In this paper an improved sub-component fatigue testing method is proposed, in which structural optimization is used to obtain specimens in which fatigue failure is precipitated in the designated area away from the boundaries, i.e., load application and fixture points. This is achieved by optimizing the nonlinear beam taper and the dynamic excitation. The major requirement for accurate material characterization through sub-component tests concerns unbiased stress states in the gauge section. However, empiricism shows that many sub-component high-cycle fatigue testing methods suffer from failure in the boundaries rather than the gauge section, which causes bias. The common practice for reinforcing those regions only shifts the issue into new areas of local discontinuities where failure is still caused remotely from the gauge section. An experimental proof of concept demonstrates that optimization of the beam taper can be used to obtain unbiased fatigue test data.