

A Study on the Effect of Torsional Stiffness Improvement on Chassis Frame Durability

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ABSTRACT: Torsional loads during vehicle operation significantly affect the fatigue life and durability performance of a chassis frame. This study investigates the relationship between torsional stiffness and fatigue durability performance. First, a 1D element-based parameter study was conducted to identify major design parameters related to cross-sectional geometry and sheet metal thickness. The selected parameters were then verified using a detailed 2D shell finite element model for stiffness evaluation. Finally, fatigue durability analysis was performed to evaluate the effect of torsional stiffness improvement on fatigue damage and durability index. The results confirmed that increased torsional stiffness reduced local stress concentration and improved fatigue durability performance. These results indicate that securing structural stiffness during the early design stage is important for enhancing overall durability.

KEY WORDS: Chassis Frame, Torsional Stiffness, Fatigue Durability, Design Parameters, FEM (Finite Element Method)

1.INTRODUCTION

A chassis frame is continuously subjected to various road-induced loads during vehicle operation. Among these loads, torsional loading is one of the major factors affecting structural deformation, local stress concentration, and fatigue durability performance. If sufficient torsional stiffness is not secured during the early design stage, local deformation may increase at side members, cross members, body mounting brackets, and other mounting regions. This can lead to a reduction in fatigue life under repeated loading conditions.

In general, the torsional stiffness and durability performance can be evaluated using a detailed finite element model. However, repeated evaluation of multiple design alternatives using a detailed 2D shell mesh model requires considerable time for model modification and mesh generation. In the early design stage, the overall layout is generally constrained, while key design parameters such as side member cross-sectional dimensions, member thickness, and cross member configuration can still be modified. Therefore, an efficient analysis method is required to rapidly investigate the effect of major design parameters before detailed model verification.

In this study, a 1D beam-based parameter study was used to identify design parameters affecting torsional stiffness. The selected design modification was then verified using a detailed 2D finite element model. Finally, fatigue durability analysis was performed to evaluate whether torsional stiffness improvement reduces fatigue damage and improves the durability index. The results were evaluated in terms of torsional rigidity, fatigue damage, and durability index.

2.ANALYSIS MODEL AND PROCEDURE

2.1. Chassis Frame Model

The target model used in this study is a ladder-type chassis frame composed of longitudinal side members, cross members, brackets, and body mounting regions. The base model was constructed as a detailed 2D shell finite element model to represent the main structural members and load transfer paths of the chassis frame. This model was used as the reference model for torsional stiffness evaluation, 1D parameter study correlation, and fatigue durability comparison.



Fig. 1 Chassis Frame Model

2.2 Analysis Procedure

The analysis procedure consisted of four steps: torsional stiffness evaluation of 2D shell FE base model, 1D beam-based parameter study, detailed 2D FE verification, and fatigue durability evaluation. The fatigue durability results of the base and improved models were compared using fatigue damage and the durability index. The same boundary and loading conditions were applied to all models to ensure a consistent comparison.