Journal of World Architecture, 2025, Volume 9, Issue 2
https://ojs.bbwpublisher.com/index.php/JWA
Online ISSN: 2208-3499
Print ISSN: 2208-3480

Management Measures for Large-scale Machinery and Equipment in Highway Construction

Yang Yu*

Chongqing Chengyu Dianfengwu Expressway Co., Ltd., Chongqing 400000, China

**Author to whom correspondence should be addressed.*

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Abstract: This article focuses on the management of large-scale machinery and equipment in highway construction, with the research objective of identifying issues at the management level and exploring more effective management measures. Through practical observation and logical analysis, this article elaborates on the management connotations of large-scale machinery and equipment in highway construction, affirming its management value from different perspectives. On this basis, it carefully analyzes the problems existing in the management of large-scale machinery and equipment, providing a detailed interpretation of issues such as the weak foundation of the equipment management system and the disconnection between equipment selection and configuration from reality. Combining the manifestations of related problems, this article proposes strategies such as strengthening the institutional foundation of equipment management, selecting and configuring equipment based on actual conditions, aiming to provide references for large-scale machinery and equipment management to relevant enterprises.

Keywords: Highway; Construction; Large-scale machinery and equipment management

Online publication: April 28, 2025

1. Introduction

A variety of large-scale machinery and equipment needs to be applied in highway construction. In construction management, the management of large-scale machinery and equipment is particularly important. After careful observation, comparison, and analysis, it can be found that although the importance attached to large-scale machinery and equipment management has significantly increased, there are many influencing factors related to equipment management in actual construction. Under the combined influence of many factors, various problems are likely to arise in equipment management. When these problems accumulate, the normal use of equipment and normal construction can be adversely affected. Therefore, it is particularly important to carefully manage large-scale machinery and equipment. For construction entities, how to systematically manage large-scale machinery and equipment while using them is also worthy of deep consideration[1].

2. Overview of large-scale machinery and equipment management in highway construction

2.1. Connotation of large-scale machinery and equipment management in highway construction

Large-scale machinery and equipment management in highway construction refers to the systematic planning, meticulous coordination, and control of large equipment used in construction, to ensure the safe and stable operation of various large equipment [2]. Through **Table 1**, it can be observed that there are many types of large-scale machinery and equipment used in highway construction, indicating that large-scale machinery and equipment management has the basic characteristic of high complexity. In large equipment management, it is also necessary to take into account different key points. Among them, the construction of the management system will have a lot of impact on subsequent management, and it is also very important to select and configure various equipment according to construction needs.

Table 1. Types and names of common large machinery and equipment in highway construction

Equipment type	Equipment name
Earthwork construction equipment	Bulldozer, excavator, loader, grader, etc
Road construction equipment	Concrete mixing equipment, asphalt paver, etc
Bridge construction equipment	Crane, prestressed tensioning equipment, etc
Tunnel construction equipment	Shield machine, rock drilling jumbo, etc

2.2. Value of large-scale machinery and equipment management in highway construction

The increasing focus on the management of large-scale machinery and equipment in highway construction is closely related to its important value. In summary, the value of large-scale machinery and equipment management is mainly reflected in ensuring the normal use of related equipment and supporting the construction of highway projects. From the perspective of ensuring equipment use, various types of large-scale machinery and equipment are usually required for highway construction. The management status of machinery and equipment will have a direct impact on whether the machinery and equipment configuration is reasonable and whether the performance can be exerted [3]. After doing a good job in various management tasks at this level, large-scale machinery and equipment can be more scientifically configured and used. From the perspective of supporting construction, large-scale machinery and equipment management can ensure that various equipment is in good operating condition. This can guarantee construction progress on the one hand and construction quality on the other. After fully utilizing various large-scale machinery and equipment for efficient construction, construction costs can also be effectively controlled. Using large-scale machinery and equipment to replace manual construction also helps improve construction safety [4].

3. Issues in large machinery and equipment management in highway construction

3.1 Weak foundation of equipment management system

Many construction enterprises actively engage in large machinery and equipment management during highway construction projects. However, the human and material resources invested in management often fail to fully translate into the expected management effectiveness. This situation is directly related to the weak

institutional foundation of management [5]. For instance, some construction enterprises have historically not focused on the institutional development of construction management, resulting in a lack of institutional guidance for large machinery and equipment management. Both the absence and inadequacy of basic institutional frameworks constitute fundamental problems at the management level. Without the guidance and norms provided by basic institutional frameworks, various management activities cannot be effectively directed and standardized during implementation. Managing without proper standardization can easily lead to efforts becoming mere formalities. Furthermore, without institutional support and guarantees, management activities conducted at different levels and stages lack internal coherence, and there is a lack of holistic advantages in management practices. More seriously, when management is conducted haphazardly without institutional guidance, it can easily give rise to new management issues. This indicates that the weak institutional foundation of large machinery and equipment management is not only a standalone management problem but also a potential trigger for other management issues [6].

3.2. Equipment selection and configuration not based on reality

The large machinery and equipment that may be used in highway construction are diverse. However, many construction enterprises fail to conduct a detailed analysis of equipment usage needs and also lack adequate construction research and planning. This leads to certain deficiencies in the selection and configuration of large machinery and equipment. One common problem in large machinery and equipment management is that equipment selection and configuration are not based on reality. Inadequate early planning prevents construction enterprises from accurately grasping the demand for large machinery and equipment during construction. Additionally, when some personnel lack sufficient understanding of the performance, characteristics, and scope of application of large machinery and equipment, equipment selection can be somewhat blind [7]. Regardless of the reason, equipment selection and configuration that are not based on reality can have many adverse effects on normal construction. For example, when large machinery and equipment are not delivered to the site in a timely manner, construction schedule management will be affected. At the same time, when the number of large machinery and equipment on site is significantly higher than the construction demand, equipment usage fees during construction will increase, driving up construction costs.

3.3. Insufficient standardization of equipment maintenance management

Large machinery and equipment management in highway construction involves multiple levels of management tasks, among which equipment maintenance management is a crucial aspect. The performance of large machinery and equipment is directly affected by maintenance conditions. Whether maintenance is proper not only impacts equipment usage but also extends to the construction of highway projects [8]. Some construction enterprises have not paid attention to the systematic maintenance of large machinery and equipment, especially when some equipment is rented. Their maintenance often lacks scientific planning support, maintenance records are filled out irregularly, and problems such as chaotic management of wearing parts and other spare parts are common. Additionally, many construction enterprises lack professional maintenance talent for large machinery and equipment, making it difficult to guarantee high-quality maintenance. When it is difficult to fully ensure scientific and standardized maintenance, deficiencies in this aspect can easily lead to hidden faults or safety hazards during equipment use. Insufficient standardization of maintenance management is also not conducive to extending the service life of large machinery and equipment and may even directly lead to an increase in equipment failure rates.

3.4. Low effectiveness of equipment safety management

Large equipment management in highway construction includes safety management, which is also an important component of construction management. When the construction volume of highways is large and the frequency of using large equipment is high, the pressure on equipment safety management is significantly higher. Although many construction enterprises attach great importance to safety management during the use of large machinery and equipment, the effectiveness of safety management is relatively low. For example, some equipment operators have a relatively weak safety awareness, and construction enterprises have not provided systematic safety education to relevant personnel, which is a common cause of equipment usage risks. In on-site safety supervision, there are limitations in the supervision of large machinery and equipment usage. Some supervisors have low comprehensive literacy and find it difficult to discover equipment safety issues in a timely manner. Most of the supervision they conduct is not routine supervision. Equipment safety management is highly professional, and it is not advisable to rely solely on on-site inspections for safety supervision. When multiple large machinery and equipment are used simultaneously in highway construction projects, the drawbacks of traditional safety management methods are further amplified.

4. Large machinery and equipment management measures in highway construction

4.1. Strengthen the institutional foundation of equipment management

The management of large machinery and equipment in highway construction relies heavily on institutional support. Integrating the concept of institutionalized management into management practices, building and strengthening the institutional foundation on this basis is crucial. For example, a certain highway construction enterprise places great emphasis on institutional development in large machinery and equipment management. The specific institution includes various management requirements (as shown in **Table 2**). The establishment and implementation of this institution provide effective guidance for various management activities. Simultaneously, the institution fully considers management affairs at different levels, proposes various management requirements, and the implementation of the institution also enhances the comprehensiveness of large machinery and equipment management to a certain extent. For highway construction enterprises, they also need to actively carry out institution building based on the needs of large machinery and equipment management, refine the management requirements in the institution, provide institutional guidance and norms for management practices, create a better institutionalized management environment, and avoid other management problems caused by irregular management.

Table 2. Basic content of large machinery and equipment management institution

System content module	Management components
Equipment purchase (lease) and acceptance	Management of equipment purchase (lease), acceptance criteria and processes, etc.
Equipment ledger and file management	Ledger establishment, file management, etc.
Equipment use and operation management	Operating procedures and standards, operator management, etc.
Equipment maintenance and servicing management	Maintenance plan development and implementation, maintenance quality assessment, etc.
Equipment safety management	Safety supervision, identification of safety hazards, safety rectification, etc.

4.2. Selection and allocation of equipment based on actual conditions

In the management of large-scale machinery and equipment for highway construction, attention should be paid to the scientific selection and reasonable allocation of equipment to avoid adverse effects on normal construction due to improper selection and allocation. For example, highway construction enterprises should carefully analyze construction requirements before formal construction, and determine the types and quantities of large-scale machinery and equipment required based on the analysis of project scale, progress, technology, and quality requirements. Equipment selection should consider equipment versatility and compatibility to facilitate flexible configuration of large-scale machinery and equipment at different construction stages. Taking the selection of loaders as an example, some models of loaders have multiple operating functions, and selecting such loaders can improve their comprehensive utilization rate. In the allocation of large-scale machinery, it is necessary to fully integrate the construction process and needs to ensure coordination in the use of large-scale machinery and equipment. Taking concrete pouring construction as an example, it is advisable to calculate the production capacity of the concrete mixing station, transportation distance, and the demand for concrete quantity during construction to determine the number of mixer trucks and pump trucks, which can not only ensure a stable supply of concrete during construction but also take into account the economic principles in the use of large-scale machinery and equipment. After effectively selecting and configuring various large-scale machinery and equipment based on highway construction needs, the value of large-scale machinery and equipment in construction can also be fully utilized.

4.3. Standardized equipment maintenance management

Large-scale machinery and equipment used in highway construction cannot be separated from maintenance management, which is directly related to the performance and service life of related equipment. Apart from giving sufficient attention to maintenance management issues, construction enterprises should also standardize equipment maintenance management. For example, a highway construction enterprise develops equipment maintenance plans in the maintenance management of large-scale machinery and equipment, and carries out standardized maintenance and maintenance quality supervision based on specific plans. Working with equipment manufacturers and technical personnel, and combining equipment maintenance requirements, the maintenance plan includes maintenance cycles, projects, and responsible persons, and also puts forward detailed requirements for routine maintenance, regular maintenance, and special maintenance matters. After developing a strict maintenance plan, the construction enterprise will carry out large-scale machinery and equipment maintenance based on the plan, fill in maintenance records in detail, promptly report problems and perform equipment maintenance to ensure stable equipment operation, and inspect and evaluate equipment maintenance quality based on the maintenance quality supervision mechanism. Thanks to the standardized maintenance management of large-scale machinery and equipment, the performance of different equipment is guaranteed, and the service life can also be extended, which also provides great help in avoiding equipment performance problems. Naturally, highway construction enterprises need to standardize equipment maintenance.

4.4. Dynamic safety management of equipment

Safety management is a top priority in highway construction, and its importance is self-evident in the management of large-scale machinery and equipment. At this stage, most construction activities require the use of large-scale machinery and equipment, which necessitates dynamic safety management. Specifically,

highway construction enterprises should establish a safety inspection mechanism related to the use of large-scale machinery and equipment, and assign safety inspectors, technicians, and operators on the construction site to conduct safety inspections together. Safety inspections should take into account safety performance checks, inspection of protective device configuration, electrical system checks, and brake system checks. Since the safety risks in the use of large-scale machinery and equipment are difficult to completely avoid, highway construction enterprises should develop emergency plans, clarify emergency response divisions based on common safety accidents involving large-scale machinery and equipment used in construction, organize regular emergency drills for construction workers, and focus on strengthening the safety awareness of operators. By conducting regular safety inspections and dynamically managing the safety of large-scale machinery and equipment based on these inspections, potential safety hazards in equipment use can be identified in a timely manner. This provides numerous guarantees for the normal use of large-scale machinery and equipment in construction. Naturally, highway construction enterprises need to consider safety management as the core of large-scale machinery and equipment management.

5. Conclusion

Through research, it can be found that multiple key points need to be considered in the management of large-scale machinery and equipment in highway construction, and managing related equipment is also of great value. At this stage, there are some problems in the management of large-scale machinery and equipment, and solving these problems is the key to improving the effectiveness of management. Consolidating the foundation of equipment management systems can provide institutional support for management practices. Selecting and configuring equipment based on construction needs can provide more assistance for highway construction. While using various equipment, it is also necessary to carefully maintain the equipment and normalize equipment safety management. Besides managing from the above perspectives, detailed evaluations should also be conducted during management. On this basis, various problems can be solved, and continuous optimization can be carried out, which can also promote the improvement of management effectiveness.

Disclosure statement

The author declares no conflict of interest.

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