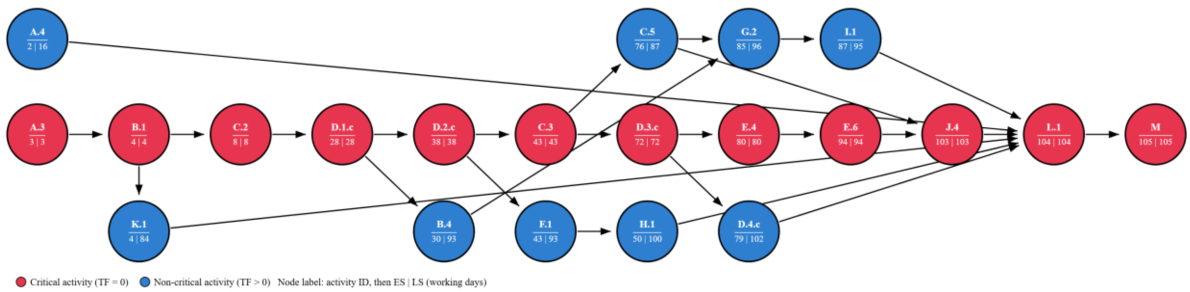

Figure 2. CPM network diagram of the Type 63 house. Critical activities (TF = 0) are shown in red and float-bearing activities in blue; each node reports the activity ID with its earliest and latest start. All terminal branches reconnect at final cleaning (L.1)

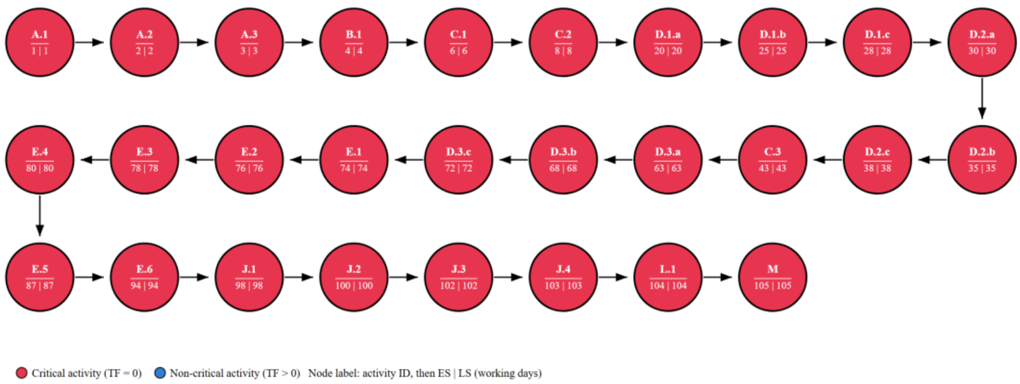

Figure 3. Critical path of the Type 63 house: 28 activities with zero total float, running from site clearing (A.1) to the key-handover milestone (M) on day 105.

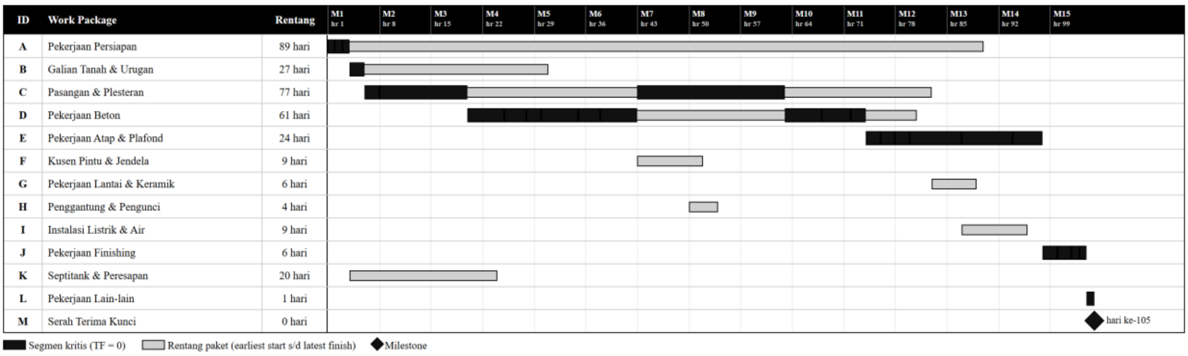

Figure 4. Baseline Gantt chart of the verified 105-day schedule at work-package level. Grey bars show the package span from earliest start to latest finish; black segments show the critical activities within each package.

Reading the critical chain package by package clarifies why it takes the shape it does. The preparatory activities occupy days 1 to 3 and are critical simply because nothing else can begin until the site is cleared and set out. Foundation excavation follows on days 4 to 5, and the foundation sequence of aanstamping and mountain-stone masonry occupies days 6 to 19; the twelve-day stone foundation is the first substantial block of critical time. The sloof sequence runs from day 20 to day 29 and the practical-column sequence from day 30 to day 42, each following the invariable reinforcement, formwork, casting order. Brick masonry then occupies days 43 to 62, the single longest critical activity at twenty days, followed by the ring beam from day 63 to day 73. The roof and ceiling package carries the chain from day 74 to day 97, within which the hollow-iron ceiling frame and the gypsum ceiling board each take seven days. Finishing runs from day 98 to day 103, final cleaning occupies day 104, and handover occurs on day 105.

The float profile is equally informative for management. The septic-tank package carries the largest float in the project: excavation for the septic tank (K.1) can start as early as day 4 but is not required before day 84, a total float of 80 days, because the package is technologically independent of the main structure and only has to be complete before handover. The door and window frame package has a total float of 50 days on the frame timber (F.1) and 52 days on the wind-hook installation (F.4). The front-terrace concrete (D.4.c) carries 23 days of float. Closer to the critical chain, the wall acian (C.5) and the ceramic tiling (G.2) each carry 11 days, and the electrical and water installation (I.1) carries only 8 days, which makes it the nearest of the non-critical packages to becoming critical. The administration activity (A.4) carries 14 days of float, but as a level-of-effort obligation this figure should be interpreted as reporting latitude rather than as an opportunity to reallocate labour.

The status snapshot recorded in Microsoft Project at the observation date is reproduced in Figure 5. At that date the project registered 81 percent physical completion, computed with the physical-weight method in which the completion percentage is the sum of the weighted progress of each work package relative to its planned weight. The snapshot is consistent with the position of the work on the critical chain at that moment: the structural and roofing packages were complete and the ceiling and finishing packages were in progress, which corresponds to a position beyond day 85 on the computed baseline. The overview also records the project window from the start date to the planned finish date used in the software model.

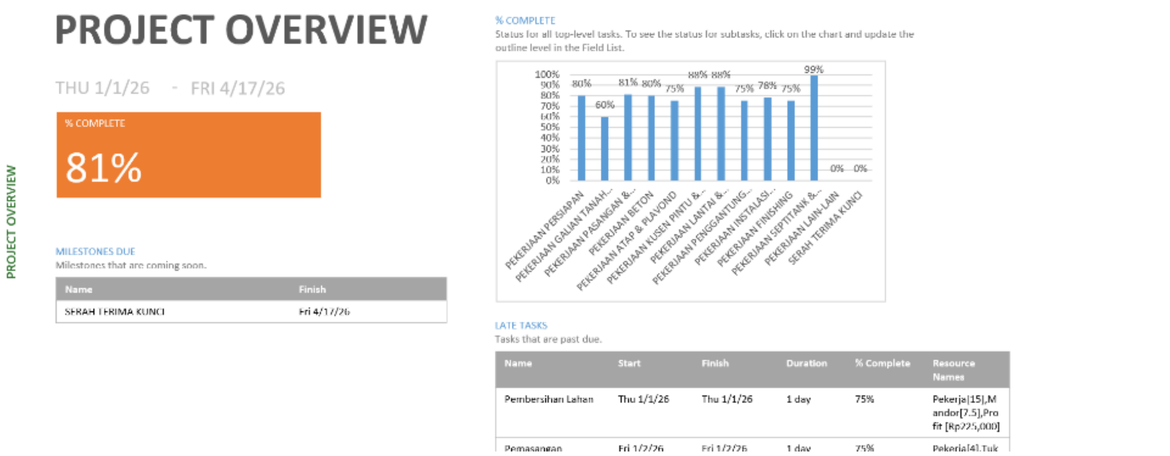

Figure 5. Microsoft Project overview and physical progress snapshot at the stated status date, recording 81 percent completion by the physical-weight method. Source: Microsoft Project output (2026).

Finally, the contradiction in the original documentation can be stated and resolved precisely. The original documents reported a headline duration of 90 days. The detailed activity network, computed through the forward and backward pass and verified in Microsoft Project, gives 105 days. The 15-day difference arises because the 90-day figure was taken from the span of the physical construction trades and did not carry the network through to the point at which every mandatory branch, in particular the electrical and water installation and the septic-tank package, has converged and final cleaning and handover can occur. Once the terminal branches are reconnected, as described in the dependency-validation procedure, the computed duration is

105 days. This study therefore reports 105 days as the single verified baseline, and the 90-day figure is superseded rather than averaged with it.

The central result is not the number 105 but the structure that produces it. The critical path runs through the structural-to-finishing sequence and contains no discretionary activity whatsoever. Every member of the chain is a hard technological predecessor of the next: the sloof cannot be cast before the foundation exists, the practical columns cannot be cast before the sloof has set, the masonry cannot rise before the columns are in place, the ring beam cannot be cast before the masonry reaches its level, the roof structure cannot be erected before the ring beam is complete, the ceiling cannot be fixed before the roof is closed, and painting cannot proceed before the ceiling is installed. This is why the total float on each of these activities is exactly zero and why no amount of resequencing will shorten the project without changing the construction method itself.

That structural reading has a direct managerial consequence. Because the chain is technological rather than administrative, the schedule risk on this project is concentrated in material readiness for a small and identifiable set of trades. The twenty-day brick masonry activity (C.3) is the single longest critical item and therefore the largest exposure: a shortfall in brick or cement delivery during days 43 to 62 translates day for day into a later handover. The three concrete sequences are the next most exposed, and they share a characteristic that deserves emphasis: each consists of reinforcement, formwork, and casting in a fixed order, so a delay in bar-bending capacity early in the sequence cannot be recovered later within the same sequence. The roof and ceiling package concentrates 24 days of critical time in six consecutive activities and depends on the delivery of light-steel truss components and gypsum board, which in Samarinda are typically ordered from suppliers outside the immediate area.

The sensitivity of the completion date to delay was quantified directly from the float profile. Because every critical activity has zero total float, delay on any of them propagates one for one to the finish date. Table 4 sets out the simulation required by the analysis.

Table 3. Delay sensitivity simulation on critical and float-bearing activities

Scenario	Activity Affected	Total Float (days)	Delay Applied (days)	Resulting Project Duration (days)	Effect on Handover
Baseline	None	-	0	105	No change
S1	C.3 Brick masonry (critical)	0	3	108	Delayed 3 days
S2	C.3 Brick masonry (critical)	0	7	112	Delayed 7 days
S3	E.5 Gypsum ceiling board (critical)	0	3	108	Delayed 3 days
S4	E.5 Gypsum ceiling board (critical)	0	7	112	Delayed 7 days
S5	J.1 Wall paint (critical)	0	7	112	Delayed 7 days
S6	K.1 Septic-tank excavation	80	7	105	No change
S7	F.1 Frame timber	50	7	105	No change
S8	I.1 Electrical installation	8	7	105	No change (1 day margin left)
S9	I.1 Electrical installation	8	12	109	Delayed 4 days

Source: Processed Data (2026)

Three conclusions follow from Table 4. First, the one-for-one propagation on critical activities means that schedule protection on this project is not a matter of general vigilance but of targeted vigilance: a three-day slip on brick masonry costs exactly as much as a three-day slip on ceiling board, and both cost three days of handover. Second, equal delays on genuinely float-bearing activities cost nothing at all in schedule terms, which is a strong argument against spreading supervisory attention evenly across the site. Third, and least obvious, float is finite and its consumption changes the critical path: scenario S9 shows that once a delay on electrical installation exceeds its eight days of float, the activity becomes critical and further delay propagates in the ordinary way. Near-critical activities therefore require monitoring even though they are not critical today, and the eight-day float on the electrical package is the narrowest margin in the project.

Comparing these findings with the prior literature reveals both agreement and difference. The agreement concerns the shape of the result. (Venn Y. I. Ilwaru, Dorteus L. Rahakbauw, 2018), (Alicia et al., 2023), and (Rafiqa Fijra, Anindita Rahmalia Putri, Fahrurrozi Mawasandi, 2025) all report that CPM applied to residential projects identifies a critical path dominated by the structural sequence and yields a duration that differs from the contractor manual plan; the present study reproduces exactly that pattern, with a structural critical path and a computed duration that supersedes the original 90-day figure. (M. S. A. Perdana & Sari, 2022) similarly find that the finishing trades close the critical chain in residential work, which matches the position of the painting sequence here. The differences are equally instructive. Most of the cited studies report a duration shorter than the original plan, whereas this study reports one that is longer. The reason is the treatment of terminal branches: where prior work generally accepts the network as given, this study found unconnected branches and reconnected them, which lengthens the computed schedule but makes it a truthful representation of the point at which a habitable house is actually handed over. A further difference concerns reporting. (Alicia et al., 2023) and (Rafiqa Fijra, Anindita Rahmalia Putri, Fahrurrozi Mawasandi, 2025) publish aggregate results; the present study publishes the full register in Appendix A, so the critical path can be verified rather than accepted. Finally, unlike (Sa & Rijanto, 2021) and Zebua and Halim (2023) this study does not extend into crashing or earned-value analysis, because the necessary cost data were not available, and it declines to make claims that the data cannot support.

The reconciliation of the reported figures is worth restating as a finding in its own right, because it has a general lesson. Two apparently anomalous numbers appeared in the original documentation, and neither turned out to be a simple mistake. The 89-day preparatory package is a summary span containing a level-of-effort administration activity, and the 90-day headline is a physical-trade span that stops short of the converged handover point. In both cases the number was a correct answer to a different question. Small-project schedules routinely mix summary spans, activity durations, and level-of-effort obligations in a single table without labelling which is which, and the resulting ambiguity is a recurring source of dispute between owner and contractor. The practical recommendation is that any schedule presented to a client should state explicitly whether each duration is an activity duration or a package span, and should identify level-of-effort activities separately so that they are not read as controlling work.

For small residential contractors and owner-builders, the managerial implications are concrete. The first is prioritisation of supervision: the register identifies 28 activities out of 79 that control the delivery date, so roughly two thirds of the activities on this project cannot cause a delay on their own. Supervision, expediting, and inspection effort should be concentrated on the 28. The second is material scheduling: because the critical path is a chain of hard technological dependencies, the binding constraint is almost always material availability at the moment the preceding activity finishes, so purchase orders should be timed against critical-activity earliest starts rather than against the calendar month. The third is the use of float as a deliberate resource: the 80-day float on the septic-tank package means that work can be moved to whichever week the excavation crew is otherwise idle, and the 50-day float on frame timber allows carpentry to be scheduled around the availability of a single carpenter, which is a common constraint on small sites. The fourth is contractual: a baseline computed and published in this form gives the contractor a defensible position when a delay occurs, because the schedule states in advance which activities were controlling and what their float was.

The findings also carry an implication for progress claims and cash flow. Since the critical path is known, the contractor can align payment milestones with the completion of critical packages rather than with arbitrary calendar dates, which reduces the risk of claiming for work that does not advance the project. The 81 percent physical-completion snapshot illustrates the point: reading it against the baseline shows not merely how much has been done but whether what has been done lies on the chain that determines the finish date.

Several limitations bound these conclusions and should be stated plainly. The study is a single-case design, so the specific durations and the specific critical path are not generalisable to other houses; what is transferable is the procedure. The durations are deterministic single-point estimates, so the result depends on the quality of the input data and carries no probability statement; a PERT or Monte Carlo extension would be required to express the uncertainty. The network models only finish-to-start relationships with no leads or lags, which simplifies the partial overlaps that occur in practice between trades. Classical CPM assumes unconstrained resources, so where one crew is shared between activities that the network treats as concurrent, the computed schedule is optimistic and resource levelling would be required. The project calendar was modelled as continuous, without public holidays or weather stoppages, so working days and calendar days coincide; a calendar with non-working days would extend the elapsed duration without changing the critical path. Finally, verified actual completion data were not collected after the observation window, so the baseline has been validated for internal consistency and against the project manager judgement, but not against a realised outcome.

5. Conclusion

This study applied the Critical Path Method, operationalised in Microsoft Project, to construct and verify a baseline time schedule for a Type 63 residential house in Samarinda. Decomposing the project into 13 work packages and 79 activities, estimating durations from work volumes and labour-productivity coefficients, validating the dependency network with the project manager, and computing the forward and backward pass produced a verified baseline duration of 105 days. The manual computation and the Microsoft Project output agreed on Earliest Start, Earliest Finish, Latest Start, Latest Finish, Total Float, critical-path membership, and total duration.

The critical path comprises 28 activities and runs from preparatory work through excavation, the stone foundation, the sloof and practical-column concrete sequences, brick masonry, the ring beam, the roof and ceiling package, and the finishing trades to final cleaning and key handover. All of these activities carry zero total float, and delay sensitivity analysis confirms that a three-day slip on any of them extends the project to 108 days and a seven-day slip to 112 days, one for one, while equal delays on float-bearing packages such as the septic tank and the door and window frames do not move the completion date at all. The practical significance of this result is that supervision, material expediting, and inspection should be concentrated on the critical activities rather than distributed evenly, and that the near-critical electrical and water package, with only eight days of float, requires monitoring because it becomes critical once that margin is consumed.

The study also reconciles the contradictions in the original planning documents. The verified duration is 105 days, and the previously reported 90-day figure is superseded because it did not carry the network through to the point at which all mandatory branches converge at handover. The 89-day preparatory package was shown not to be a data-entry error but a summary span containing a level-of-effort administration activity running alongside three days of physical preparatory work.

The schedule reported here is a verified baseline. It is not described as optimal and it is not a minimum-cost schedule, since no cost, resource-levelling, or acceleration analysis was performed and no cost, earned-value, or competitive-performance data were collected. The study is limited by its single-case design, its deterministic durations, its finish-to-start-only network, its assumption of unconstrained resources, and the absence of verified actual-completion data.

Future research should extend the model in three directions. First, probabilistic scheduling through PERT or Monte Carlo simulation would attach confidence levels to the 105-day figure rather than presenting it as a point estimate. Second, resource-loading and resource-levelling analysis would test whether the computed schedule is achievable with the crews actually available, which is the most likely source of optimism in the present result. Third, integrating verified cost data would permit earned-value tracking and a time-cost trade-off analysis, moving the work from baseline planning towards genuine time and cost optimisation.

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