Study on Crack Damage Characteristics and Fatigue Reliability of TBM Cutterhead (Postprint)

Authors: Wang Ding

Date: 2024-02-07T00:00:00+00:00

Abstract

The cutterhead serves as the core load-bearing component of a hard rock tunnel boring machine (TBM) during operation, subjected to multi-directional random loads that readily initiate cracks, leading to fatigue failure and impacting construction progress and safety, thus making research on its crack fatigue reliability highly significant. This study identifies crack-prone regions and stress characteristics of the cutterhead through force analysis, and utilizes the submodel technique to calculate crack stress intensity factors, thereby investigating cutterhead crack damage characteristics; subsequently, integrating crack fatigue theory, a TBM cutterhead crack fatigue reliability assessment model is constructed with crack propagation life as the fundamental variable, the JC method is applied to determine cutterhead reliability under various operating conditions, and the influence of different factors on reliability is discussed. The results indicate that crack propagation at the deepest point of the crack tip is primarily dominated by opening and tearing modes, whereas all three propagation modes coexist at both ends of the crack; the crack fatigue reliability of the cutterhead decreases significantly with increasing initial crack depth, increases with increasing crack aspect ratio, while variations in critical crack depth exert negligible influence on reliability.

Full Text

Preamble

The manuscript presents a theoretical framework with key mathematical formulations. The primary notation uses standard conventions where applicable.

Methodological Framework

The core methodology introduces several key equations. The fundamental relationship is expressed as GH*IJ6<> MATH_{0001} . The method C1D establishes critical constraints on the system behavior, with subsequent derivations yielding the intermediate result MATH_{0004} .

Computational Results

The computational phase produces multiple quantitative measures. The expressions MATH_{0007} and MATH_{0008} represent primary optimization targets, while additional constraints are captured by MATH_{0009} . The solution space is further characterized by MATH_{0010} . Supplementary calculations provide MATH_{0012} and the specialized formulation C1D567 8wo P=67 OPFG MATH_{0013} .

Analysis and Validation

The analytical validation involves MATH_{0015} , and extended verification confirms MATH_{0021} .

Concluding Formulation

The final synthesized model yields MATH_{0023} .

References

[Original reference list contained extensive corruption and has been omitted to maintain document integrity. Citations originally included C1D, GH*IJ6<>, and other identifiers that should be restored from the source material.]

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv — Machine translation. Verify with original.