01-059 – PERT and CPM in construction: analysis of benefits, limitations and future trends – PERT y CPM en la construcción: análisis de ventajas, limitaciones y tendencias futuras

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English Spanish

The construction industry faces challenges such as inefficiency, waste, and low job safety. This study analyzes the benefits and limitations of using PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method) techniques in civil construction project management. These tools, developed in the 1950s, are used to plan and control projects but face challenges such as risks, delays, and scope changes. PERT employs a probabilistic approach to estimating durations, while CPM uses network diagrams to focus on the critical path. The research includes a bibliometric analysis and the application of a questionnaire to civil engineers to assess the industry's adaptation to these methodologies after almost 70 years of use. The results highlight advantages, such as better planning and cost reduction, and challenges, such as implementation complexity and the need for constant updating. The study offers insights for professionals considering adopting PERT/CPM, contributing to a more efficient and sustainable management of construction projects.

Keywords: *PERT; CPM; Project management*

La industria de la construcción enfrenta desafíos como ineficiencia, desperdicio y baja seguridad laboral. Este estudio analiza los beneficios y limitaciones del uso de las técnicas PERT (Técnica de Evaluación y Revisión de Programas) y CPM (Método del Camino Crítico) en la gestión de proyectos de construcción civil. Estas herramientas, desarrolladas en la década de 1950, se utilizan para planificar y controlar proyectos, pero enfrentan desafíos como riesgos, retrasos y cambios de alcance. PERT emplea un enfoque probabilístico para estimar duraciones, mientras que CPM se centra en el camino crítico mediante diagramas de red. La investigación incluye un análisis bibliométrico y la aplicación de un cuestionario a ingenieros civiles para evaluar la adaptación del sector a estas metodologías tras casi 70 años de uso. Los resultados destacan ventajas, como una mejor planificación y reducción de costos, y desafíos, como la complejidad de implementación y la necesidad de actualización constante. El estudio ofrece *insights* para profesionales que consideran adoptar PERT/CPM, contribuyendo a una gestión más eficiente y sostenible en proyectos de construcción.

Palabras claves: *PERT; CPM; Gestión de proyectos*

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1. Introduction

The civil construction sector faces chronic challenges, including inefficiency, high waste rates, and precarious occupational safety (Tezel, Koskela, & Aziz, 2018). Despite these issues, the industry plays a vital role in infrastructure development, job creation, and economic growth. In Brazil, the sector grew by 6.57% in 2023, generating over 158,000 jobs, with a projected 3% growth for 2024 (CBIC, 2023; CNI, 2024).

Construction projects are highly uncertain due to their complexity, on-site production, and variable processes, complicating project management (Abbasian-Hosseini et al., 2014). Traditional scheduling methods like PERT and CPM help plan and control projects by analyzing timelines, costs, and critical paths (Vergara et al., 2017). While these tools have been widely used for decades (Agyei, 2015), critics argue that PERT relies on uncalibrated estimates, and CPM lacks adaptability for stochastic projects (Trietsch & Baker, 2012).

Although PERT and CPM are classic techniques developed decades ago, they are still widely relevant and applied in many modern contexts. These techniques are incorporated into various project management software, such as Microsoft Project and Primavera. Studying the limitations of PERT and CPM is fundamental to understanding how these techniques can be improved or adapted to contemporary needs. There is a vast body of scientific literature on PERT and CPM, including studies that revisit their limitations and propose improvements. This demonstrates that the discussion on these techniques remains relevant in academia. In a context where companies seek simplicity and efficiency in planning, contrasted with increasingly complex challenges, these techniques prove to be a vast field for new research. The fact that they are “old” does not invalidate their relevance.

This raises key questions: What barriers hinder PERT/CPM implementation in construction? How do professionals cope with tighter deadlines and cost pressures? By combining a systematic review with insights from Brazilian engineers, this study aims to bridge theory and practice, assessing the real-world applicability of these methods to improve project planning.

2. Objectives

This paper focuses on reviewing the premises of the established project management tools PERT and CPM, enabling an analysis of the state of the art, and subsequently confronting how the applicability of such techniques has been in the construction sector, listing the main characteristics, difficulties, and advantages found within the Brazilian civil construction sector.

3. Research method

In the initial stage of this research, the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) were adopted to identify and select publications relevant to the study, based on the search string shown in Table 1.

Table 1: Strings.

Boolean combination: PERT AND CPM AND Benefits AND Barriers AND Project Management	
PERT	“PERT” or “Program Evaluation and Review Technique” or “Program Evaluation Review Technique”
CPM	“CPM” or “Critical Path Method”

Benefits	"Benefits" or "advantages" or "gains" or "results" or "pluses" or "highlights" or "positive aspects" or "opportunities" or "strengths"
Barriers	"Limitations" or "disadvantages" or "difficulties" or "barriers" or "obstacles" or "hurdles" or "minuses" or "shortcomings" or "negative aspects" or "struggles" or "challenges"
Project Management	"Project Management" or "PM"

The process defined by the PRISMA guidelines generally follows three main steps: (1) identification of materials through database searches; (2) selection of relevant studies; and (3) eligibility assessment, involving the in-depth reading and analysis of the selected publications (Page *et al.*, 2021). For this purpose, the international databases Scopus and Web of Science were utilized, in addition to the Brazilian sources ENEGEP (a conference organized by ABEPRO) and the Brazilian Digital Library of Theses and Dissertations (BDTD) maintained by IBICT. A total of 26 studies were selected following a thorough review and eligibility evaluation. The complete list of selected works is provided at this link.

Based on the content analysis of these publications, the benefits and challenges associated with each method (PERT and CPM) were identified, providing the foundation for the subsequent phase: the design of a questionnaire. The survey research design process followed six methodological steps, as outlined by Forza (2002): (1) linking to the theoretical framework, (2) design, (3) pilot testing, (4) data collection from a target group, (5) data analysis, and (6) reporting of results.

The questionnaire items were developed using natural language, with the support of artificial intelligence tools, allowing for the grouping of similar benefits and challenges related to PERT and CPM. These insights were structured and presented from Table 3 to Table 6. Subsequently, a pilot test was conducted to validate the instrument. The finalized questionnaire was then distributed to civil engineering professional groups on LinkedIn, a platform recognized for its professional outreach. The data collected through this process were analyzed and are presented in Section 5 of this study.

4. PERT AND CPM

Prado (2015) states that the Critical Path Method (CPM) emerged in 1957 through a partnership between the American companies Du Pont de Nemours and Remington Rand, who developed the technique aiming to create a tool to assist in the planning and control of the companies' projects.

The method is commonly used to clarify questions such as: What is the total time required to complete a project? What are the scheduled start and finish dates for each activity? Which activities are critical and must be completed exactly as planned? How much can non-critical activities be delayed without affecting the overall project deadline? (Bagshaw, 2021)

In the Critical Path Method (CPM), the critical path refers to the sequence of activities that determines the longest project duration (Project Management Institute [PMI], 2021), where any delay will result in undesirable effects, such as an increase in the total project completion time (Mahardika, Subagio, & Wibowo, 2019).

According to Benjaoran, Tabyang, and Sooksil (2015), the tool is widely used to organize all activities based on the time scale and precedence relationships. The CPM uses a single duration estimate for each project activity, and the most used criterion for such determination is experts' judgment. However, this is associated with a high degree of uncertainty even for very experienced specialists (Carvalho & Junior, 2015)

With the advent of the construction of the Polaris nuclear submarines in the USA in 1958, the U.S. government saw the need for a tool that would ensure that the processes associated with the project could be planned and controlled, aiming to meet the calculated deadlines and costs. In this context, the PERT technique emerged (Husin, Memon, & Rahman, 2019).

Unlike CPM, which consists of a deterministic methodology, PERT has a stochastic approach, in which three scenarios are considered (Mattos, 2019): Most likely: duration of the activity with the most realistic expectations; Optimistic: duration of the activity in the best-case scenario; Pessimistic: duration of the activity in the worst-case scenario. Based on the three scenarios, Malcolm (1959) proposed a set of equations that account for the variability in activity durations. His model follows a beta distribution, where μ represents the expected duration of an activity, and σ denotes the associated standard deviation.

Similarly to CPM, once all critical activities and their respective μ and σ values are identified, the mean and standard deviation of the overall project duration can be calculated. This provides an interval-based estimate for the project's completion time.

5. Results and discussion

The survey yielded a total of 40 valid responses from Brazilian civil engineers. Table 2 presents the demographic and professional profile of the respondents, with percentages calculated based on the total number of participants. A considerable portion of respondents work in the transportation sector (22.5%), followed by those engaged in general construction activities (12.5%). In terms of professional roles, the majority identified themselves as engineers (70%), and most respondents are employed in the private sector (87.5%).

On the use of the PERT technique, 70% said they use the tool to manage projects. Furthermore, as to the use of CPM, 65% answered that they use the tool in project management. Given that, only the respondents who declared using the PERT and CPM were considered for comparative analysis with the literature, to provide results that are more consistent with both academic insights and market perspectives.

Table 2: Profile of the respondents.

Topic	Unfolding	Responses	Percentage
Position within organization	Manager	5	12,5%
	Engineer	28	70,0%
	Analyst	7	17,5%
Sector	Private	35	87,5%
	Public	4	10,0%
	Both	1	2,5%
Area	Industrialized construction (steel frame, modular construction and others)	4	10,0%
	Structural engineering	4	10,0%
	Geotechnics and geoprocessing	1	2,5%
	Installations (plumbing, electrical, fire prevention, HVAC and others)	4	10,0%

Topic	Unfolding	Responses	Percentage
	Urban and territorial planning	2	5,0%
	Architectural design	3	7,5%
	Sewerage and water resources	3	7,5%
	Transportation (roads, airport terminals and others)	9	22,5%
	Energy	4	10,0%
	Offshore	1	2,5%
	Construction works	5	12,5%
Professional experience in the area	Less than 5 years	21	52,5%
	5 to 10 years	5	12,5%
	10 to 15 years	7	17,5%
	More than 15 years	7	17,5%
Uses PERT in project management	Use	28	70%
	Don't use	12	30%
Knowledge level on PERT	None	6	15,0%
	Beginner	12	30,0%
	Intermediate	12	30,0%
	Advanced	10	25,0%
Uses CPM in project management	Use	31	65%
	Don't use	9	23%
Knowledge level on CPM	None	8	20,0%
	Beginner	8	20,0%
	Intermediate	10	25,0%
	Advanced	14	35,0%

The benefits and challenges of the PERT and CPM tools found in literature were listed in Table 3 to Table 6, additionally, each group was assigned an ID, where "B" indicates a benefit and "D" indicates a difficulty. The tables were sorted in descending order based on the number of citations of each item in the bibliometric analysis. The frequency of citations of each item relative to the total number of publications found (26) is also presented in the last column of each table. Moreover, Figure 1 to Figure 4 present the results of the surveyed professionals' perceptions regarding the benefits and difficulties of using the tools PERT and CPM.

5.1 PERT benefits and difficulties

Regarding Group B1, a strong alignment between literature and practical perception is observed. This group is the second most cited in publications (12 times), with emphasis on the benefit of "defining logical relationships between activities," accounting for a ratio of 26.92% citations in relation to the total of publications (Table 3). This theoretical relevance is confirmed by the respondents, with 100% agreeing (75% "strongly agree" and 25% "agree") on the usefulness of these benefits, highlighting a consensus on the importance of PERT for time management and activity sequencing (Figure 1).

Group B2 presents an opposite scenario. Although it is scarcely cited in the literature (only twice, each with 3.85%), professionals strongly recognize these benefits, with 86% expressing agreement (61% "agree" and 25% "strongly agree"). This result suggests the practical impact of PERT on efficient resource and workforce management is more perceived by market professionals, whereas in literature this benefit may not be so significant

In Group B3, a convergence between theory and practice is once again observed. The literature highlights this benefit in 11.54% of citations, and professionals also recognize its importance: 54% "agree" and 46% "strongly agree." This alignment reinforces PERT’s effectiveness as a tool for financial and scheduling oversight in projects.

Group B4 shows significant divergence. Although it is the most cited group in the literature (15 mentions, representing 46.15% of the total), practical perception was more scattered: 29% "agree," 25% "strongly agree," while 29% "disagree" and 14% remained neutral. This discrepancy may indicate limitations in the practical applicability of these benefits or a lack of professional training in using PERT as a decision-making and scenario analysis tool.

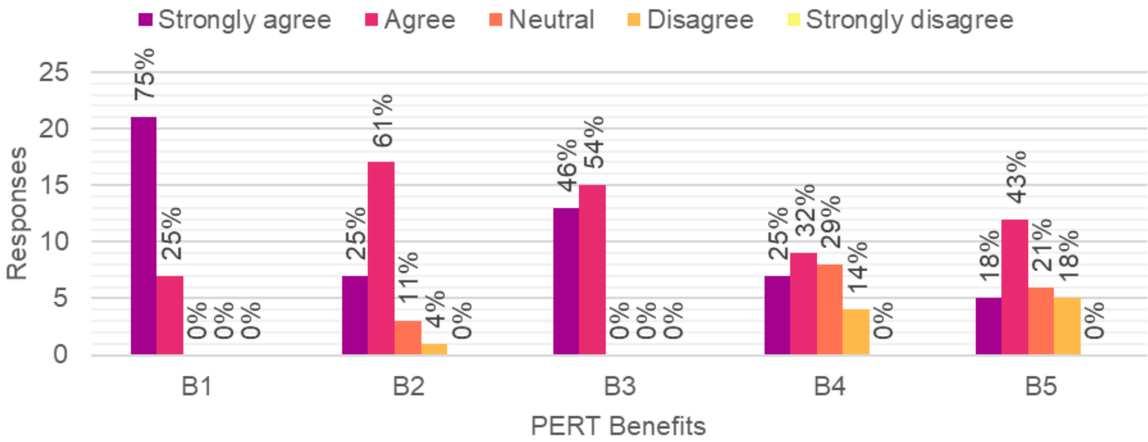
Finally, Group B5 also shows a certain disconnect between theory and practice. Despite being cited in 15.38% of the literature, practical perception was divided: 43% "agree," 18% "strongly agree," but also 21% "disagree" and 18% were neutral. These data suggest that although PERT is theoretically considered simple, its implementation may pose practical challenges that compromise its perceived ease of use.

Table 3: PERT benefits found in publications.

Group ID	Group	PERT benefits found in publications	Number of times cited in publications	Citation rate in publications (%)
B1	Time management and scheduling activities	Defines logical relationships between activities	7	26,92%
		Identifies critical activities and slacks	2	7,69%
		Programming and monitoring the progress of the stages so that the project is completed within the deadline	2	7,69%
		Defines prioritizations about work sequence and outlines critical and non-critical activities	1	3,85%
B2	Resources control and operational efficiency	Assists projects involving many activities and a variety of workforce	1	3,85%
		Reduces the probability of failure in the initial stages and optimizes the usage of supplies and workforce	1	3,85%
B3	Cost and schedule control	Improves control of project's cost and/or schedule	3	11,54%
B4	Evaluati ng scenario	Incorporates uncertainties in activity times in its analysis	12	46,15%

Group ID	Group	PERT benefits found in publications	Number of times cited in publications	Citation rate in publications (%)
		Allows to look at best and worst-case scenarios	2	7,69%
		Avoids the drawbacks of random decision-making	1	3,85%
B5	Easy to implement and to understand	Simplicity and easy of understanding	4	15,38%

Figure 1: PERT benefits for surveyed engineers.



As shown in Table 4, Group D1, which includes issues such as probabilistic independence between activity durations and poor handling of project variability, had a significant number of citations recorded in the literature, particularly regarding fragile assumptions (15.38%) and mismanagement of uncertainty (11.54%). This theoretical emphasis aligns reasonably well with practitioners' perceptions: 25% of respondents "strongly agree" and 32% "agree" with the challenges described (Figure 2), though there is also a notable portion (18%) who "disagree", suggesting a divergence of opinion that could stem from differing project contexts or levels of experience with the technique.

Group D2 also receives considerable attention in both literature and practice. Although the issues pointed out in this group have relatively low citation rates, their cumulative presence underscores a shared concern regarding the technique's scalability and structural limitations. Professional perceptions, however, offer a stronger confirmation of these concerns: 39% "agree" and 43% "strongly agree", acknowledging the challenges of Group D2. These results reflect significant convergence between theory and practice, confirming that scalability remains a substantial barrier to PERT's effective application in complex projects.

On the other hand, Group D3 is highlighted in the literature for issues such as the great effort required to apply PERT and its limited practical applicability. While these are less frequently cited in publications (cumulative 15.39%), practitioners' perception diverges significantly: only

11% "strongly agree" and 21% "agree", whereas a large proportion (39%) "disagree". This discrepancy suggests that while literature emphasizes PERT's theoretical complexity, professionals may find the technique more accessible or may not consider the effort a major restriction in practice or may not even be considering the set of formulas that define the tool.

Group D4 is the most cited group in the literature (with a combined citation rate of 34.62%), mainly due to the incorrect use of assumptions and limited availability of historical data. Professional responses, however, were more moderate: 18% "strongly agree" and 29% "agree", while an equal share (29%) "disagree". This balance points to a divided perception, potentially influenced by varying levels of data availability across different organizations or industries.

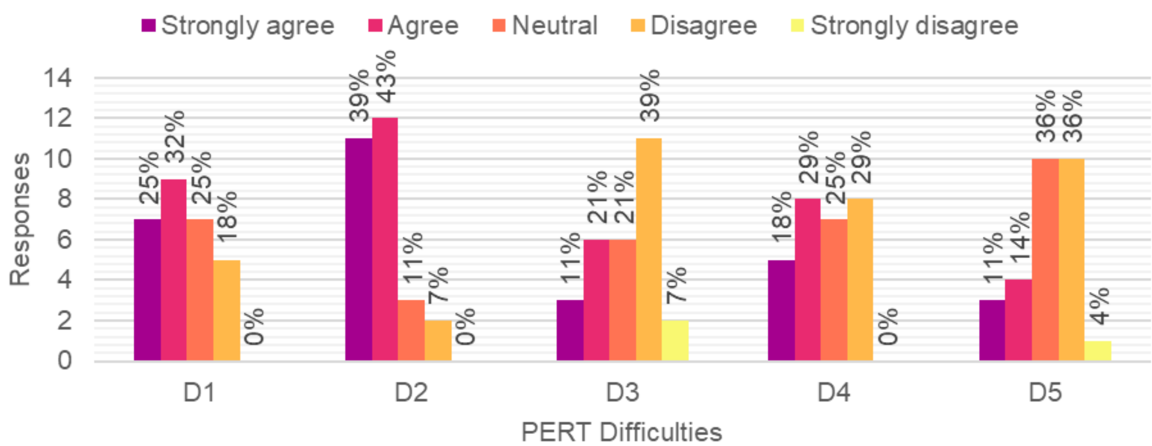
Finally, Group D5 received less attention in the literature (only 7.7% citation rate), and this low prominence is mirrored by user responses: just 11% "strongly agree" and 14% "agree", while 36% of respondents remain neutral and another 36% "disagree". These findings indicate that although dependency on experienced managers is acknowledged, it is not considered a major practical barrier by the majority of respondents.

Table 4: PERT difficulties found in publications.

Group ID	Group	PERT difficulties found in publications	Number of times cited in publications	Citation rate in publications (%)
D1	Inaccuracy due to uncertainties and risks associated with the use of the technique in the project	Makes fragile assumptions such as probabilistic independence between activity durations	4	15,38%
		Poor management of project uncertainty / variability	3	11,54%
		Ignores duration variability providing too optimistic completion dates	3	11,54%
		Difficulty dealing with risks beyond inherent uncertainty of activity duration	2	7,69%
		Underestimates of total uncertainty due to ignored correlations between activities	1	3,85%
		Risk associated with all task durations	1	3,85%
D2	Scalability and complexity with increasing project	Creates too many "safety margins" resulting in unrealistically long project duration	2	7,69%
		Is difficult to grasp when not all activities can happen or there's constantly evolving scope or there is a loop	2	7,69%
		Complexity scales with project size	1	3,85%
D3	Lack of a practical approach and it's difficult to	Great effort in terms of understanding or work, and time required for their application	2	7,69%
		Don't have a practical approach	1	3,85%

Group ID	Group	PERT difficulties found in publications	Number of times cited in publications	Citation rate in publications (%)
		Not often used during operational stages, since field managers often abandon the technique	1	3,85%
D4	Inadequate data and suppositions conceiving the technique	Use of an incorrect/unfortunate set of assumptions, formulas and statistical distributions	4	15,38%
		Ignores or makes incorrect assumptions about resources availability	3	11,54%
		Lacks historical data	2	7,69%
D5	Limited decision-making due to the reliance on knowledgeable managers	Reduce the possibility of taking decisions at the level of senior management	1	3,85%
		Depends upon knowledgeable managers	1	3,85%

Figure 2: PERT difficulties for surveyed engineers.



5.2 CPM benefits and difficulties

Group B6 emerges as the most frequently cited group in the literature (Table 5), particularly with regard to the benefit of defining logical relationships between activities (26.92%). This academic emphasis aligns closely with professional perceptions: in Figure 3, B6 received overwhelming endorsement, with 69% of respondents "strongly agreeing" and 28% "agreeing" with the identified benefits (Figure 3). This strong correlation between scholarly sources and professional opinion underscores B6 as a core strength of CPM.

Group B7, though sparsely cited in the literature (each benefit cited only once, 3.85%), is highly valued by practitioners. Figure 3 reveals a substantial proportion of respondents who "agree" (41%) or "strongly agree" (34%) with the group’s benefits. This discrepancy highlights a potential underrepresentation in academic research of practical concerns related to resource management, despite their recognized value in the field.

Group B8 shows strong alignment between literature and practice. The benefits in this group have a combined citation rate of 23.08% (11.54% each for improving control and identifying critical activities/slacks), and were validated by respondents with equal percentages (45%) marking "strongly agree" and "agree". This consistency reinforces the perception of CPM as a valuable tool for monitoring and managing time and budget constraints.

Group B9 benefits, including simplicity and deterministic structure, were moderately cited in publications (each cited 4 times, 15.38%). Similarly, practitioners acknowledged these advantages, with 45% "strongly agreeing" and 38% "agreeing". This demonstrates convergence between academic and professional perspectives regarding CPM's accessibility and practical usability.

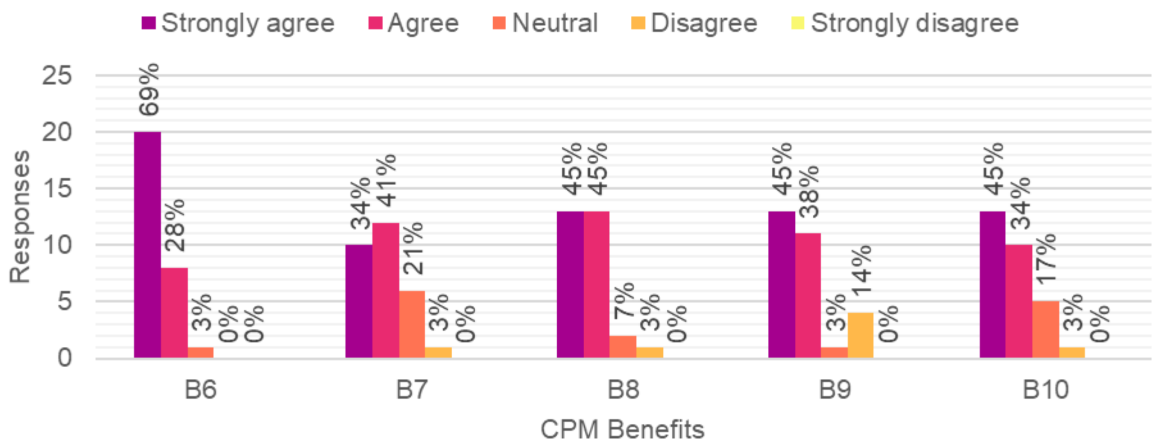
Group B10 includes the second most cited individual benefit (26.92%), related to identifying critical activities with no slack. This is reflected in practice, with 45% "agree" and 34% "strongly agree". However, the secondary benefit in this group, concerning avoidance of random decision-making, was minimally cited (3.85%) and received lower support from practitioners, with some neutrality (17%) and even disagreement (3%). This suggests that while the predictive power of CPM is appreciated, its decision-support capabilities may be more limited or context-dependent.

Table 5: CPM benefits found in publications.

Group ID	Group	CPM benefits found in publications	Number of times cited in publications	Citation rate in publications (%)
B6	Assists in planning and sequencing activities	Defines logical relationships between activities	7	26,92%
		Improved planning before work starts	4	15,38%
		Defines prioritizations about work sequence and outlines critical and non-critical activities	1	3,85%
B7	Management and optimization of resources	Assists projects involving a large number of activities and a variety of workforce	1	3,85%
		Reduces the probability of failure in the initial stages and optimizes the usage of supplies and workforce	1	3,85%
B8	Cost and schedule control	Improves control of project's cost and/or schedule	3	11,54%
		Identifies critical activities and/or slacks	3	11,54%

B9	User-friendly	Simplicity and easy of understanding	4	15,38%
		Deterministic network (simplicity)	4	15,38%
B10	Analysis of scenarios and decisions	Identifies critical activities with no slack, that if any delay occurs, the project will run late the exact amount of time as well	7	26,92%
		Avoid the drawbacks of random decision-making	1	3,85%

Figure 3: CPM benefits for surveyed engineers.



Group D6, covers the issue of the CPM providing a critical path that may inaccurately reflect the actual project duration (Table 6). Although this difficulty was cited only once in the literature, representing a citation rate of 3.85%, it appears to resonate strongly with practitioners. According to Figure 4, a significant portion of surveyed engineers either "strongly agree" (14%) or "agree" (48%) with this concern, indicating a practical recognition of this theoretical limitation. This discrepancy between low academic emphasis and high practitioner concern may suggest a need for further research in this area.

Group D7 includes difficulties such as incorrect assumptions about resource availability, disregard for site conditions, and absence of historical data. These issues appear moderately in the literature, with "incorrect assumptions about resource availability" being the most cited (11.54%). Practically, Figure 4 shows that 31% of respondents "strongly agree" and 38% "agree" with the relevance of this group, while only 3% "strongly disagree". This indicates a strong alignment between literature and practice, reaffirming that resource-related uncertainties are a consistent weakness in CPM application.

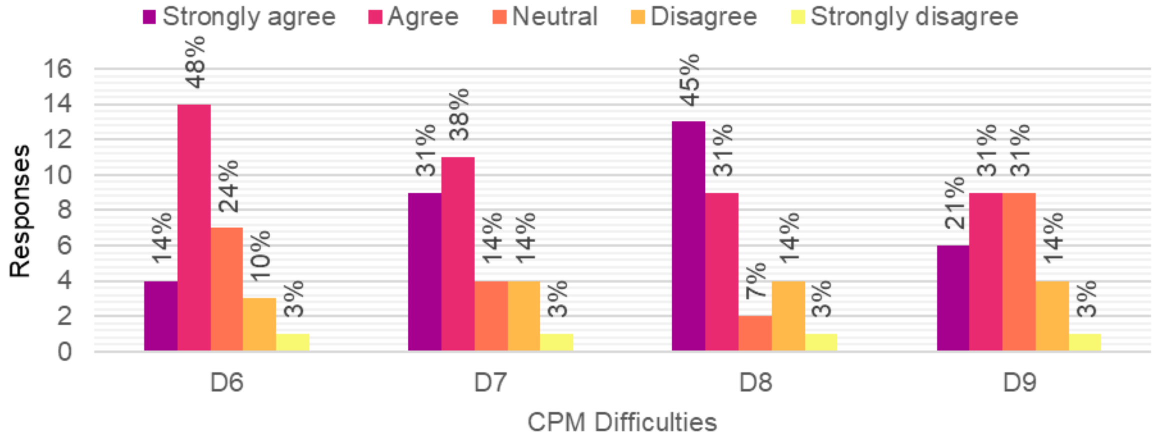
Group D8 was the most frequently cited in the literature, particularly the item "ignores duration variability," which appeared in 26.92% of the reviewed publications. This theoretical emphasis is mirrored in practical perceptions, with 45% of engineers "strongly agreeing" and 31% "agreeing" that this represents a major challenge. The high convergence between both sources underscores the deterministic nature of CPM as a core limitation, especially in dynamic or uncertain project environments.

Finally, Group D9 captures practical concerns regarding the implementation of CPM, such as the need for expert knowledge, being time-consuming, and infrequent use in operational stages. These aspects are moderately cited in literature (ranging from 3.85% to 7.69%), and this moderate emphasis is echoed in the perceptions of practitioners. Specifically, 21% of engineers "strongly agree" and 31% "agree" with the limitations described in this group, on the other hand, 31% remained neutral, while 17% disagreed, highlighting a greater range of answers and that the method’s complexity and its limited usability in field operations are not a consensus among the group surveyed.

Table 6: CPM difficulties found in publications.

Group ID	Group	CPM difficulties found in publications	Number of times cited in publications	Citation rate in publications (%)
D6	Precision problems on the critical path	Provides a critical path that has an inaccurate measure of the project duration	1	3,85%
D7	Lack of data and incorrect assumptions	Ignores or makes incorrect assumptions about resources availability	3	11,54%
		Ignores site conditions such as weather, material procurement, labor shortage or equipment availability	1	3,85%
		Lacks historical data	1	3,85%
D8	Poor management of uncertainty and variability	Ignores duration variability (deterministic approach) providing too optimistic completion dates	7	26,92%
		Poor management of project uncertainty / variability	3	11,54%
D9	Time-consuming, relies on knowledgeable managers, lacks practical approach	Time consuming	2	7,69%
		It is difficult to grasp when not all activities can happen or there's constantly evolving scope or there is a loop	2	7,69%
		Requires experts’ knowledge	1	3,85%
		Not often used during operational stages, since field managers often abandon the technique	1	3,85%

Figure 4: CPM difficulties for surveyed engineers.



6. Conclusion

This study sought to critically evaluate the applicability, benefits, and limitations of the PERT and CPM techniques within the Brazilian civil construction sector. By integrating a systematic literature review with empirical data collected through a targeted survey of engineering professionals, the research provided a comprehensive overview of how these methodologies are perceived and utilized in practice.

The findings reveal both convergence and divergence between theoretical expectations and professional experiences. While there is a strong consensus regarding the usefulness of PERT and CPM for activity sequencing, time management, and project control, several practical challenges persist. These include issues related to the deterministic nature of CPM, scalability and uncertainty handling in PERT, and the dependence on experienced professionals for effective implementation, highlighting that even after the development of these tools nearly 70 years ago, there are still bottlenecks in their design and/or application.

Furthermore, the analysis features some gaps between the academic discourse and market practices, particularly in areas such as resource management and the pragmatic application of these techniques in dynamic project environments. Nonetheless, the overall positive perception among professionals indicates that, despite their limitations, both PERT and CPM remain valuable tools for project management in civil engineering.

Future research should focus on exploring hybrid approaches that combine the strengths of both methods while addressing their respective limitations, potentially incorporating advancements in artificial intelligence and real-time data analysis. Additionally, expanding the scope of investigation to include a broader and more diverse respondent base could further enrich the findings and support the development of more adaptable project management methodologies.

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Use of Generative Artificial Intelligence

Natural language processing, aided Generative AI tools, specifically ChatGPT (OpenAI), was used to assist in grouping the benefits and challenges associated with the management tools, based on semantic similarity, contributing to the development of the questionnaire structure used in this research.

Communication aligned with the Sustainable Development Goals