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Rate of Productivity for Bore Pile Construction: A Case Study in Shah Alam

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Abstract

This study investigates the productivity rate of bore pile construction at a site in Shah Alam, focusing on identifying factors influencing efficiency. Bore pile construction productivity is critical to project success, yet comprehensive data remains limited. This research measures production rates and analyzes factors such as equipment performance, worker efficiency, soil conditions, and weather. Utilizing site observation methods, data on bore pile depths ranging from 900 mm to 2000 mm was meticulously recorded. The analysis revealed variations in productivity rates based on pile size and identified bottlenecks in equipment availability and weather disruptions. These findings highlight the importance of effective equipment management, proactive construction planning, and optimized resource allocation to minimize delays and enhance operational efficiency. Overall, this study provides practical recommendations for improving bore pile construction productivity and serves as a valuable reference for contractors, project managers, and researchers in geotechnical engineering.

1. Introduction

Delays in construction projects are widespread and costly, leading to extended project durations, increased expenses, and decreased customer satisfaction [1]. Research indicates that only 25% of projects are completed within 10% of their original timelines, with larger projects being more susceptible to delays [2]. These setbacks can result in reputational damage, reduced profitability, and diminished on-site productivity. Low productivity, often caused by time-intensive start-up tasks, poses significant challenges to project success. Key factors influencing labor productivity include worker experience, skills, training, leadership, and site management [3]. Effective site management plays a critical role in ensuring smooth project progress by producing accurate estimates and implementing efficient practices.

Studies emphasize the importance of effective communication, planning, resource allocation, conflict resolution, and quality control in improving construction productivity. However, challenges remain in accessing adequate productivity rate data and precise duration estimates, particularly for specialized tasks like piling works. This study aims to identify the optimal production rate for such activities in specific regions to address these gaps The objectives of this project are to measure the quantity of piling works and analyze their productivity rate. The study focuses on a single construction site in Shah Alam, using primary data collection methods like case studies and field observations. Challenges such as time constraints, resource limitations, and data collection difficulties may impact the study's depth. Data will be analyzed using descriptive statistics, such as mean, to determine the productivity rate.

The significance of this study lies in its potential to provide valuable insights into piling work productivity in Shah Alam. Improved productivity is crucial for economic growth and competitiveness, enabling construction companies to optimize resource use, reduce costs, and meet project deadlines. Additionally, studying productivity rates helps identify the best practices, set benchmarks, and develop industry standards, leading to better project outcomes and client satisfaction. Adopting lean construction principles and addressing inefficiencies, such as reducing non-value-added tasks, can further enhance productivity, benefiting the construction industry as a whole.

2. Methodology

This study was carried out in accordance with the methodology flow chart, which provided an overview of the overall framework of the studies. The project begins by formulating the issue statement, which is to find and analyse data on productivity in piling work. The next step is to perform a thorough literature study to gather existing studies and information on the issue. This stage aids in understanding the present level of studies and identifying relevant data on productivity rates in construction activity. Following the literature review, data collecting begins, which was most likely include a site survey to obtain information on productivity measures and any other relevant data that may affect the task. The obtained data is then examined to find trends, patterns, and major factors influencing productivity. This explains the observed patterns and suggests areas for improvement. Finally, suggestions are developed based on the findings.

This study was conducted at the one site construction in Shah Alam, Malaysia. The projected project aims for the construction of a five-story warehouse that satisfies contemporary industrial standards. Because of the soil conditions on the site and the structural requirements of the warehouse, bore piling was chosen as the best method of foundation building. A total of 562 boring piles are slated for construction, providing a strong and stable foundation for the multi-level structure. Bore piling requires precision drilling, reinforcing installation, and concrete pouring to provide the required load-bearing capacity. The scope of work highlights the project's magnitude and technical complexity, highlighting the significance of meticulous planning, adherence to safety standards, and successful execution in order to finish it on time.

From the previous studies, the duration for collecting data was conduct in one month. The data for this study were gathered every day from 8:00 AM to 12:00 PM and 1:00 PM to 5:00 PM has been selected as a guide to this project. This approach enabled regular monitoring of bore piling activities and ensured that critical information about progress and possible concerns was documented. However, the data collection period was changed to reflect the time required to finish each boring pile. A studies instrument in these studies was using site observation to collect data by monitoring a bore pile construction. For instance, Surya emphasizes the importance of direct on-site observations in analyzing labor productivity, noting that such observations can effectively capture the scope of work, construction time, and worker efficiency in various construction projects, including those involving lightweight steel structures [4]. This device is designed to collect firsthand data, which can give rich, contextual insights on building processes and practices.

The bore piling productivity analysis assessed job efficiency by measuring the duration of each segment in the process, including boring, concreting, and pile installation. Real-time observations recorded the time taken for various pile sizes (900 mm, 1350 mm, 1650 mm, and 1800 mm), enabling comparisons of productivity based on dimensions. Traditionally, productivity was defined as the ratio of input to output. In construction, output is measured in weight, length, or volume, and input is measured in labor expenses or man-hours [5]. the equation for productivity can be expressed as:

$$Productivity = \frac{Output}{Input} \tag{1}$$

The study evaluated trends and variations in productivity, identifying factors like equipment efficiency, labor performance, weather, and soil conditions that influenced operations. A complete data gathering form was created as shown in Fig 1. Key challenges, such as equipment downtime, unexpected soil conditions, and logistical delays, were analyzed to understand their impact on productivity. Data visualization techniques, including graphs and charts, were employed to make patterns and insights more accessible. The chapter concluded with an assessment of productivity rates across different stages of the process, providing a comprehensive view of the project's progress and recommendations for improving bore piling efficiency in future projects.

J. of Struct. Monit. and Built Environ. Vol. 6 No. 1 (2026) p. 37-42

				DRILLING WORK				CONCRETE WORK			NO OF WORKERS		MACHINERY				
NO	BOREPILE MARK	DEPTH	SIZE	DATE	HOUR	MECHINERY	WEATHER	DATE	HOUR	WEATHER	SKILL WORKERS	GANERAL WORKERS	EXCAVATOR	DRILLING MACHINE	CRAWLER CRANE	SOIL CONDITION	REMARK
1	B27	50.423	1800	8/19/2024	15.33	BG38	SUNNY	8/19/2024	6.5	CLEAR NIGHT	2	6	1	1	1	SILT CLAY	EXCHANGE POLYMER PIPE
2	B9	43.103	900	8/20/2024	14.00	BG30	HEAVY RAIN	8/20/2024	2.1	CLEAR NIGHT	2	6	1	1	1	SILT CLAY	
3	B34	51.827	2000	8/20/2024	13.50	BG38	SUNNY	8/20/2024	4.5	CLEAR NIGHT	2	5	1	1	1	SILT CLAY	
4	B46	50.227	1800	8/20/2024	10.00	BG38	SUNNY	8/20/2024	5	CLEAR NIGHT	2	6	1	1	1	SILT CLAY	
5	B52	63.934	2000	8/22/2024	20.00	BG38	HEAVY RAIN	8/22/2024	6	CLOUDY	2	5	1	1	1	SILT CLAY	
6	B36	46.448	1350	8/21/2024	11.00	BG30	SUNNY	8/21/2024	3.5	CLEAR NIGHT	2	6	1	1	1	SILT CLAY	
7	B42	53.505	1800	8/21/2024	10.00	BG38	SUNNY	8/21/2024	6.5	CLEAR NIGHT	2	6	1	1	1	SILT CLAY	
8	B4	38.653	900	8/22/2024	11.00	BG30	HEAVY RAIN	8/22/2024	1.8	CLEAR NIGHT	2	6	1	1	1	SILT CLAY	

Fig. 1 *Data collection form for bore pile construction productivity*

3. Results and Discussion

All The bore piling activities for this project involved installing 564 piles, with rigorous daily and weekly monitoring to track progress and identify delays. Data collected included the number of piles installed, site conditions, equipment performance, and personnel efficiency. Trends and variations were analyzed by comparing actual progress against targets, with findings presented in tables and charts for clarity. A graph in Fig 2 illustrated the daily progress of pile installation from August 19 to September 19, showing a gradual increase in completed piles over time. Early phases saw limited output from1 to 3 piles daily due to restricted machinery and labor availability. Larger-diameter piles (900mm, 1650mm, and 2000mm) were most commonly installed, with smaller sizes like 1350mm mm being less frequent but highlighting the project's diverse pile size requirements. The analysis provided insights into production trends, enabling better evaluation of milestones and recommendations for future operations.

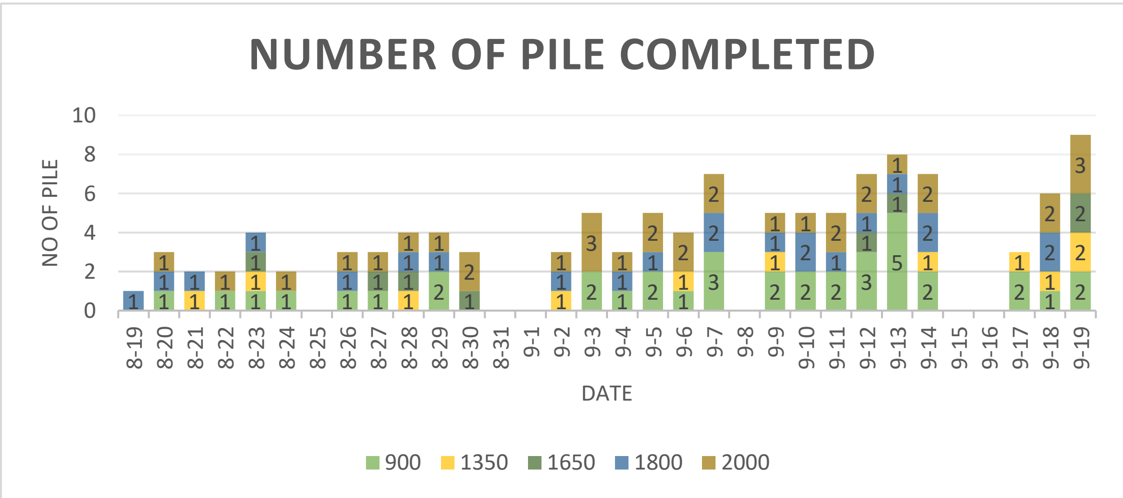

Fig. 2 *Number of piles completed by diameter in one month*

3.1 Productivity Analysis for Bore Pile By size

The examination of bore pile productivity gives useful information about the efficiency and performance of bore piling activities. This study focusses on determining productivity rates by investigating several operational components of the bore piling process. The volume of boring and concreting represents the amount of work performed, whilst time measurements highlight the efficiency of each step. The manpower and machinery records give information about resource allocation and operating capabilities. Weather conditions are monitored to determine their impact on the work schedule, and comments provide qualitative observations that may influence the results.

3.1.1 Bore Pile Size 900 mm

Upon reviewing the data, it is evident that the highest time consumed for boring is recorded for bore pile number B9, with a boring time of 14.0 hours. This extended duration can be attributed to several factors, including the weather condition and the depth of the borehole. It shows that point B9 was a deepest borehole for 900 mm diameter which is 43.103 m, this led to the extended duration of boring then the other point of bore pile. Additionally, weather condition during boring time it indicate that site facing a heavy rain, which may need to halt the operation for safety reason, seek a shelter and wait until condition is improve. Besides that, the condition of soil at site was a silt sand that can led to become waterlogged and unstable. Which is it can reducing the movement and safety of workers during boring activity. In concreting, bore pile B492 recorded the longest duration of 3 hours. This delay was caused by the use of a backup concrete plant due to high demand at the primary plant and the extended travel time of the concrete lorry from the distant plant to the site.

Overall, the total time spent on all operations for 900mm bore piles was 338.8 hours, with an average boring time of 6.853 hours and concreting time of 1.833 hours. The productivity rate for boring was 5.46 meters per hour, while concreting was 20.414 meters per hour. The combined productivity rate for the entire bore piling process was calculated at 4.308 meters per hour.

3.1.2 Bore Pile Size 1350 mm

The data depicts the productivity of bore piles with a diameter of 1350mm, including criteria such as boring time, concreting time, total time, and the number of skilled and general personnel employed. The entire boring time recorded is 82.0 hours, and the total concreting time is 33.3 hours, for a total duration of 115.3 hours over 11 bore piles. The average depth of these heaps is 42.00 meters, with an average boring time of 7.45 hours, an average concreting time of 3.03 hours, and an average total time of 10.48 hours per pile. Productivity indicators show a boring productivity of 5.63 m/hour and a concreting productivity of 13.88 m/hour, for an overall productivity of 4.01 m/hour, depending on the volume of concrete used per pile.

Boring times ranged from 4.25 hours (B146) to 11.00 hours (B36 and B48), influenced by factors such as soil conditions, equipment efficiency, and borehole depth. Despite being the second-shallowest pile at 37.3 meters, B146 had shorter boring times due to the use of the more powerful BG30 machinery compared to the BG26 used for B384 (33.7 meters). This highlights the significant impact of equipment type on productivity. Concreting times varied between 1.5 hours (B59) and 5 hours (B14), depending on pour complexity and concrete volume. The labor force was stable, with two skilled workers and six general laborers allocated per pile, reflecting efficient workforce management. The average total time per pile was 16.33 hours, with an average depth of 42.00 meters. While deeper piles generally required more time, the analysis showed that depth alone was not the sole factor affecting productivity. Equipment capability and operational strategies were critical in achieving efficiency.

3.1.3 Bore Pile Size 1650 mm

The investigation of bore pile production using the data presented In Table 4.3 shows many critical findings. Nine boring piles were built, with an average depth of 45.5 meters and a constant diameter of 1650 mm. The workforce was normally made up of two skilled workers and five to six ordinary labourers', with appropriate machinery utilization, such as excavators, drilling machines, and crawler cranes. The majority of drilling activities took place under bright weather, while heavy rain had an influence on production during bore pile B13 drilling. Notably, a borehole collapse was recorded for B12, raising concerns about soil stabilization measures.

The average boring time for bore piles was approximately 8.4 hours, with variations due to machinery type, site conditions, and unforeseen events. Pile B479 demonstrated high productivity, completing in just 4.5 hours, aided by the use of a more powerful BG42 machine. Conversely, B13 required 14 hours due to a borehole collapse, necessitating additional procedures such as welding extra casing lengths, which significantly delayed operations. Weather conditions, particularly heavy rain, also negatively impacted productivity. B13, which experienced rain during both boring and concreting, recorded the longest total duration for completing a single bore pile. This highlights the importance of weather monitoring and strategic scheduling to mitigate delays and enhance efficiency.

3.1.4 Bore Pile Size 1800 mm

The analysis of bore pile productivity for 23 piles with a uniform diameter of 1800 mm and depths ranging from 35.206 to 64.553 meters revealed significant variations in efficiency. The average pile depth was 50.4 meters, requiring substantial effort. Drilling times ranged from 4 hours and 33 minutes (B522) to 20 hours (B57), with an average of 11.5 hours. Concrete work was relatively faster, averaging 5.45 hours per pile. The workforce allocation was consistent, comprising two skilled workers and five to six general labourers. Equipment such as excavators, drilling machines, and crawler cranes was used effectively, though challenges arose from silty clay soil, which was particularly difficult to handle when wet.

Weather conditions and equipment reliability significantly influenced productivity. Rain during the drilling of B55 and B66 caused delays, while a machine breakdown at B549 further hampered progress. The average daily production rate was 298.5 meters for drilling and 54.7 meters for concrete pouring. While drilling showed relatively high efficiency, concrete work had room for improvement, with an average productivity of 13.04 meters per day. Overall, the productivity rate for completing the construction of 1800 mm diameter bore piles was 3.37 meters per hour, highlighting areas for operational enhancements.

3.1.5 Bore Pile Size 2000 mm

The analysis of bore piles with a 2000mm diameter reveals significant time variations during both boring and concreting due to external factors like weather conditions and equipment performance. The longest boring time, 20 hours, was recorded during heavy rain, likely caused by reduced visibility, unstable ground, and slower operational speeds. Similarly, concreting for larger piles faced delays, with the maximum duration of 9.5 hours also occurring under rainy conditions. The rain caused soil instability, hampering worker movement and machinery operation, and requiring pauses to prevent concrete dilution, which could affect its strength.

On average, the boring process took 10.22 hours, and concreting took 5.2 hours. The combined productivity rate for the entire process was 3.22 meters per hour. This rate serves as a useful benchmark, balancing operational efficiency with the challenges posed by large-diameter bore piles. Variations in productivity were influenced by factors such as soil conditions, equipment reliability, and team coordination, which together impacted the overall construction timeline

4. Conclusion and Recommendation

Avoid The study successfully met its objectives of measuring pile output and analyzing productivity rates through comprehensive data collection and site inspections. It revealed that pile production rates varied depending on factors like pile diameter, soil conditions, and equipment performance. For example, smaller 900mm bore piles had higher productivity rates (5.46 meters per hour) compared to larger 1800mm and 2000mm piles, which had slower rates of 5.07 and 4.87 meters per hour, respectively. Larger piles required more time due to their increased depth and volume, highlighting the need for more resources and advanced technologies.

The analysis of productivity rates identified key factors affecting efficiency, including equipment type, weather conditions, and soil composition. Larger bore piles, especially the 2000mm size, were significantly impacted by adverse weather, such as heavy rain, which led to slower work rates. Machinery performance was crucial, with more powerful rigs like BG42 and BG38 improving productivity, particularly for deeper piles. Additionally, experienced workers contributed to faster task completion and reduced downtime. The study emphasized the importance of proper planning, aligning equipment with project needs, and scheduling work during favorable weather conditions to optimize productivity.

The study's recommendations focus on improving efficiency and reducing inefficiencies in piling operations. Industry practitioners are advised to invest in advanced drilling rigs like the BG42 and BG38, which offer higher boring capacity and can significantly reduce drilling times. Weather mitigation strategies, such as scheduling critical tasks during dry seasons and using water-resistant casings, can help minimize delays caused by rainfall. Additionally, constructing backup concrete facilities can prevent disruptions caused by overreliance on a single supplier, ensuring a continuous concrete supply. Workforce development, especially in machinery handling and safety, is also crucial for improving performance and minimizing operational mistakes.

For future research, it is recommended to extend the observation period to gather comprehensive data from all project stages and explore production trends over time. Comparative studies across different construction sites with varying soil conditions could provide deeper insights into the factors influencing productivity. Further investigation into the integration of digital technologies, such as real-time monitoring and predictive analytics, could help identify bottlenecks and optimize processes. Additionally, more research into the geotechnical characteristics of bore piling would enable the development of targeted techniques to improve piling performance, ultimately contributing to higher standards and continuous improvements in the construction industry.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors are responsible for the study conception, research design, data collection, data analysis, result interpretation and manuscript drafting.

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