Abstract

According to the damage accumulation model of Palmgren-Miner and its modifications, fatigue failure under variable amplitude loading occurs when the damage sum D reaches a theoretical limit value of $D_{Grenz} = 1.0$. At this point the structural component reaches its predicted fatigue life. However, fatigue strength tests have shown that experimental fatigue lives at failure can be higher as well as lower than the predicted fatigue lives. This means that the actual damage sum at failure deviates from the theoretical limit value, which reflects the inaccuracy of the Miner's rule and the related fatigue life prediction, which - in turn - can lead to safe, but also unsafe structural design.

The main objective of this thesis is to assess the accuracy of the Miner's rule and its modifications for welded steel connections by means of calculating the actual damage sum at failure. For this purpose, results of fatigue tests under constant and variable amplitude loadings were edited and stored in a databank. The statistical evaluation of the S-N and the fatigue life curves was conducted with and without implementing input parameters of standardized S-N curves (for example according to Eurocode 3). The well-established modifications of the Miner's rule were applied to determine the predicted fatigue lives. Moreover, the actual damage sums were evaluated taking into consideration different influencing parameters. The resulting statistical values act as indicators for the accuracy of the fatigue life prediction as well as of the damage accumulation model.

In addition, the actual damage sums together with their statistical values were used as basic variables in order to assess the safety concept of the damage accumulation model according to Eurocode 3. The purpose was mainly to introduce the scattered limit damage sum into the fatigue verification. For that, the limit state functions of the Miner's rules were derived analytically for different normalized loading spectra of 2-parameter Weibull distribution. The functions were solved - both analytically and with Monte-Carlo-Simulations - at the reliability indices required in Eurocode 3. The resulting safety factors account for both material scattering and inaccuracy of the damage accumulation model. By means of the normalized loading spectra, the influence of a variety of spectrum shape and length parameters on the solution of the probabilistic safety problem was examined.