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STAFFING GAP ANALYSIS FOR CONCRETE PUMP TECHNICIANS: A WLA AND FTE APPROACH IN THE HEAVY EQUIPMENT RENTAL INDUSTRY

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Abstract

Ensuring operational efficiency in the heavy equipment rental business requires a precise alignment between equipment availability and workforce capacity, particularly for concrete pump technicians operating across demanding project sites. This study addresses the empirical gap in technician staffing adequacy by applying Workload Analysis (WLA) and Full-Time Equivalent (FTE) within a heavy equipment rental company. Activity data from five technicians were collected through structured interviews and verified through layered validation involving HRD judgment, managerial review, and company work reports. The analysis produced a total annual workload of 6,221.25 hours, equivalent to 3.31 FTE, quantifying an overstaffing condition in which individual FTE values ranged from 0.60 to 0.71, all classified as underload. Scenario analysis further demonstrated that a staffing level of three technicians yields an FTE of 1.10, the only configuration falling within the normal workload range. These findings extend the application of WLA and FTE to concrete pump maintenance in heavy equipment rental, a context that remains limited in prior workforce planning literature, and demonstrate the value of multi-layered data validation in improving the accuracy of workforce requirement assessments.

Keywords: *Workload Analysis, Full-Time Equivalent, Workforce Planning, Concrete Pump Technicians, Heavy Equipment Rental.*

INTRODUCTION

In the heavy equipment rental business, efficiency is determined not only by the number of units but also by the company's ability to maintain equipment availability with proportionate workforce support. This pressure is particularly evident in concrete pumps because these machines are used in concreting activities that demand high continuity and often take place at external project sites. Under these conditions, downtime not only reduces equipment utilization but can also disrupt project schedules, interfere with customer service, and increase operational costs. Studies on concrete pump maintenance indicate that unit reliability is influenced by proper technical handling, but they have not addressed the adequacy of the number of technicians in rental companies, even though weak planning decisions in heavy equipment operations can lead to wasted cost and time (Deepak et al., 2025; Gurcanli et al., 2017).

Without a structured workload evaluation, determining the number of technicians tends to be carried out intuitively and reactively. For concrete pump technicians, this issue is particularly complex because the work depends not only on workshop routines but also on mobility to project sites, variations in damage complexity, and dependence on field conditions, making workforce requirements difficult to assess solely on the basis of operational habits or managerial perceptions. Ruppert et al. (2025) emphasize that maintenance workforce management requires a structured and data-based approach, but the study places greater emphasis on operator competence and resilience than on the quantitative evaluation of the optimal number of workers. In the company under study, indications of overstaffing have emerged, yet they have never been tested quantitatively.

WLA and FTE have been applied across various sectors to evaluate workload and estimate workforce requirements, yet their contextual boundaries remain consequential. In maintenance service and engineering project environments, these methods have demonstrated effectiveness in identifying workload mismatches and mapping cross-functional distribution (Khotimah & Jufriyanto, 2025; Rachmuddin et al., 2021). However, the work settings in those studies were relatively controlled and static, with limited exposure to cross-location mobility or real-time variability in damage complexity. Concrete pump technicians operate under fundamentally different conditions: their workload is shaped by field displacement, equipment failure unpredictability, and direct consequences for project continuity. This operational character has not been addressed in prior WLA-FTE applications, and the empirical gap it creates is not merely contextual but also methodological, given that existing studies generally relied on a single data source without structured validation mechanisms suited to mobile, multi-technician work environments. Studies on workforce planning for maintenance personnel are also still largely dominated by computational simulation and optimization. Akl et al. (2024) showed that maintenance workforce planning integrated with preventive and corrective maintenance decisions provides a more realistic picture because it simultaneously considers recruitment, promotion, backlog, and system costs, but the framework is also more complex in terms of data and computation. This condition makes the approach not always practical for medium-sized companies that require a rapid and operational basis for decision-making. In the context of concrete pump technicians, the need for validation is particularly important because activity data do not only record routine work but also cross-location assignments and differences among technicians. Therefore, the novelty of this study lies not only in the application of WLA and FTE to concrete pump technicians in a heavy equipment rental company, but also in strengthening methodological rigor through structured interviews validated in multiple layers by HRD judgment, managerial judgment, and company work reports. To the best of the authors' knowledge, no prior study has simultaneously addressed this contextual gap and methodological limitation within a single workforce requirement assessment framework. Accordingly, this study aims to assess technician workload and conduct a gap analysis between current staffing conditions and actual workforce requirements using WLA and FTE in a heavy equipment rental company.

THEORETICAL BACKGROUND

Workforce planning positions the number, distribution, and capacity of workers as strategic decisions that affect operational continuity. Within this framework, workforce requirements cannot be understood merely as the number of personnel, but must be linked to the available effective work capacity. Girasek et al. (2016) demonstrate the importance of distinguishing between headcount and FTE in monitoring labor supply, although their study was situated in the more standardized healthcare sector. In the maintenance function, this issue is also related to retention, skill gaps, and working conditions, as shown by Tretten et al. (2025). Meanwhile, Asres & Gessesse (2024) and Khotimah & Jufriyanto (2025) show that a needs-based approach can capture workload pressure and staff redistribution, but it has still been developed for healthcare facilities. Therefore, manpower planning requires a quantitative approach that remains operational in technical work contexts outside highly standardized sectors. This need becomes clearer when compared with workforce planning studies based on simulation and optimization. Akl et al. (2022) and Golbasi & Sahiner (2024) offer analytically robust models for maintenance staffing decisions, but they require extensive historical data and computational support that are not always realistic for medium-sized companies. This condition indicates that workforce requirement issues in technical functions do not always require the most complex model, but rather a model capable of translating actual work activities into measurable workforce requirements. In this context, the relationship between workload and work capacity becomes the core of the analysis.

Equation (1) shows that workload is formed by the accumulation of activities actually performed by workers. Mahmudi et al. (2020) shows that WLA can be used to measure workload and organize workforce requirements based on actual activities, while Ahmad et al. (2023) emphasize its relation to work execution efficiency. Widhiarso et al. (2022) also show that WLA can guide the determination of optimal workforce levels through time measurement and root-cause evaluation, while Sari et al. (2018) and Sekarjati et al. (2024) demonstrate that workload measurement remains relevant in SMEs and service industries. Nevertheless, most of these studies are situated in work contexts that are more structured than those of field technicians. Therefore, WLA is adequate for forming and measuring workload, but its main output is still limited to the total required working hours. In order for the total workload to be translated into more operational workforce requirements, a further instrument is needed to compare it with the effective work capacity per person.

$$Working\ Hours = \sum(Activity\ Frequency \times Activity\ Duration) \quad (1)$$

Equation (2) shows that Full-Time Equivalent (FTE) functions to convert the total workload calculated through WLA into workforce requirements based on the effective work capacity per person. A value below 1.00 indicates underload, a range of 1.00 to 1.28 indicates a normal condition, and a value above 1.28 indicates overload (Hardiansyah et al., 2022; Hudaningsih & Prayoga, 2019; Pangestu et al., 2024; Rachmuddin et al., 2021). Thus, the relationship between WLA and FTE is sequential: work activities form workload, workload generates required working hours, and FTE translates those required working hours into workforce requirements. Within this framework, the analysis results are determined not only by the formula but also by the accuracy of the activity data used as input (Sunarya et al., 2019; Yudhistira et al., 2023). Therefore, the need for data validation becomes important as a reinforcement of methodological rigor, particularly in addressing the limitations of previous studies that tended to rely on a single source of information (Hallowell & Gambatese, 2010; Yasmin & Ariyanti, 2019). At this point, this study occupies its position in the literature by applying WLA and FTE in the context of concrete pump technicians in a heavy equipment rental company, a context that remains limited in prior discussion, as existing studies on concrete pump operations have predominantly emphasized maintenance decision priorities rather than workload-based workforce requirements (Deepak et al., 2025).

$$FTE = \frac{Working\ Hours}{Effective\ working\ Hours} \quad (2)$$

METHOD

This study employed a quantitative descriptive design to assess the workforce requirements of concrete pump (CP) technicians in an anonymized heavy equipment rental company. The study covered all five active CP technicians at the time of data collection, making the technician workforce the unit of analysis. This focus was chosen because the objective was to measure workload and determine workforce requirements based on the activities performed by technicians, their annual frequency, and the time required to complete each task, rather than on the technical characteristics of the CP units themselves.

Before collecting activity data, this study first established annual effective working time as a comparison parameter in the analysis of workforce requirements. This parameter was necessary so that the total workload obtained could be compared with the annual work capacity of each technician under normal working conditions. For clarity of presentation, the non-effective time components are grouped into three functional categories. Off day refers to scheduled absences from work, including weekends, national holidays, and annual leave. Non-productive time refers to work-related activities that do not contribute directly to technician task completion, such as training, toolbox meetings, and inter-staff coordination. Personal time refers to rest periods within the working day. The calculation of effective working time is presented in Tables 1 through 4, organized by functional category.

Table 1. Off Day Components

Component	Days/Year	Hours/Year
Weekends	52	416
National holidays	12	96
Leave	12	96
Total	**76**	**608**

The off day category, as presented in Table 1, accumulated 76 days or 608 hours per year, representing the largest single deduction from the annual calendar, governed by company policy and national regulation.

Table 2. Non-Productive Time Components

Component	Days/Year	Hours/Year
Training	6	48
Toolbox meetings	1.5	12
Inter-staff coordination	15.05	124
Total	**22.55**	**184**

As shown in Table 2, the non-productive time category accumulated 22.55 days or 184 hours per year, with inter-staff coordination constituting the largest component at 15.05 days, reflecting the substantial coordination demands inherent in a field technician role.

Table 3. Personal Time Components

Component	Days/Year	Hours/Year
Breaks	31	248
Total	**31**	**248**

As detailed in Table 3, the personal time category recorded 31 days or 248 hours per year, treated as a direct deduction rather than an allowance percentage so as not to alter the structure of the FTE formula.

Table 4. Effective Working Time Summary

Component	Days/Year	Hours/Year
Calendar Days	365	2,920
Off Day	76	608
Non-Productive Time	22.55	184
Personal Time	31	248
Effective Working Days	**235**	**1,880**

As summarized in Table 4, after deducting all three categories from the annual calendar, each technician had 235 effective working days or 1,880 effective working hours per year, subsequently used as the fixed divisor in the Full-Time Equivalent analysis. Work activity data were collected through structured interviews with all five CP technicians to obtain comparable information on activity types, annual frequency, and duration. The use of a structured interview instrument supported consistency in collecting operational data in a specific technical context (Hallowell & Gambatese, 2010). Because activity compositions differed across technicians, all activity variations were recapitulated to construct the workload of the CP technician position as a whole. Before calculation, the interview data were validated through three layers: HRD review, managerial review, and cross-checking with company work completion reports. When discrepancies were found, the final decision was determined through managerial judgment based on available work evidence. This procedure was intended to strengthen the accuracy and consistency of the operational data used in the analysis, in line with the use of interviews in previous workload studies on technical field activities (Rachmuddin et al., 2021).

RESULTS AND DISCUSSION

Result

The workload analysis was initially conducted for each CP technician individually and then aggregated to determine the total workload of the position. This sequence was necessary because the workload of CP technicians consisted of different activity compositions, frequencies, and durations across individuals. Therefore, the individual tables are presented first to show each technician's workload profile prior to aggregation.

The WLA calculation may first be illustrated through one explicit example from Technician A's workload by applying Equation (1):

$$213 \times 0.5 = 106.5 \; Hours$$

$$106.5 + 852 + 72 + 53.25 + 96 + 52 + 24 + 24 = 1{,}279.75 \; Hours$$

Using Equation (1), the annual workload was obtained by multiplying the frequency of each activity by its duration and then summing all activity loads into an individual subtotal. Technician A is presented here as an explicit example to demonstrate the calculation procedure. The same equation was subsequently applied to all technicians before recapitulating the total annual workload of the CP technician position.

Table 5. Annual Workload of Technician A

Detailed Activity	Frequency (times/year)	Duration (hours)	Working Hours (hours/year)
Backlog and spare part checking	213	0.5	106.5
Pump unit repair	213	4	852
Sudden mobilization	24	3	72
Reporting to admin	213	0.25	53.25
On-site project repair	48	2	96
Maintaining area cleanliness	52	1	52
Remote repair coordination	48	0.5	24
Electrical troubleshooting	24	1	24
Total working hours for Technician A			**1,279.75**

As presented in Table 5, Technician A recorded a subtotal of 1,279.75 hours/year, with pump unit repair dominating at 852 hours/year, accounting for approximately 66.6% of the total workload.

Table 6. Annual Workload of Technician B

Detailed Activity	**Frequency (times/year)**	**Duration (hours)**	**Working Hours (hours/year)**
Backlog and spare part checking	52	0.5	26
Spare part and tools coordination	214	0.5	107
Unit backlog repair	214	4	856
Assisting TC maintenance	20	7	140
Maintaining area cleanliness	52	1	52
On-site project repair	4	7	28
Total working hours for Technician B			**1,209**

As shown in Table 6, Technician B recorded 1,209.00 hours/year, with unit backlog repair contributing 856 hours/year, representing roughly 70.8% of the total workload.

Table 7. Annual Workload of Technician C

Detailed Activity	**Frequency (times/year)**	**Duration (hours)**	**Working Hours (hours/year)**
Backlog and spare part checking	52	0.5	26
Spare part and tools coordination	214	0.5	107
Unit backlog repair	214	4	856
500-hour equipment maintenance	20	4	80
Maintaining area cleanliness	52	1	52
On-site project repair	4	4	16
Total working hours for Technician C			**1,137**

Table 7 shows that Technician C recorded the lowest subtotal at 1,137.00 hours/year, again with unit backlog repair as the dominant activity at 856 hours/year.

Table 8. Annual Workload of Technician D

Detailed Activity	**Frequency (times/year)**	**Duration (hours)**	**Working Hours (hours/year)**
Backlog and spare part checking	52	0.5	26
Spare part and tools coordination	214	0.5	107
Unit backlog repair	214	4	856
Unit/goods mobilization	24	4	96
500-hour equipment maintenance	20	4	80
Maintaining area cleanliness	52	1	52
Remote repair coordination	52	0.5	26
On-site project repair	4	4	16
Total working hours for Technician D			**1,259**

As detailed in Table 8, Technician D recorded 1,259.00 hours/year across the broadest activity portfolio of eight tasks, yet the workload remained anchored to the same 856-hour unit backlog repair function.

Table 9. Annual Workload of Technician E

Detailed Activity	Frequency (times/year)	Duration (hours)	Working Hours (hours/year)
Damaged unit repair	213	5	1065
Stock part repair	53	1	53
Product service	29	2	58
Preparing P2H spare parts	213	0.25	53.25
Preparing FBP spare parts	213	0.25	53.25
Maintaining area cleanliness	54	1	54
Total working hours for Technician E			**1,336.5**

As presented in Table 9, Technician E recorded the highest subtotal at 1,336.50 hours/year, driven predominantly by damaged unit repair at 1,065 hours/year, constituting approximately 79.7% of the total workload.

Across all five technicians, the workload structure was consistently concentrated in one dominant repair-related activity. Greater task variety, as seen in Technician D, did not translate into meaningfully higher total workload, and the divergence in activity types across individuals did not alter the underlying pattern. This indicates that workload differences among technicians were driven more by task composition than by broad differences in role breadth, and that the concentration of workload in a single core function appears to be a structural feature of how maintenance work is organized in this operational context rather than an individual anomaly.

The FTE value for each technician was calculated using Equation (2), as illustrated through Technician A:

$$\frac{1279.75}{1880} = 0.68$$

The same calculation was subsequently applied to all remaining technicians, with the complete results presented in Table 10.

Table 10. Individual FTE Results

Technician	Working Hours (hours/year)	Full-Time Equivalent (FTE)	Status
A	1,279.75	0.68	Underload
B	1,209	0.64	Underload
C	1,137	0.60	Underload
D	1,259	0.67	Underload
E	1,336.5	0.71	Underload
Total	**6,221.25**	**3.31**	

As shown in Table 10, the FTE values ranged from 0.60 to 0.71, with none reaching the lower boundary of the normal threshold as defined by Rachmuddin et al. (2021) and Hudaningsih & Prayoga (2019). Technician E recorded the highest FTE at 0.71, while Technician C fell at the lowest end with 0.60. Notably, the spread of only 0.11 across five individuals suggests that underload here was not a product of uneven task distribution among technicians, but rather a reflection of insufficient total workload relative to the existing headcount. The aggregate FTE of 3.31 makes this explicit: the combined annual workload of five technicians was only sufficient to justify approximately three full-time positions, pointing to a structural misalignment between staffing decisions and actual operational demand.

Based on this finding, the optimal staffing level for the CP technician position is established at three technicians, as this is the only whole-number configuration that produces a per-person FTE within the normal range. The lower threshold of the normal category is 3.31 technicians, obtained from dividing the total workload by effective working time at the FTE boundary of 1.00 per person. The upper threshold is 2.59 technicians, calculated using the FTE boundary of 1.28 per person. Because the number of workers in practice must be expressed as a whole number, only the 3-technician scenario operationally falls within that range. The 3-technician scenario yielded an FTE of 1.10, which not only satisfies the normal threshold but also retains a meaningful capacity margin. The distance between the achieved FTE of 1.10 and the upper boundary of 1.28 represents an absorption capacity of 0.18

FTE units per technician, equivalent to 338.4 additional working hours per technician per year. This margin is not merely a statistical residual. It suggests that each technician under the recommended staffing configuration could absorb a moderate increase in workload before reaching the overload threshold, providing the company with operational flexibility should demand for concrete pump services expand in the future.

Discussion

The findings indicate that the total workload of CP technicians, amounting to 6,221.25 hours per year, is equivalent to 3.31 full-time workers, confirming quantitative overstaffing under the existing condition of five technicians. The gap between aggregate FTE (3.31) and the current headcount (5) reflects a staffing decision that appears to have been shaped by operational convention rather than empirical workload measurement. This is consistent with Wahyuni et al. (2019) and Rachmuddin et al. (2021), both of whom identified similar mismatches between headcount and actual workload in technical work contexts. What distinguishes this study, however, is that the underload condition here was not confined to one or two individuals but was uniform across all five technicians, with FTE values ranging narrowly from 0.60 to 0.71. This uniformity suggests that the overstaffing was structural rather than distributional, meaning the problem was not how work was divided among technicians but that the total available work was insufficient to justify the existing number of positions.

This structural character of the finding has implications that extend beyond simple headcount reduction. Suryadi et al. (2025) similarly found workload mismatches in engineering work environments, but their context involved more predictable and internally bounded task structures. Concrete pump technicians, by contrast, operate in a more episodic and mobile environment where workload is sensitive to project demand cycles and equipment failure patterns. The underload condition identified here may therefore intensify or partially resolve depending on seasonal demand fluctuations, fleet expansion, or changes in service contract volume. These dynamics were not captured in the current cross-sectional measurement, which means the recommendation of three technicians should be understood as a baseline grounded in the observed operational period rather than a fixed permanent prescription.

From a managerial perspective, the 3-technician scenario is supported not only by its FTE of 1.10 falling within the normal range, but also by the absorption margin it retains. Each technician under this configuration could absorb up to 338.4 additional working hours per year before reaching the overload threshold, providing the company with operational flexibility should concrete pump service demand increase. This margin is practically meaningful in a rental context where demand can shift with construction project cycles. Consequently, WLA and FTE offer a viable basis for periodic staffing re-evaluation, particularly if the company expands its concrete pump fleet or takes on new long-term service contracts.

CONCLUSION

This study quantifies the workforce requirement of concrete pump technicians in a heavy equipment rental company, yielding a total annual workload of 6,221.25 hours and an aggregate FTE of 3.31. This figure falls below the existing headcount of five technicians, quantitatively confirming overstaffing across the entire technician group. Among the staffing configurations evaluated, only three technicians produced a per-person FTE of 1.10, the sole whole-number scenario falling within the normal workload range. Academically, this study extends the application of WLA and FTE to concrete pump technicians in the heavy equipment rental sector and strengthens methodological rigor through layered operational data validation involving HRD judgment, managerial review, and company work reports. This study is subject to several limitations. The cross-sectional nature of the data collection means that workload variation driven by seasonal demand, fleet size changes, or service contract dynamics was not captured. Additionally, the findings are primarily relevant to the operational context of the company under study, and generalization to other heavy equipment rental companies should be made with caution. Future research is recommended to integrate multi-year historical data for a more dynamic workload assessment and to examine how fleet composition and contract volume interact with technician workforce requirements over time.

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