Industrial Engineering and Innovation Management (2020) 3: 97-101
Clausius Scientific Press, Canada
DOI: 10.23977/ieim.2020.030204
ISSN 2522-6924

Discussion on Loading and Reinforcement Method of Equipment Transportation Based on Dynamic Programming

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Keywords: civil equipment, Dynamic planning, Loading reinforcement

Abstract: As an important support of the national economy, railway transportation has developed rapidly in recent years, while various wheeled equipment rely on railway transportation, and its traffic volume also has a certain increase every year. The research on the loading and reinforcement scheme of civil equipment railway transportation can provide theoretical support for the preparation of the negotiation plan and help to reduce the negotiation differences and disputes. How to deal with the problem of determining the loading and reinforcement scheme caused by the large number of flat cars and the increasing types and quantities of special equipment under the consideration of economy becomes the starting point of this study. Based on the principle and method of dynamic programming, combined with practical cases, this paper studies the optimal selection of equipment transportation routes, and provides important scientific decision-making basis for equipment managers. This paper introduces the loading and reinforcement equipment and methods of railway special flat car transportation equipment, analyzes the advantages and disadvantages of these equipment and reinforcement methods, puts forward improvement suggestions, and puts forward suggestions for future development.

1. Introduction

In equipment management activities, decision-making is a multi-stage and multi-step analysis and judgment process, which runs through all stages of equipment management activities. The vast majority of equipment transportation management decisions are multi-stage decision-making issues [1]. As an important support of the national economy, railway transportation has developed rapidly in recent years, while various wheeled equipment rely on railway transportation, and its traffic volume has also increased to a certain extent every year [2]. How to deal with the problem of determining the loading and reinforcement scheme caused by the large number of flat cars and the increasing types and quantities of special equipment under the consideration of economy has become the starting point of this study [3]. Due to the limitations of transportation routes, the dynamics of decision variables, the instability of the optimal scheme and other constraints, how do equipment manufacturers choose the shortest transportation route according to the existing traffic conditions [4]. The choice of equipment transportation route is a multi-stage decision-making

problem often encountered in equipment management. At present, the transportation demand for special self-propelled roller equipment is growing rapidly, and most of them are ultra-high and ultra-long equipment. The traditional ordinary railway flat cars can no longer meet the demand. In recent years, they have gradually developed into special vehicles with special low bearing surface to transport these special equipment [5]. Carrying out research on the civil equipment railway transportation loading and reinforcement plan can provide theoretical support for the preparation of the negotiation plan, help to reduce negotiation differences and disputes, and improve cross-border railway delivery safety and efficiency [6]. This paper takes the problem of equipment transportation route selection as the specific research object, adopts the principles and methods of dynamic programming, and gives specific mathematical models and decision-making processes in combination with actual cases, thereby contributing to scientific decision-making in equipment management activities.

2. Main Factors Affecting Loading and Reinforcement Scheme

The section headings are in boldface capital and lowercase letters. Second level headings are typed aCross-border railway delivery is one of the assessment subjects of the joint civil exercise. It has strict requirements on the delivery time limit. Participating organization must be proficient in railway loading and unloading and reinforcement and binding technology methods to meet the time limit. The higher the safety of a loading and reinforcement plan for an overrun equipment, the less it is restricted by various railway rules and regulations, and the more adaptable its transportation environment, the higher the timeliness of delivery. On the contrary, the worse the safety of the scheme, the lower the adaptability of the transportation environment, and the more restricted the transportation conditions must be [7]. In this scheme, transportation measures such as speed limit, ban, detour, etc. are often adopted, and the speed of transportation is bound to be poor. Therefore, the speed of railway transportation of over-equipment equipment can be attributed to the safety of the loading and reinforcement scheme. My country's railway civil transportation loading standards are based on individual equipment, and they have formulated more detailed loading standards. If the equipment types are different, it is necessary to refer to similar equipment standards. After calculating the relevant force values, a detailed loading and reinforcement plan is re-established.

Because of the many factors involved in the civil equipment support program and the strong structural hierarchy, research on such issues requires the use of structural modeling techniques. Major developed countries generally attach importance to quality construction and limit the cost of weapons and equipment development and manufacturing. This change has had a major impact on the development of civil equipment. The armies of developed countries have a more mechanized basis of weaponry systems. Civil equipment will continue to improve its technical performance and further play its basic role as an organic component of weaponry and a mobile platform.

3. Evaluation Model of Vehicle Equipment Support Scheme

Mark the comparison space finger as $G=(S,E,\omega,X)$. Among them, $S=\{s_1,s_2,\ldots,s_m\}$ represents the set of equipment support teams to be evaluated, and s_k is the kth vehicle equipment support team. $E=\{e_1,e_2,\ldots,e_n\}$ indicates the evaluation index set, e_r is the rth index, consider the characteristics of the evaluation index in the index set E, and record E_1 as the efficiency type index (the bigger the better), E_2 is the cost type index, then: $E_1,E_2\subset E, E_1\cup E_2=E, E_1\cap E_2$; $\omega=\{\omega_1,\omega_2,\ldots,\omega_n\}$ means Index weight set, ω_r is the weight of the evaluation index e_r,

$\sum_{r=1}^{n}\omega_r = 1, \omega_r > 0$; $X = (x_{kr})_{m\times n}$ is the decision matrix, where: x_{kr} is the index value of the s_k of the vehicle equipment support team regarding the evaluation index e_r.

In order to analyze in the same space, the optimal evaluation set $U = \{u_1, u_2, \ldots, u_n\}$ and the worst evaluation set $V = \{v_1, v_2, \ldots v_n\}$ are determined from the index values of each index, where u_r and v_r represent the optimal and worst index values of the evaluation index set e_r, respectively. The selection of the comparison interval involves the type of evaluation index. For $e_r \in E_r$, the comparison interval is $[u_r, v_r]$; for $e_r \in E_2$, the comparison interval is $[u_r, v_r]$. The optimal and worst evaluation sets U and V together constitute the comparison space [V, U].

In order to maximize the existing support forces and restore the combat effectiveness of the equipment in the shortest time, it is necessary to optimize and evaluate the existing support programs. The assessment is considered from the two aspects of guarantee purpose and guarantee benefit, each of which contains multiple sub-assessment indicators. For the benefit index $e_r \in E_1$, it is in the comparison interval $[v_r, u_r]$. There is $\frac{x_{kr}}{u_r + v_r}, \frac{x_{kr}^{-1}}{u_r^{-1} + v_r^{-1}} \in [0,1]$, and numerically represent the closeness of x_{kr} and u_r, and the closeness of x_{kr} and v_r. At the same time, in $[v_r, u_r]$, the closeness of x_{kr} and v_r also shows the distance between x_{kr} and x_{kr}, and the definition of the same degree of the pair of $\{x_{kr}, u_r\}$, a_{kr} and c_{kr}, is opposite:

$$a_{kr} = \frac{x_{kr}}{u_r + v_r}, c_{kr} = \frac{x_{kr}^{-1}}{u_r^{-1} + v_r^{-1}} = \frac{u_r v_r}{(u_r + v_r)x_{kr}} \tag{1}$$

Furthermore, the difference b_{kr} of the set pair $\{x_{kr}, u_r\}$ is defined by equation (2):

$$b_{kr} = 1 - (a_{kr} + c_{kr}) = \frac{(u_r - x_{kr})(x_{kr} - v_r)}{(u_r + v_r)x_{kr}} \tag{2}$$

According to the above analysis, for the benefit index, the connection degree between the set and $\{x_{kr}, u_r\}$ is defined as:

$$\mu\{x_{kr}, u_r\} = \frac{(u_r - x_{kr})(x_{kr} - v_r)}{(u_r + v_r)x_{kr}} i + \frac{u_r v_r}{(u_r + v_r)x_{kr}} j + \frac{x_{kr}}{u_r + v_r} \tag{3}$$

Similarly, for the cost index $e_r \in E_2$, in the comparison interval $[u_r, v_r]$, the connection degree of the set pair $[x_{kr}, u_r]$ is defined as:

$$\mu\{x_{kr}, u_r\} = \frac{u_r, v_r}{(u_r + v_r)x_{kr}} + \frac{(u_r - x_{kr})(x_{kr} - v_r)}{(u_r + v_r)x_{kr}} i + \frac{x_{kr}}{u_r + v_r} j \tag{4}$$

When $x_{kr} = u_r$ or v_r, the degree of difference is 0, indicating that the uncertainty of characterization is the smallest. When $x_{kr} = \sqrt{u_r v_r}$, the difference is the largest, which is $1 - \frac{2\sqrt{u_r v_r}}{u_r + v_r}$, which means that the uncertainty of portrayal is the largest.

4. Discussion on Strengthening Methods of Equipment Transportation and Loading

In the railway transportation of civil equipment and materials, except for sporadic transportation, the whole train transportation and sporadic transportation vehicles with no shunting restrictions do not have shunting impact conditions. The existing wheel stopper is of integral structure, heavy in mass and large in volume, and is not easy to store and transport. The folding structure can effectively solve the above problems. The device takes a bottom plate as a main body, and wheel stop panels with different arc radii are respectively installed on two sides. The material can be metal or non-metal materials with low density such as aluminum alloy to better reduce self-weight. When the organization maneuver, the vehicles and equipment they carry should be mainly general consumption equipment, and the repair teams accompanying the support should also prioritize and carry some vulnerable equipment according to the type of vehicles they support [8]. When countries design the protection of civil vehicles, they put forward different protection grade requirements according to the combat mission of the vehicles, and meet the needs of different users by providing armored protection components. This ensures the mobility, fuel economy and safety of the vehicle when used in safe areas. Serialization and seriation development not only improves the capability of civil equipment modification and matching and adaptability to various tactical missions, but also is beneficial to maintenance and support due to the high degree of generalization of various series of civil equipment.

Scientific research institutions should be close to actual combat needs, adapt to the rapid mobility of organization, and develop portable personal special tools and maintenance kits. During the maneuver, the tool box and equipment box carried by the repairman should be carried on the back of the person. It should not be too heavy, but should be simplified. The organization should make full use of the advantages of local vehicle repair plants, such as complete equipment and strong technical force, establish and improve the rapid repair team and civilian repair leading group, coordinate with the emergency training of the organization, carry out necessary drills in a planned way, and form a civil-civilian joint vehicle technical support system. Loading and reinforcement shall be organized and implemented by the transported organization. During the normal railway delivery training, the transported organization all train their own equipment and reinforcement equipment, and they are not familiar with reinforcement equipment of other countries. If the particularity of civil transportation and the actual situation of long-term transportation safety are fully considered, it is feasible to discount the loading and reinforcement strength of equipment and materials.

5. Summary

The core issue in formulating the loading and reinforcement plan is stress and stability analysis. When our civil transportation and delivery department formulates the loading and reinforcement plan for equipment at ordinary times, it should not only consider the railway transportation environment within China and the requirements of the railway department, but also conduct in-depth research on the railway status quo of other countries that are in line with China's railway. Scientific and reasonable equipment transportation, loading and reinforcement scheme is an important guarantee to quickly restore the civil combat effectiveness, but in practical application, the scheme selection is often unsatisfactory due to lack of appropriate methods. On the premise of sufficient preparation time for exercises and training in normal times, special vehicles can be considered to transport out-of-gauge equipment. In case of emergency transportation and emergencies, the better model of ordinary flat cars can be selected.

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