Demand Analysis of Emergency Rescue Engineering Machinery Based on AHP and QFD

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Abstract. Aiming at the problem of emergency rescue engineering machinery and equipment demand analysis, the demand analysis method based on AHP and QFD is used to establish an index system. Through the analysis of the AHP method and the construction of the house of quality method, the mapping relationship between user needs and equipment performance requirements is completed. It better solves the processing relationship from user needs to equipment performance requirements, and provides a reference for the system design of rescue engineering machinery.

1. Introduction
My country has a vast territory and abundant resources. It is one of the countries in the world where natural disasters are more serious. Earthquakes, hurricanes, tsunamis, mudslides and other major natural disasters have brought huge threats to people’s lives and property safety. In the face of severe natural disasters, excavators, loaders, bulldozers and other construction machinery have become important equipment in the hands of rescuers. In recent years, construction machinery has played an important role in rescue and disaster relief operations.

2. Development status of emergency rescue engineering machinery equipment
Rescue and rescue is an important task undertaken by the PAP, and it is also a normalized task in performing diversified tasks. In rescue operations, we participate in rescue operations against natural disasters such as floods, earthquakes, droughts, and mudslides. In the face of the ever-increasing number of disasters, construction machinery and equipment are an indispensable material foundation and important tool for efficiently completing rescue and relief tasks. Therefore, scientific analysis of the demand for construction machinery and equipment for emergency rescue operations is the key to effectively dealing with disasters and accidents, and it is also a powerful guarantee for improving the troop's ability in emergency rescue and disaster relief missions.

With the development of society, there are more and more emergency rescue and rescue tasks, and the scope of rescue is getting wider and wider. Whether it is traffic accidents, mine accidents, or natural and geographical disasters with high frequency, new rescue capabilities of the troops are requirements and challenges. Therefore, building and developing emergency rescue equipment with advanced technical performance, giving full play to the technical performance of the equipment, and increasing the success rate of accident rescue operations are important guarantees for improving the success of rescue operations.
From the perspective of rescue operations, at present, construction machinery and equipment have not yet formed a complete support capability in terms of forming a rescue capability. First of all, rescue operations require high tactical and technical performance of construction machinery, but there is still a certain gap between the capability level of existing construction machinery and the requirements to complete the task. Secondly, the emergency response of rescue equipment is outstanding, the requirements for technical performance are high, and a certain amount of scale is required. It is difficult to accurately grasp the law of demand for equipment and technology, which makes the demand for rescue equipment face great challenges. Finally, emergency rescue operations have diverse needs for construction machinery, and correct analysis of their actual needs is an important guarantee for scientifically improving the rescue capabilities of construction machinery.

In the process of product development, it is a systematic method of multi-level deductive analysis that maximizes the satisfaction of customer needs and user-driven improvement. The basic idea is that in the process of product development, everything is driven by customer needs, preferences and expectations, and customer needs are transformed into quality requirements, so that products can meet customer needs. This method better reflects the demand mapping relationship in equipment design and manufacturing, but this method of demand analysis is only a qualitative analysis method, and it cannot quantify the relationship between the development layers. When these relationships are fully reflected Has certain limitations. In order to ensure that the demand analysis can truly reflect the true needs of the troops for equipment capabilities, can correctly reflect the relationship between the mission and operational performance of the equipment, and ensure that newly developed construction machinery can complete the rescue mission, it is necessary to analyze the theory of construction machinery. , Methods and technologies for in-depth research.

3. Method of demand analysis of emergency and rescue construction machinery based on AHP and QFD

3.1 The general idea of the demand analysis of construction machinery equipment

Requirement analysis is the process of determining the operational performance of equipment. In the current equipment design theories and methods, the main method is to analyze, synthesize, and weigh according to the characteristics of the equipment itself and the needs of combat tasks. To complete the demand analysis of construction machinery, The basic idea is shown in Figure 1. the following tasks should be done:

![Figure 1 Construction machinery demand analysis structure diagram](image)

First of all, combining the characteristics of construction machinery and the need to complete tasks, clarify the types of missions that construction machinery may undertake.

Secondly, analyze the characteristics of the tasks that the construction machinery and equipment may undertake, qualitatively make the functions that the construction machinery and equipment need to have, and accurately propose the capability requirements of the construction machinery and equipment.
Thirdly, in view of the capacity requirements of construction machinery and equipment, investigate and study the current scientific and technological capabilities and the level of economic support, and evaluate the feasibility of technical and economic realization.

Finally, on the basis of understanding the capacity requirements and constraints of construction machinery equipment, determine the use performance requirements of the equipment, and form performance indicators that meet the requirements and constraints.

3.2 Methods in demand analysis of construction machinery equipment

3.2.1 The use of analytic hierarchy process. Different missions have different ability requirements, and different ability requirements have different degrees of importance relative to the overall goal of equipment requirements. The determination of needs should meet the following requirements, namely: as complete as possible, integrating various needs from multiple customers; determining the importance of needs; distinguishing needs and solutions; clarifying needs that can be negotiated and those that cannot be changed; correct Divide the level of demand, the demand items of the same house of quality must be at the same level.

The use of analytic hierarchy process to identify the importance of equipment capability requirements, compared with traditional qualitative analysis methods, can effectively reduce randomness and improve the accuracy of equipment meeting user needs. The mission of construction machinery and equipment is mainly embodied in the rescue mission. The abilities that construction machinery equipment should possess mainly include: maneuverability, operation ability, survivability, environmental adaptability and communication ability.

On the basis of the hierarchical structure model, construct a new judgment matrix, single-level ordering and its consistency test, total level-ordering and its consistency test. The second level of single sorting is the weight of mission tasks, and the third level of single sorting is the weight of equipment capability requirements for a certain mission. The overall ranking is the degree of importance of military construction machinery capability requirements relative to equipment targets.

3.2.2 The use of expert scoring method. In the process of completing the analytic hierarchy process, the judgment matrix is involved, which is usually determined by practical investigation or expert scoring. For the judgment matrix in the analytic hierarchy process, multiple industry experts can be used to judge separately, and then the method of comprehensive analysis can be realized. For the value of related characteristics, you can invite multiple industry experts to score the importance and find the average value according to the following rules: the score is determined according to 5 levels of very weak, weak, medium, strong, and strong. Then calculate the values corresponding to 1, 3, 5, 7, and 9.

| relativity       | Expert A | expert B | expert C | expert D | average value |
|------------------|----------|----------|----------|----------|---------------|
| Support ability  | 8        | 7        | 7        | 7        | 7.25(7)       |
| Work ability     | 6        | 6        | 6        | 8        | 6.5(6)        |

4. Demand analysis of construction machinery equipment

4.1 Analysis of task requirements of construction machinery

According to the requirements of rescue missions and the characteristics of construction machinery and equipment, the missions are determined as follows:

4.1.1 Participate in emergency rescue engineering support. mainly for repairing roads, especially in mountainous jungles and other complex terrain conditions, to ensure that troops can move smoothly
and carry out various emergency rescue operations. At the same time, it ensures the smooth
development and conduct of various rescue operations.

4.1.2 Participate in various rescue operations. Natural disasters usually occur under more complex
terrain conditions, such as disasters and accidents caused by earthquakes, mudslides and floods in
mountainous terrain, and landslides make road traffic unsmooth. Construction machinery needs to
develop various machinery Operations, such as opening up passages, grabbing passages, cleaning up
waste residues, and so on.

In order to complete the above tasks, the abilities it should possess mainly include mobility,
operation ability, survivability, environmental adaptability and communication ability, etc. The
established analytic hierarchy model is shown in Figure 2.

![Figure 2. Hierarchy of needs analysis model](image)

On the basis of the hierarchical structure model, construct a judgment matrix, single-level ordering
and its consistency test, and total level-ordering and its consistency test. The second level of single
sorting is the mission weight. The construction, calculation and consistency check of the judgment
matrix are shown in Table 2. The third-level single ordering is the weight of equipment capability
requirements for a certain mission.

4.2 Performance indicators and autocorrelation degree of construction machinery
According to the tactical and technical performance characteristics of construction machinery and
equipment, the performance indicators corresponding to the required capacity requirements are mainly:
engine power, total equipment weight, overall dimensions, maximum driving speed, traction quality,
maximum gradeability, operating device capacity (corresponding For excavation, loading, bulldozing
and other equipment.

Among the above performance indicators, the autocorrelation characteristic is more obvious. If it is
a mutual promotion relationship, the two properties are positively correlated; if it is a mutual
cancellation relationship, the two properties are negatively correlated.

For machinery that uses chassis traction, such as bulldozers, graders, loaders, etc., the weight of the
whole machine is directly related to the traction, that is, it has a positive correlation with the operating
rate and traction quality, and the machinery that uses the operating characteristics of the working
device to work , Such as digging machine, etc., its operation rate is not directly related to the weight of
the whole machine, small multi-functional engineering vehicles belong to the former. The engine
power has a direct relationship with the traction force and the operating force of the working device,
that is, the engine power has a positive correlation with the traction quality, operating rate, maximum
travel speed, and maximum climbing degree; the maximum travel speed, maximum climbing degree
and the weight of the whole machine have a positive correlation. Strong negative correlation, weak
negative correlation with external dimensions.
4.3 Establish a mapping relationship between capability requirements and performance indicators

Using the QFD method, the established house of quality is shown in Figure 4. Place the construction machinery equipment capability requirement item on the left wall, and place its importance on the right wall. Put the performance index on the ceiling and the degree of autocorrelation on the roof. The floor is the performance index importance value calculated by weighting, and the underground floor is the final output, that is, the performance index weight value. The size of the weight value indicates the priority of the corresponding performance index setting or adjustment.

|                   | Mechanical power | Traction | Traction quality | Operation rate | Maximum travel | Maximum grade |
|-------------------|------------------|----------|------------------|----------------|----------------|---------------|
| Work ability      | 6                | 4        | 3                | 8              | 2              | 0.39          |
| Survivability     | 5                | 4        | 6                |                | 2              | 0.32          |
| Communication ability | 2            | 5        | 6                | 3              |                | 0.29          |
| Maneuverability   | 3                | 5        |                  |                |                | 0.23          |

Figure 3. Demand-indicator QFD

For different missions, different ability requirements are required to be transformed into performance indicators through the House of Quality. Among them, priority should be given to engine power, maximum driving speed, overall weight, and operating rate. These indicators are the key to fulfilling the mission and tasks required by users. The technical and economic constraints are then comprehensively analyzed to provide for the design of construction machinery and equipment.

5. Concluding remarks

This paper proposes an AHP-based demand analysis method for construction machinery and equipment. Through the comprehensive application in demand analysis, various performance indicators are sorted, and the feasibility of this method in demand analysis is verified with examples. To a certain extent, the accuracy and scientificity of the demand analysis of construction machinery and equipment are guaranteed. In actual application, it is necessary to analyze the characteristics of construction machinery and equipment in a more in-depth and detailed manner, and conduct specific analysis in combination with specific model requirements to obtain more effective conclusions and provide reference for equipment design and development.

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