

## Research on Comprehensive Evaluation Model of Ship Shape Based on Fuzzy Mathematics Theory

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### ABSTRACT

This paper briefly describes the development characteristics of ship type standardization in the United States and the European Union, and also discusses the development process of ship type standardization in China, and establishes a fuzzy comprehensive evaluation model based on the fuzzy mathematics theory and the comprehensive evaluation method. Based on the theory of fuzzy mathematics and the comprehensive evaluation method, the fuzzy comprehensive evaluation model is established. This paper discusses the selection of evaluation indexes in the evaluation method by using the analysis of participants' interests, analyzes the composition of the existing ship type standardization index system, and defines the factors for the selection of value indexes. Finally, the principle and composition of the evaluation index system are given.

**Keywords:** Standard ship; principal dimension; fuzzy evaluation; evaluation index

### INTRODUCTION

The developed countries of inland water transport attach great importance to the construction and development of the main scale series of standard ship types.

With reference to the United States and the European Union, the choice of barge fleet or single motor-driven ship as the main mode of waterway transportation is influenced by many factors, such as water channel and freight, which will also affect the maximum capacity of single self-propelled ship and the maximum capacity of fleet transportation.

It can be seen from the scale development of transportation capacity that the fleet transportation mode is obviously superior to the self-propelled single ship. The selection of transportation mode should be determined according to channel scale, lock scale, flow conditions, traffic volume and other factors.

In order to improve the role of inland ships in the water transport system, enhance the external positive effect of ships, and accelerate the development of modern ships, since 2001, the Ministry of transport and the Ministry of finance, together with relevant provinces and

cities, began to implement a series of ship type standardization demonstration projects.

In 2001, the former Ministry of Communications issued the regulations on the standardization management of inland transport ships. In 2003, the demonstration project was implemented in the Beijing Hangzhou canal. In 2009, the standardization of ship types was promoted in the Yangtze River main line. In 2013, the standardization of ship types was promoted nationwide.

### FUZZY EVALUATION

The word "fuzziness" comes from the definition of mathematical concept to realistic phenomenon. From the mathematical point of view, the phenomenon can be divided into three categories: deterministic, stochastic and fuzzy. It can be seen from the classification that fuzziness is neither definite nor random. For the deterministic phenomenon, the set is used to process, and the corresponding characteristic function is the feature function; for the fuzzy set to deal with, the corresponding membership function.

The fuzzy evaluation model is based on the fuzzy mathematics theory, using the comprehensive evaluation method, with the help of the analytic hierarchy process, under the condition of basic

parameters, through the model; we can get the method to measure the advantages and disadvantages of the main dimensions of multi scheme ship.

The comprehensive evaluation method is a systematic and scientific evaluation method, which considers all indicators comprehensively and gives a certain weight to each indicator. By scoring each indicator and multiplying the weight, we can get the overall evaluation of things or programs.

Firstly, the factor set of fuzzy comprehensive evaluation is determined, and the factor set is the set of evaluation indexes; The second step is to determine the evaluation set, which is the set of optional values of each evaluation index; The third step is to determine the weight of each factor, that is, to score the importance of the evaluation index; The fourth step is to establish the evaluation matrix, evaluate the degree of each factor belonging to each comment (judge scoring or membership function), determine the fuzzy comprehensive evaluation matrix, and evaluate each factor; The fifth step is fuzzy comprehensive evaluation, which is based on the appropriate fuzzy synthesis operator to calculate the total evaluation, and then make the judgment according to the maximum membership principle.

### EVALUATION CRITERIA

Appropriate evaluation criteria should be based on the analysis of participants' interests.

The typical evaluation criteria are related to the expected benefits or the necessary costs of the project participants. For the inland transport ships, the stakeholders include the ship owner, the shipping management department and the ship lock management department, and the benefit evaluation of these three parties is the core part of the ship type scheme evaluation.

First of all, in order to improve the competitiveness of shipping, ship-owners who take profit as their main business purpose must reduce the shipping cost, improve the profit margin and shorten the investment payback period;

Secondly, the shipping management department, whose primary goal is to ensure the safety and smoothness, will pay more attention to improving the efficiency of the logistics channel and the safety level of energy conservation and environmental protection of ship transportation;

For the typical ship passing through the lock of the Three Gorges project, the most concerned is

the adaptability of the main dimensions of the ship to the lock of the Three Gorges project, that is, whether multiple ships can make full use of the lock room space to improve the passing capacity of the lock.

At the same time, with the different starting point of the evaluation, there are different degrees of evaluation results. It is necessary to establish comprehensive evaluation criteria to integrate the opinions of all parties, so as to form scientific and objective conclusions.

Therefore, the comprehensive evaluation method is used to evaluate the main dimensions of ship types comprehensively, establish comprehensive evaluation criteria, and comprehensively consider the opinions of all parties.

### INDEX SYSTEM

Compared with the previous documents, the existing ship type standardization management documents expand the technical requirements of the standard ship type from the "main scale series" to the "index system". The standardization index is no longer only the value of the master, ship width and draft of the single main scale of the ship type, but also the mandatory index of the ship energy conservation and emission reduction. At the same time, the recommended index reflecting the advanced aspects of the ship is added.

The establishment of the evaluation index system of ship type needs to combine with the existing index system, and the selection of the main scale evaluation index of ship type needs to consider all aspects of "safety, efficiency, green and advanced".

First of all, on the safety level, it meets the safety requirements and the ship building codes and regulations;

Secondly, in the aspect of high efficiency, meet the requirements of energy conservation, meet the energy consumption index, and improve the energy efficiency performance of ships and the capacity of navigation facilities;

Thirdly, on the green level, it meets the emission reduction requirements and emission indicators;

Finally, in the advanced level, meet the requirements of progress; meet the management, structure, equipment technology, materials, technology innovation.

## PRINCIPLE OF FORMULATION

According to the standard evaluation criteria of main dimensions of ship type, the following three aspects should be considered in the analysis of the index system of standard ship type and the formulation principle of comprehensive evaluation index.

Firstly, on the premise of meeting the transportation demand and ensuring the safety of the ship, the main goal is to improve the passing capacity of the lock;

Secondly, the adaptability of shipping infrastructure (channel, wharf, bridge, lock, etc.), social benefits (energy efficiency design index of inland ships), technical performance (ship safety, ship rapidity, maneuverability, etc.), economic performance (ship loading capacity, cost index, benefit index, etc.) should be considered comprehensively;

At last, the comprehensive evaluation model is established by qualitative and quantitative analysis, theory combined with practice and multi-disciplinary integration to objectively evaluate the comprehensive benefits of ship type;

Effectively alleviate the contradiction between the demand of passing through the lock and the insufficient capacity of the lock, and maximize the economic benefits of transportation.

## SYSTEM COMPOSITION

The evaluation index system consists of four kinds of indexes, i.e. adaptability index, navigation safety index, technical and economic index of ship passing through the lock and energy conservation and environmental protection index of ship.

The first is the adaptability index of the ship lock. Starting from improving the passing capacity of the Three Gorges ship lock, the adaptability index of the ship lock reflects the efficiency of each selected ship combination passing through the lock, that is, the utilization ratio of the lock room area and the tonnage per unit time passing through the lock. The larger the two indexes, the better.

The second is the navigation safety index, which mainly includes the safety of the lock facilities and the safety of the ship itself.

For the navigation safety index of the lock, the Berthing Capacity of the floating bollards is taken as the evaluation index, the maneuverability of the new main scale ship type is analyzed, and the high initial stability of the ship is taken as

the navigation safety index to evaluate the navigation safety of the ship.

Thirdly, it is the technical and economic index. The naval coefficient and cargo capacity coefficient are selected as the technical index of ship type.

The larger the technical index value is, the better. The necessary freight, unit oil consumption and transportation efficiency are selected as the economic index.

Finally, the energy conservation and emission reduction index is selected as the energy conservation and emission reduction standard index of ship type. The ship energy efficiency design index is a measurement tool to characterize the inherent CO<sub>2</sub> emission level of ship in the design and construction stage.

## RESULTS AND DISCUSSION

This paper discusses the current situation of the development of ship form scale at home and abroad, constructs a fuzzy evaluation model, expounds the formulation principles of the evaluation index system, and constructs the evaluation index system.

Based on the theory of fuzzy mathematics and the comprehensive evaluation method, the operation steps of the fuzzy comprehensive evaluation method are put forward.

For the selection of indicators in the fuzzy comprehensive evaluation method, from the perspective of ship owner, shipping management department and ship lock management department respectively, the multi-dimensional stakeholder analysis of the evaluation indicators is carried out.

## CONCLUSION

The establishment of index system is mainly from four aspects of "safety, efficiency, green and advanced". For the composition of the fuzzy comprehensive evaluation index system, the paper puts forward the formulation principle of the evaluation index with the main objective of improving the passing capacity of the ship lock on the premise of meeting the transportation demand and safety. The evaluation index system is composed of four kinds of indexes, i.e. adaptability index, navigation safety index, technical and economic index and energy conservation and environmental protection index.

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