

GENERATION AND CHARACTERIZATION OF TAKT PLANNING STRATEGIES IN PRECAST-SLAB BASEMENTS

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ABSTRACT

Selecting a Takt Planning strategy for basement construction with precast slabs is a production system design problem, since different combinations of sectorization and takt time lead to different tradeoffs in duration, variable cost, and implementation demands. Existing Takt Planning research provides limited support for systematically generating comparable alternatives and justifying strategy selection for a specific project context. This paper proposes a framework to generate, compare, and select Takt Planning strategies and applies it to six basement levels of a multifamily building in Lima, Peru. The alternatives are defined by combining sectorization and takt time and are assessed through project duration, variable cost, and implementation demands related to structural capacity, supervision, material logistics, labor, and cash flow. Results show that shorter duration alone is not a sufficient basis for selection, because alternatives with similar time and cost performance can impose substantially different implementation demands. In the case studied, the alternative with five sectors and a one day takt provided the best balance between economic performance and implementation feasibility. The paper contributes a structured procedure to support early Takt Planning decisions under real project constraints. Future research should test the framework in other project types and refine the assessment of implementation demands.

KEYWORDS

Takt Planning, lean construction, basement construction, implementation demands.

INTRODUCTION

Basement construction with precast slabs poses a demanding production system design problem. Work is performed in confined spaces, with limited access, strong interdependence among trades, and high simultaneity of operations. Under these conditions, decisions on sectorization, takt time, and work package structure directly affect flow stability, crew continuity, coordination effort, and overall program duration. Planning in this context is therefore not only a matter of sequencing activities, but of designing a production system capable of sustaining reliable flow during execution.

From a Lean Construction perspective, this challenge requires designing and controlling flow rather than only scheduling tasks, in order to reduce variability, waiting, and rework (Koskela, 1992). In the Peruvian context, repetitive and location based practices such as sectorization and activity trains are commonly used to organize building work, but they often

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lose stability when balancing and control are not made explicit (Fernández Rea, 2018). Takt Planning extends these practices by organizing production through takt areas and work packages while incorporating load balancing and explicit flow control under variability (Heinonen & Seppänen, 2016; Lehtovaara et al., 2019).

Precast slabs can support this objective as a partial industrialization strategy intended to reduce cycle time, formwork demand, and on site labor. However, these benefits do not arise automatically from the use of prefabricated elements. They depend on how coherently the components are integrated into planning and operations, especially in basement construction, where spatial restrictions and simultaneous fronts intensify coordination demands (Yarasca Colca, 2021). This is consistent with evidence showing that prefabrication performs better when it is embedded in the production system rather than treated as an isolated technical decision (Jaillon & Poon, 2014). In this setting, Takt Planning provides a useful basis for structuring repetitive work fronts and translating the potential of precast slabs into schedule and cost performance.

Although Takt Planning research has advanced in the definition of zones, load balancing, and flow control, it provides less guidance on the front end decision process needed to define a strategy for a specific project context. In particular, the literature offers limited support for systematically generating comparable alternatives, characterizing the operational and financial demands associated with each option, and justifying final selection on a consistent basis. This gap is especially relevant in basement projects with precast slabs, where time, cost, logistics, supervision, labor, and cash flow interact strongly during implementation.

This paper addresses that gap by proposing a structured framework to generate, compare, and select Takt Planning strategies under real project conditions. The framework is tested through a comparative study of six basement levels of a multifamily building project in Lima, Peru, in which precast slabs are adopted as a project condition. The research question is as follows: How can alternative Takt Planning strategies be generated and selected by jointly considering economic performance and implementation demands? To answer this question, the paper develops a discrete and traceable procedure based on sectorization and takt time, compares alternatives in terms of duration and variable cost, and characterizes the implementation demands associated with each strategy. Although the case is project specific, the procedure is intended to be transferable to projects with spatial repetitiveness and high simultaneity, where sectorization and takt time strongly shape front coordination and flow stability.

METHODOLOGY

RESEARCH DESIGN

This study follows an artefact development and evaluation logic aimed at supporting early Takt Planning decision making in basement projects with precast slabs. The research addresses a production system design problem in which project teams must select among alternative combinations of sectorization and takt time under real implementation constraints. Accordingly, the study does not seek to identify a universally optimal Takt Planning method, but to develop and examine a structured decision support framework that enables the explicit generation of alternatives, their comparable evaluation, and the justification of strategy selection under project conditions.

The research was organized in two stages. First, the framework was developed by structuring practitioner knowledge and project planning criteria into a traceable procedure. Second, it was evaluated through a real case study involving six basement levels of a multifamily building in Lima, Peru. The evaluation focused on whether the framework could support explicit alternative generation, consistent economic comparison, and a structured

reading of implementation demands under actual project constraints. The framework itself is presented in the results section as the main research outcome.

FRAMEWORK DEVELOPMENT

The framework was developed with input from five professionals with 10 to 20 years of experience in multifamily residential projects, incorporating perspectives from construction, project control, logistics, structures, and site management. Their input was gathered through iterative working sessions oriented to the planning of basement works and supported by available project information, including floor plans, quantity distribution, budget based productivities, internal planning records, and cost data. These sessions were used to identify the recurrent decisions that define a Takt Planning strategy in this context and the criteria required to compare alternatives before execution.

The development process began by delimiting the decision problem. The team first identified sectorization and takt time as the primary decision variables, since both determine front size, simultaneity, crew continuity, handoffs between specialties, and overall pace of execution. Once these variables were defined, the team identified the information required for like for like comparison across alternatives, namely work package structure, labor requirements, planned duration, and variable cost. This allowed the alternatives to be framed as discrete and comparable planning options rather than as isolated scheduling exercises.

Subsequent iterations focused on the conditions that could affect implementation even when alternatives showed similar time and cost performance. Through this process, the team identified the demand dimensions that were most relevant for the case and most useful for differentiating strategies under real execution constraints, namely structural capacity, supervision, material logistics, labor availability, cash flow, and technology. These dimensions were then translated into a common demand profiling logic intended to make explicit the management effort required by each alternative. As the discussions progressed, the procedure was consolidated into four linked components: alternative generation, economic quantification, implementation demand profiling, and synthesis for strategy selection. In this way, the framework emerged from iterative refinement of the decision problem, the comparison logic, and the implementation conditions observed in the project context.

CASE STUDY EVALUATION

The framework was evaluated through its application to the construction of six basement levels of a multifamily building in Lima, Peru. The case was selected because it combines the conditions that make Takt Planning strategy selection particularly demanding, namely spatial repetitiveness, confined work areas, strong interdependence among trades, high simultaneity of operations, and the use of precast slabs.

The evaluation used the information available for early planning in the project, including floor plans, quantity distribution, budget based productivities, internal labor and cost records, the daily indirect cost structure, and the project team's judgment regarding implementation conditions. The purpose was to assess whether the framework could generate feasible alternatives, compare them on a common economic basis, make explicit their implementation demands, and support a justified strategy selection under real project constraints.

RESULTS

FRAMEWORK FOR GENERATING, COMPARING AND SELECTING TAKT PLANNING STRATEGIES

The resulting framework is intended for early project planning, once floor plans and historical cost and productivity data are available. Its use assumes timely involvement of key project

stakeholders and a planning environment in which operational variability can be managed within acceptable limits.

As shown in Figure 1, the framework is organized into four connected steps. Step 1 generates discrete strategy alternatives by combining sectorization and takt time. Step 2 quantifies the program level resource and cost implications of each alternative. Step 3 profiles the implementation demands associated with each strategy under the critical conditions of the project. Step 4 synthesizes economic performance and implementation demand to support strategy selection. The logic of the framework follows the premise that no single Takt Planning method is universally optimal (Tommelein et al., 2024), and that strategy selection must therefore be made in relation to project conditions.

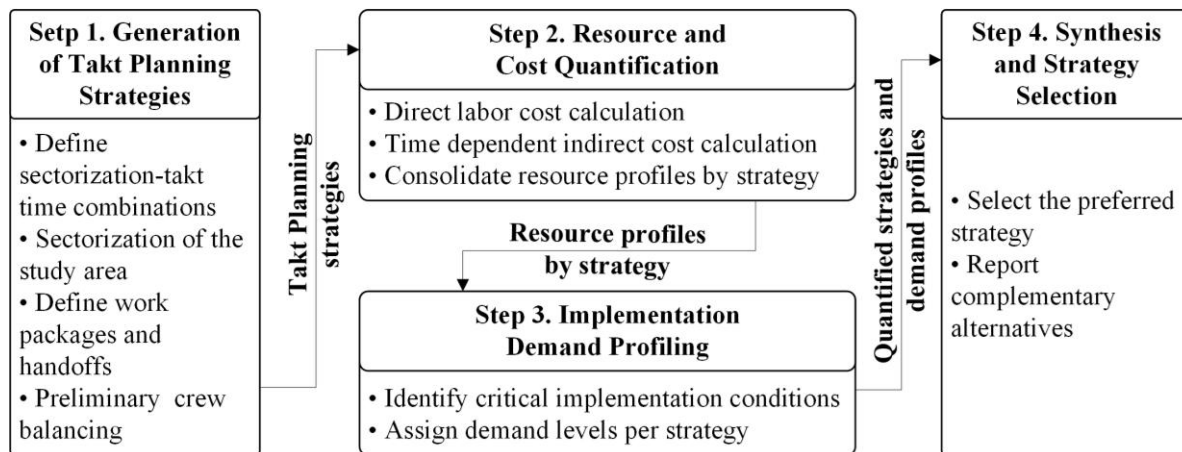


Figure 1: Framework for generating, comparing and selecting Takt Planning strategies

In Step 1, strategies are generated by combining sectorization levels with takt time values. Sector boundaries are first defined by distributing quantities as evenly as possible and then adjusting sector boundaries using construction and operational criteria. The aim is to obtain comparable work content across sectors rather than purely geometric partitioning, so as to reduce imbalance and variability (Frandsen et al., 2013). Repetitive work packages, or wagons, are then defined by specialty, making explicit simultaneity and handoffs between trades to preserve flow continuity (Binniger et al., 2017). Each trade is modeled as a single moving front that advances sequentially through sectors according to the selected package structure. Production is then balanced to the target takt time by estimating man hours per package and sector from budget based productivities and internal records, and by assigning crews consistent with the required capacity. The output of this step is a discrete set of strategies specified by sectorization, takt time, work package structure, implied duration, and labor requirements (Tommelein et al., 2024).

In Step 2, each strategy is quantified at the complete program level to enable comparable evaluation. Planned duration is calculated for each alternative, and time dependent indirect cost is estimated from the number of working days and the corresponding daily indirect rate. Direct labor cost is quantified from total man hours, hourly labor rates, and any additional staffing requirements created by the pace of the strategy. Variable cost is then calculated as the sum of direct labor cost and time dependent indirect cost over the program timeline. The output of this step is a common economic basis for comparing alternatives before demand profiling and selection.

In Step 3, the project team identifies the critical project conditions that may constrain implementation of the strategies. These conditions are project specific and may include, for example, technology, logistics, labor availability, supervision, structural capacity, or cash flow. Each strategy is then assessed in terms of the demand it imposes under each condition,

following the principle of protecting flow through early identification of factors that may compromise the operational plan if not managed before execution (Ballard, 1997). To improve comparability, demand is classified using three levels. Standard demand indicates that the strategy can be managed with ordinary project practices and resources. Care demand indicates that additional coordination or reinforcement is required in specific periods, fronts, or control windows. High demand indicates that the strategy requires sustained reinforcement, intensive coordination, or continued management attention throughout the program. The output of this step is a demand profile for each alternative, prepared by the multidisciplinary team and used as explicit input for selection.

In Step 4, the results of Steps 2 and 3 are synthesized to support strategy selection under different project scenarios. The comparison combines economic performance with the implementation demand profile of each alternative, avoiding decisions based only on cost or duration. When no dominant restriction exists, the preferred strategy is the one that provides the best balance between variable cost and a demand level compatible with the project team's management capacity. When stronger constraints are present, such as deadline pressure, labor scarcity, limited available capital, or restricted supervision capacity, other strategies may become preferable depending on the dominant condition. The output of this step is a preferred strategy for the case together with conditional alternatives aligned with different project priorities.

The framework described above establishes the logic used to generate, compare, and select Takt Planning strategies. The following sections present its application to the case study, showing how the procedure was used to define the alternatives, quantify their economic performance, profile their implementation demands, and support final selection.

GENERATION OF TAKT PLANNING STRATEGIES

In the Peruvian context, where planning is structured on a weekly basis and work is typically organized over six working days, the production cycle was limited to no more than one working week in order to maintain consistency with weekly planning and crew coordination. Based on the typical basement floor area of 1144.19 m², a minimum of four sectors was adopted as the starting point, equivalent to approximately 286 m² per sector. Smaller sectors were discarded because they would reduce front size and increase the difficulty of controlling handoffs between specialties in a confined environment. Sector boundaries were then adjusted using construction and operational criteria to obtain comparable work content and to avoid cold joints during concrete pouring, which could compromise the structure's shear performance. Under this criterion, six basic strategies were formulated by combining three levels of sectorization, namely 4, 5, and 6 sectors, with three takt time values, namely 1, 2, and 3 days, resulting in 4S–1T, 4S–2T, 4S–3T, 5S–1T, 5S–2T, and 6S–1T, all with cycles of less than or equal to one week. More aggressive configurations were excluded because they were not considered operationally feasible under the contractual, labor, coordination, and workspace conditions of the project.

Once sectorization was defined, the work train was structured using repetitive wagons or packages, each representing activities performed simultaneously. The base configuration was organized into five sequential packages. Package 1 integrates steel and pre assembled vertical elements, vertical installations, and vertical formwork. Package 2 corresponds to concrete pouring in verticals. Package 3 integrates vertical formwork removal, bottom and side formwork for beams, and steel placement in beams. Package 4 involves placing shoring for pre slabs, assembling pre slabs, placing steel in slabs, and horizontal installations. Package 5 corresponds to concrete pouring in beams and slabs. This structure makes explicit the progression of the train by sectors and the transfers between specialties that must be sustained to avoid decoupling and loss of flow continuity. In the 6S–1T strategy, a sixth package was

introduced by splitting the original fourth package in order to maintain a workable operational sequence for the crews. Figure 2 shows the train configuration of the evaluated strategies.

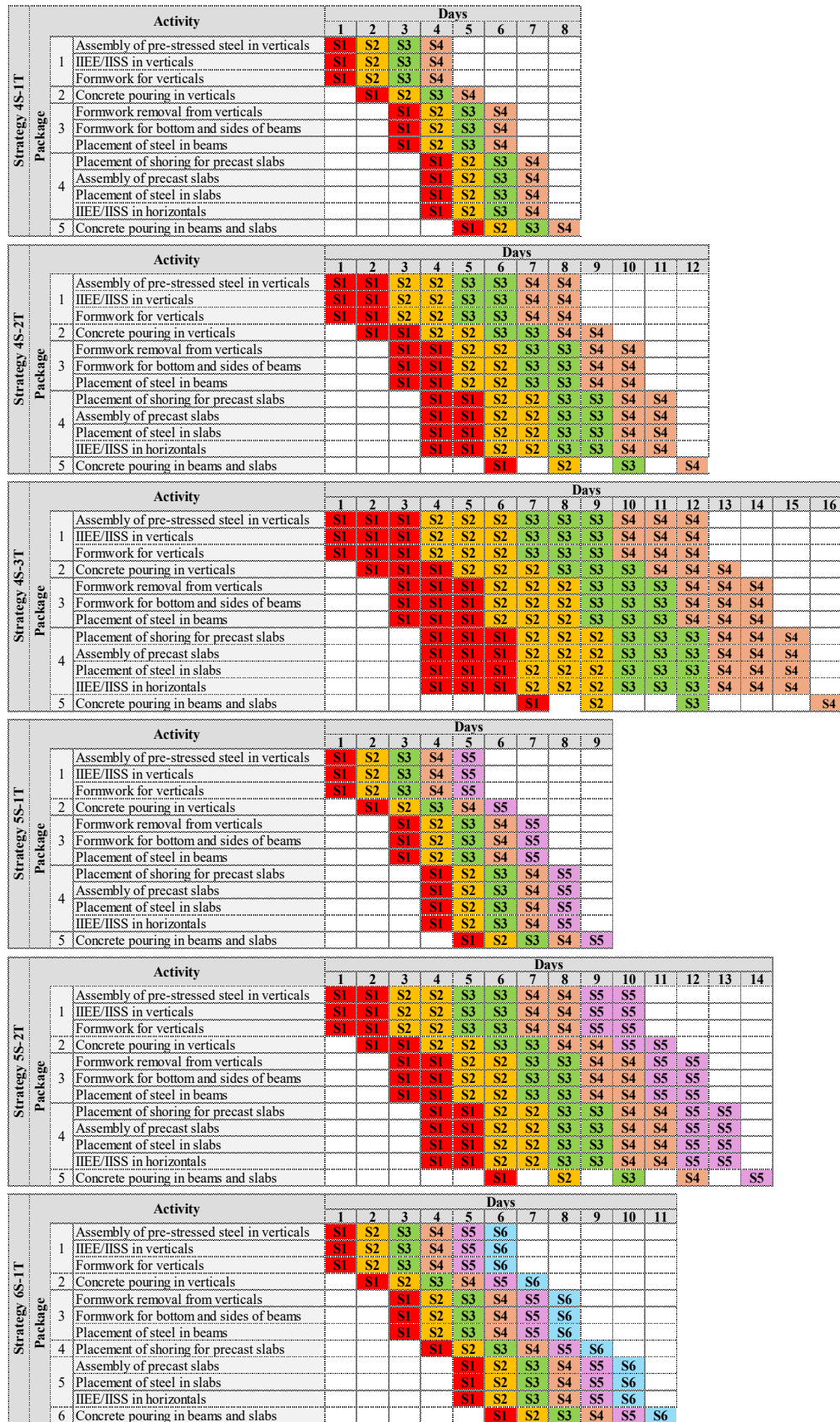


Figure 2: Work train used in each strategy.

After defining sectors and packages, each strategy was balanced to its target takt time using man hour estimates from budget based productivities and internal records. A production buffer was incorporated to protect the weekly cadence by defining staffing levels capable of completing in five days a workload that would conventionally require six, without extending the daily workday of 8.5 hours. This buffer reduces the impact of variability in critical transfers between packages. As a result, each strategy was specified not only by its sectorization and package train, but also by its associated staffing profile and expected program duration for the six basements. Together, sectorization, package structure, takt time, and staffing defined a discrete set of alternatives with different implications for duration, labor demand, and flow stability.

RESOURCE AND COST QUANTIFICATION

With the Takt Planning strategies defined, the associated resources and costs were quantified to establish a comparable basis before demand characterization and final selection. The work trains defined for one basement, shown in Figure 2, were extended to the planning of the six basements. This made it possible to determine the total duration of each strategy and to represent how resource loading evolves over the full program.

At this stage, cost was separated into two components. The first corresponds to direct cost and reflects the labor required to sustain the target pace of each strategy. Its behavior is non linear, since crew allocation is adjusted by day and by work package according to the train design and the staffing profiles obtained in the balancing stage. Therefore, the direct cost of a given day is formed by the wagons operating simultaneously across different sectors or basements, and its evolution depends on how those wagons overlap throughout the strategy. The second component corresponds to time dependent indirect cost, which varies only with strategy duration. These costs include construction staff, technical and engineering office, services, and overhead, in accordance with the contractor's internal structure and the unit price analysis developed by the team. For the project analyzed, a rate of USD 1,853.95 per day was determined. In this study, variable cost is defined as the sum of direct cost and indirect cost.

Figure 3 shows the cumulative evolution of variable cost per strategy, together with the resulting duration, and also includes the temporal pattern of direct cost to improve the reading of daily resource loading.

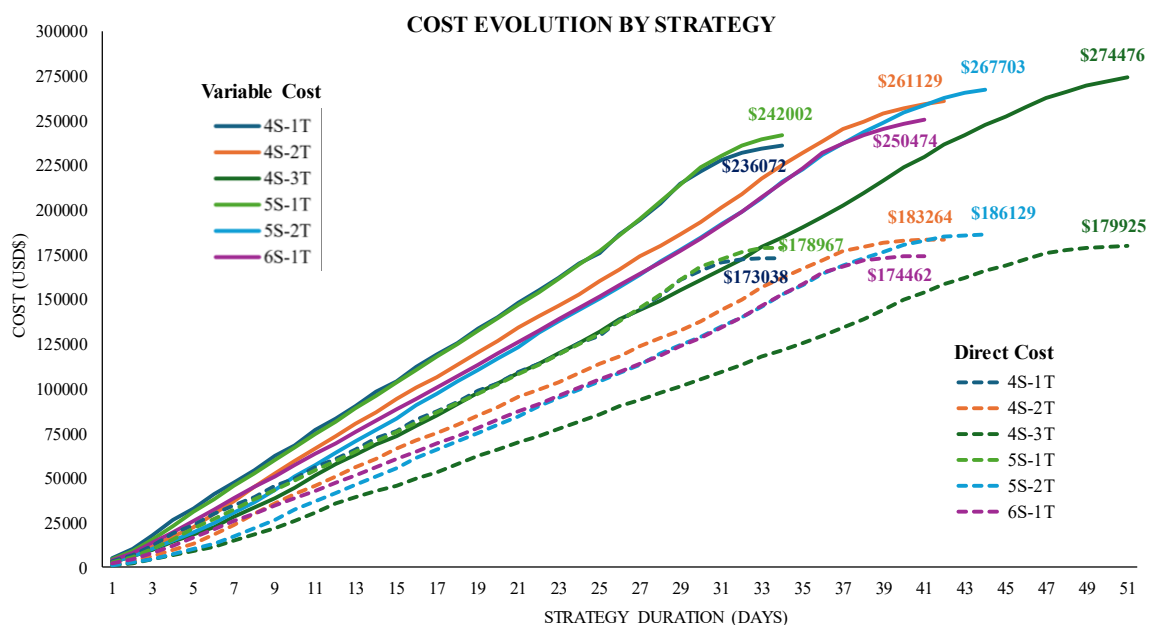


Figure 3: Cumulative evolution of variable cost by strategy

The comparison shows that shorter duration does not automatically imply lower total cost. Some strategies concentrate labor demand more intensely over shorter periods, while others distribute labor more smoothly but over longer durations, increasing indirect cost exposure. Thus, shorter duration is not interpreted as an advantage in itself, since performance must be assessed together with total cost and the project's actual capacity to sustain logistics, supply, and staffing without degrading flow.

IMPLEMENTATION DEMAND PROFILING

Once the strategies and their economic implications had been established, implementation demands were assessed under the critical conditions of the case. For this project, implementation demands were defined and assessed by the multidisciplinary technical team according to the specific conditions of the basement works and their capacity to distinguish meaningful differences among strategies. Some demands respond mainly to legal and contractual requirements, while others arise from operational conditions. Therefore, both the number and the nature of the demands may vary in other project contexts.

Structural capacity was incorporated because the construction sequence introduces shoring conditions and temporary loads associated with stockpiling and work in progress which, added to the parallelism of fronts, must be kept within the design and control requirements of the structural system established in Standard E.020 (Norma Técnica E.020, 2015). Technology was also considered, given that the effective and safe operation of critical equipment, especially that associated with the lifting and handling of prefabricated elements, depends on its availability and on having compatible access, operating spaces, and safety conditions. These factors limit the level of sustainable simultaneity and therefore condition the continuity of the work train. Supervision was incorporated because the Peruvian health and safety framework for construction establishes roles and requirements for preventive management and control on site, including formal supervisory responsibilities. Consequently, as the number of fronts and trades working in parallel increases, so does the demand for effective supervision required to maintain operational continuity and risk control (DS N. 011-2019-TR, 2019). Material logistics was incorporated because physical flows, supply, and space availability are recurring sources of constraints that affect work continuity, especially in confined environments where the work area and material handling condition the stability of flow (Ebbs & Pasquire, 2018). Labor availability was incorporated as a condition that increases the demand for coordination, given that task execution requires balanced staffing by specialty and consistency of crews over time. Feasibility therefore depends not only on the planned sequence, but also on the sustained availability of the corresponding crews. Finally, cash flow was considered because resource intensity and simultaneity increase initial cash flow demand and sensitivity to time dependent costs. Consequently, financial availability can limit the pace of the project and should be evaluated as an operational constraint in decision making (Orrechia & Howell, 1999).

To improve comparability, the demand imposed by each strategy under each condition was classified into three levels. Standard demand indicates that the strategy can be managed with ordinary project practices and resources. Care demand indicates that additional coordination or reinforcement is required in specific periods, fronts, or control windows. High demand indicates that the strategy requires sustained reinforcement, intensive coordination, or continued management attention throughout the program. Table 1 summarizes the resulting demand profile of each strategy. In the case analyzed, technology did not impose differentiating demands between alternatives, although this dimension should still be examined in other project contexts.

Table 1: Demands generated by the conditions for each strategy

Cond	4S T1	4S T2	4S T3	5S T1	5S T2	6S T1
Structural capacity	High simultaneity increases temporary loads and shoring. High demand	Temporary loads within standard range. Standard demand	Lower simultaneity reduces temporary demands. Standard demand	High simultaneity increases temporary loads and shoring. High demand	Planned and controlled shoring required. Care demand	High sectorization requires increased structural coordination. High demand
Supervision	Intensive coordination requires sustained reinforcement. High demand	Local reinforcement in specific windows. Care demand	Stable control with typical supervision. Standard demand	Intensive coordination requires sustained reinforcement. Care demand	Local reinforcement due to moderate simultaneity. Care demand	Sustained control due to multiple concurrent fronts. Care demand
Material logistics	Strict delivery windows to avoid interference. Care demand	More flexible and manageable supply. Standard demand	More flexible and manageable supply. Standard demand	Strict delivery windows to avoid interference. Care demand	Strict control of supply and access. Care demand	High spatial conflict due to increased sectorization. Care demand
Labor	Early high intensity pressures crew consistency. High demand	Hiring and reassignment by time windows. Care demand	Stable crews with low daily variability. Standard demand	Sustained high intensity pressures workforce. High demand	High labor demand manageable with control. Care demand	Variability increases risk of train decoupling. Care demand
Cash flow	Early consumption requires financial discipline. High demand	Close to threshold requires active management. Care demand	Relative buffer with respect to threshold. Standard demand	Early consumption requires financial discipline. High demand	Close to threshold requires payment control. Care demand	Close to threshold requires financial adjustments. Care demand

Note: Technology does not impose differentiating demands in the case analyzed; however, for other cases, it must be analyzed whether technological demand changes between strategies.

SYNTHESIS AND STRATEGY SELECTION

The synthesis integrates the economic performance obtained in the previous stage with the qualitative characterization of implementation demands, with the aim of selecting a strategy consistent with the priorities and capabilities of the project. Given that contractual income remains constant, the comparison focuses on variable costs and the operational implications associated with each alternative, avoiding a purely financial reading detached from the context of execution.

From an economic standpoint, strategies 4S–1T and 5S–1T show similar behavior in terms of both cumulative variable cost and total program duration, as shown in Figure 3. Both stand

out for having the lowest variable cost, which is economically attractive in the real estate context of the case study. Moreover, their shorter total program duration may improve pre sale conditions and increase financial flexibility. In this case, 5S–1T is selected as the preferred strategy because, even though it is not the lowest variable cost alternative, it is the second most economical of the set and maintains a comparable completion time that is no longer than 4S–1T. It also has a demand profile that is compatible with the capacity of the project team under real conditions, reducing relative pressures on logistics, structural coordination, and supervision. In contrast, 4S–1T defines the economic benchmark by presenting the lowest variable cost, but its demand profile is not compatible with the available capacity of the project, as it concentrates coordination and control requirements whose sustained management cannot be ensured without increasing the risk of loss of flow stability in a confined environment.

Among the alternative strategies, 4S–2T and 5S–2T show intermediate economic performance and more balanced demand profiles. Both moderate simultaneity with respect to the more aggressive configurations, which translates into more limited and manageable supervision and logistical control requirements through specific measures, while maintaining competitive economic performance. These strategies are relevant when seeking to reduce operational risk without significantly deviating from the economic performance of shorter duration alternatives.

For its part, 4S–3T has the most stable profile of the set. Its lower simultaneity and greater operational slack reduce pressure on staffing, logistics, and cash flow, at the cost of longer duration and, therefore, higher variable costs. This configuration is relevant when there are severe restrictions on supervision, labor availability, or working capital, and when operational robustness is prioritized over marginal economic efficiency.

Finally, 6S–1T represents a configuration with greater sectorization and high simultaneity that increases the complexity of coordination in confined environments. Although it can show competitive economic performance, its implementation requires greater control discipline to maintain train continuity and avoid interference associated with the coexistence of more fronts and transfers. Consequently, this strategy is interpreted as an alternative conditional on having superior organizational and logistical capacity, particularly in supply management, crew consistency, and work in process control.

Overall, the choice of strategy is not limited to identifying the lowest cost alternative, but rather to balancing economic performance and implementation demands. Under the conditions of the case analyzed, 5S–1T is adopted as the preferred strategy, while the remaining alternatives constitute a range of options consistent with different objectives and capabilities. In this way, the proposed framework provides structured support for early decision making in Takt Planning under real project constraints.

CONCLUSIONS

Selecting a Takt Planning configuration requires an integrated view that links the generation of feasible alternatives, the characterization of implementation demands under project conditions, and the economic comparison required to support commitment to execution, consistent with the need to explore alternatives rather than assume a universally optimal solution (Tommelein et al., 2024). Using this logic, the study defines a discrete set of comparable strategies, quantifies program level performance, and describes the demands each alternative places on supervision, logistics, labor, structural capacity, and cash flow. Applied to a real basement construction project, the framework provides a traceable link between strategy generation, demand profiling, and implementation oriented recommendations.

The results indicate that strategies designed to accelerate the program concentrate demand early in the execution, which increases pressure on coordination, supervision, and supply reliability, reinforcing the need for load balancing and disciplined control under variability

(Frandsen et al., 2013). Under the conditions of the case analyzed, the alternative with five sectors and a one day takt (5S–1T) emerges as the preferred strategy because it delivers competitive economic performance while keeping implementation demands within the project's ability to sustain coordination and control. As a result, the selection is not purely economic, since it reflects the tradeoff between variable cost and the demand profile required to execute without degrading flow stability.

Beyond the preferred option, the remaining strategies are best interpreted as conditional recommendations aligned with dominant constraints. Configurations with lower front concurrency and greater operational slack are suitable when supervision capacity, labor availability, or working capital are tight, as they reduce coordination pressure at the cost of longer duration and higher time related indirect exposure. Conversely, more aggressive configurations are appropriate when schedule compression is the primary objective and the project can sustain higher coordination intensity, supply reliability, and control discipline, since their performance depends on maintaining stable handoffs and preventing interference in confined work areas.

The analysis also confirms that critical conditions and their severity depend on the project type, the construction system, and the organizational and financial context. For that reason, demand profiling benefits from multidisciplinary participation and from an explicit focus on protecting the operational plan prior to execution, consistent with planning and control principles aimed at achieving reliable production conditions (Ballard, 1997). The contribution of the study is therefore not the identification of a single best strategy, but a structured and coherent basis for comparing Takt Planning alternatives against real implementation conditions, with potential applicability across different construction and contractual contexts.

This study is limited to a single case, so transferability should be interpreted with caution. In addition, the economic comparison considers only strategy dependent cost components and does not explicitly introduce variability in durations or productivities, while implementation demand assessment remains qualitative and therefore sensitive to team judgment. Future research should test the framework in other project types and strengthen its robustness by incorporating explicit variability through quantitative simulation such as Monte Carlo. This extension would make it possible to link uncertainty in durations and resource performance with the implementation demand profile and the economic evaluation, together with operational indicators such as takt compliance, cycle time variation, work in process, and site interference.

REFERENCES

- Ballard, G. (1997). Lookahead Planning: The Missing Link in Production Control. In S. N. Tucker (Ed.), *5th Annual Conference of the International Group for Lean Construction* (pp. 13–26). <http://iglc.net/Papers/Details/17/pdf>
- Binniger, M., Dlouhy, J., & Haghsheno, S. (2017). Technical Takt Planning and Takt Control in Construction. *25th Annual Conference of the International Group for Lean Construction*, 605–612. <https://doi.org/10.24928/2017/0297>
- DS N. 011-2019-TR, Pub. L. 011-2019, 130 El Peruano 41 (2019). https://www.leyes.congreso.gob.pe/Documentos/2016_2021/Boletin_de_Normas_Legales/NL20190711.pdf
- Ebbs, P. J., & Pasquire, C. L. (2018). Make Ready Planning Using Flow Walks: A New Approach to Collaboratively Identifying Project Constraints. *26th Annual Conference of the International Group for Lean Construction*, 734–743. <https://doi.org/10.24928/2018/0448>
- Fernández Rea, H. C. (2018). *Aplicación de herramientas Lean Construcción para reducir costos y tiempo en la colocación de encofrado, acero y concreto en la construcción de edificaciones en la ciudad de Huacho* [Universidad Nacional Jose Faustino Sanchez Carrion]. <http://repositorio.unjfsc.edu.pe/handle/UNJFSC/2621>

- Frandsen, A., Berghede, K., & Tommelein, I. D. (2013). Takt Time Planning for Construction of Exterior Cladding. In C. T. Formoso & P. Tzortzopoulos (Eds.), *21th Annual Conference of the International Group for Lean Construction* (pp. 527–536). <http://iglc.net/Papers/Details/902/pdf>
- Heinonen, A., & Seppänen, O. (2016). Takt Time Planning: Lessons for Construction Industry from a Cruise Ship Cabin Refurbishment Case Study. *24th Annual Conference of the International Group for Lean Construction*. <http://iglc.net/Papers/Details/1338/pdf>
- Jaillon, L., & Poon, C. S. (2014). Life cycle design and prefabrication in buildings: A review and case studies in Hong Kong. *Automation in Construction*, 39, 195–202. <https://doi.org/https://doi.org/10.1016/j.autcon.2013.09.006>
- Koskela, L. (1992). Application of the new production philosophy to construction. In *Center for Integrated Facility Engineering* (Vol. 72, p. 38). Stanford University. <https://stacks.stanford.edu/file/druid:kh328xt3298/TR072.pdf>
- Lehtovaara, J., Mustonen, I., Peuronen, P., Seppänen, O., & Peltokorpi, A. (2019). Implementing Takt Planning and Takt Control Into Residential Construction. *Proc. 27th Annual Conference of the International Group for Lean Construction (IGLC)*, 417–428. <https://doi.org/10.24928/2019/0118>
- Norma Técnica E.020, Pub. L. DS 011-2006-VIVIENDA., Reglamento Nacional de Edificaciones (2015). https://transparencia.produce.gob.pe/images/stories/Repositorio/transparencia/proyectos-de-inversion/niveles-de-servicio/2021/PNDP/NS/Norma_E_020_CARGAS.pdf
- Orrechia, F., & Howell, G. A. (1999). Reflections on Money and Lean Construction. *7th Annual Conference of the International Group for Lean Construction*, 253–262. <http://iglc.net/Papers/Details/80/pdf>
- Tommelein, I. D., Coelho, R. V., Formoso, C. T., Barth, K. B., & Vargas, F. B. de. (2024). No Single Takt Planning Method Fits All Projects. In D. B. Costa, F. Drevland, & L. Florez-Perez (Eds.), *Proceedings of the 32nd Annual Conference of the International Group for Lean Construction (IGLC 32)* (pp. 202–213). <https://doi.org/10.24928/2024/0151>
- Yarasca Colca, D. A. (2021). *Influencia en el cambio de sistema constructivo de las convencionales a prelosas en edificio multifamiliar Liberpark-Ciudaris* [Universidad Peruana Los Andes]. <https://hdl.handle.net/20.500.12848/2450>