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Large-Scale Water Conservancy Project Optimization Based on Fuzzy Grey Multi-Criteria Decision Model

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Abstract: Fuzzy grey multi-criteria decision making method is used to build the carbon fiber reinforced polymer for water conservancy engineering construction simulation analysis model of composite materials, mainly through the establishment of different sandwich relative density of carbon fiber reinforced polymer composite materials (CFRP) square honeycomb sandwich structure under the effect of underwater explosion shock wave load simulation model, analyses the structure of the deformation process, sandwich compression feature and structure of the failure and damage. Based on the empirical analysis results of the new material, the construction schedule of the water conservancy project is optimized. The results show that the maximum compression of the honeycomb sandwich of CFRP composites increases slowly and then rapidly with the increase of the initial pressure. The failure of CFRP composite sandwich structure presents different modes with the change of relative density and initial pressure, and its protection performance is better than that of equal-weight laminated structure. This research result can provide reference for optimizing the construction schedule of hydraulic engineering, especially for the construction optimization of new composite materials.

1. Introduction

With the increasing importance of new explosives in the construction of water conservancy projects, how to use new composite materials with high precision to improve the construction progress efficiency of water conservancy projects is a core problem that is widely concerned by the current architectural circle. For modern protective structures in water conservancy engineering construction, lightweight has become a key index to evaluate the stability of water conservancy engineering construction. In the past few decades, metal sandwich structure has been a hot spot in the research of hydraulic engineering construction. Many researches have been carried out on dynamic response of sandwich structures under the action of explosion shock wave in water. Thomas Seyfried (2017) proposed a systematic design method to analyze the explosion response of the structure, and divided the dynamic underwater explosion response process of the sandwich structure into three stages, namely the fluid-structure coupling stage, sandwich compression stage and panel bending and extension stage. Valerie Coleman (2019) used the finite element method to study the underwater anti-explosion performance of homogeneous structure and sandwich structure with different sandwich configurations. At the same time, theoretical modeling of related problems was carried out on the basis of considering the fluid-solid coupling effect. Based on the finite element simulation, Rajan Varadarajan (2018) analyzed the dynamic response process of sandwich structure under underwater explosion load, and studied its response mechanism, proving that the protective performance of sandwich structure is better than that of equal-weight homogeneous structure. Through experiment and numerical simulation, Indrek Ibrus (2019) studied the deformation and failure mode of stainless steel sandwich structure with honeycomb sandwich and pyramid lattice sandwich under the action of water impact load, and conducted theoretical analysis on the dynamic response of the structure [1].

However, due to the high density of metal materials, the use of metal materials for structural lightweight design and its application in hydraulic engineering construction has a higher difficulty. In contrast, fiber reinforced composites have attracted much attention in the application of protective structures due to their low density, high specific strength, high corrosion resistance and durability, and good designability. However, the research on the sandwich structure of fiber reinforced composites focuses on the processing and preparation of materials and structures, mechanical properties testing, vibration analysis and low-speed impact. For example, the preparation method and bending response of composite sandwich structures with different sandwich configurations, quasi-static mechanical analysis of carbon fiber reinforced polymer composite honeycomb sandwich structures and their dynamic response under low-speed impact conditions, and vibrations in sandwich structures Attenuation analysis, etc. However, the research on the dynamic response and failure mode of composite sandwich structures under shock wave loading in water is rarely reported [2].

In this paper, a square honeycomb sandwich structure made of CFRP composite is taken as the research object. The dynamic response of the explosion under shock wave load in water is studied by numerical simulation method. The deformation process of the structure is described and the compression characteristics of the honeycomb interlayer are analyzed. At the same time, the deformation and failure mode of the structure under different conditions are described, and the protective performance of the composite laminate with equal mass is compared. The strength of the CFRP composite sandwich structure in the explosion shock wave load protection in water can be accurately measured. . In addition, the relevant empirical results of this paper can provide reference for improving the construction efficiency of hydraulic engineering and enhancing the construction safety performance of hydraulic engineering [3].

2. Simulation Model

2.1 Geometric Model and Related Settings

The sandwich structure consists of the front and back panels of the same thickness and the honeycomb sandwich. The materials of each component are carbon fiber reinforced polymer composites. Each layer has a thickness of about 0.25 mm. The number of panel layups in the structure studied in this paper is 40. The substrate is a high thermal stability epoxy resin. Since the thickness of the composite material constituting the sandwich grid is much smaller than the grid spacing L, the relative density of the square honeycomb sandwich structure can be obtained by approximating the following formula.

2.2 Material Model

The acoustic medium is selected as the water material model, which can accurately describe the wave propagation in the material and solve the problem of acoustic-solid coupling analysis. The equilibrium equation for this model is as follows: In the above formula: p is the dynamic pressure in the fluid; is the spatial position of the fluid particles; is the velocity of the fluid particles; is the acceleration of the fluid particles; is the fluid density; is generated when the fluid flows in the matrix material Volume resistance. In this paper, the water body material density, the volume elastic modulus, and thus the water sound speed. In addition, since the water cannot withstand the tensile force, its cavitation pressure is set.

3. Results and Discussion

3.1 Cfrp Composite Sandwich Structure Deformation Process

Taking the relative of the sandwich and the initial pressure of the shock wave as an example, the deformation process of the CFRP composite sandwich structure under the shock wave load in water is described.

3.2 Cfrp Composite Sandwich Compression Characteristics

The compressive amount of the sandwich is characterized by the relative compression, that is, the ratio of the compression value in the thickness direction of the sandwich to its initial thickness. the compression amount of the core increases slowly with the increase of the initial pressure， and the core failure mode is mainly buckling.

3.3 Cfrp Composite Sandwich Compression Characteristics

The overall damage of the structure is obtained when the relative compression of the core is c/c0=0.05, 0.4 and 1.0 respectively. It can be seen that when the initial pressure is small, the compression of the CFRP composite core is low, buckling deformation occurs, and the degree of damage is light and concentrated in contact with the rear panel. The front panel has almost no damage, and the degree of deformation is small, and local bending occurs only at the position in contact with the core. The rear panel is damaged at the restraint position, and the whole body is bent and deformed. With the increase of the initial pressure, the core failure mode gradually changes from buckling to crushing and curling, and the degree of compression becomes higher and the damage is more serious. The local curvature produced by the front panel is also more serious, and delamination damage begins to occur. The damage at the constrained position of the rear panel begins to expand toward the center of the panel, and the overall bending degree is also continuously increased, and the delamination damage is also more serious.

4. Conclusions

(1) Carbon fiber reinforced polymer matrix composite material The square honeycomb sandwich structure under the impact of water shock wave, the front panel speed rapidly reaches the peak and then gradually decays, and the rear panel speed fluctuates under the restraining reaction force; current and rear panel speed When the agreement is reached, the compression of the honeycomb core reaches a maximum. This conclusion can be used as an important precondition for optimizing the construction progress of water conservancy projects.

(2) With the increase of initial pressure, the compressive amount of CFRP composite honeycomb core increases slowly and then increases rapidly. When the core is nearly fully compressed, its tendency to increase with initial pressure becomes slower; Under initial pressure, the larger the relative density, the smaller the compression of the core.

(3) Under different initial pressures, the components of the CFRP composite square honeycomb sandwich structure exhibit different failure and failure modes. When the amount of compression of the core is the same, the damage of the structural rear panel with the higher relative density of the core is more serious. This means that in the process of construction of water conservancy projects, not only the chemical properties of the new materials need to be concerned, but also the physical tolerance of the materials under different working conditions needs to be analyzed in a targeted manner.

(4) CFRP composite square honeycomb sandwich structure has better protection effect than equal weight laminate, which proves the superiority of CFRP composite sandwich structure in water shock wave protection structure. This means that the new composite material can be used as an important production material in the construction process of hydraulic engineering.

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