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# Biomimetics — Biomimetic structural optimization

*Biomimétisme — Optimisation biomimétique*



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# Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 266, *Biomimetics*.

# Introduction

Biomimetic optimization methods are based on the knowledge gained from studying natural biological structures and processes.

Structural optimization is a special branch of optimization dealing with the ideal design of components while taking the current boundary conditions into account. Commonly optimized properties include the weight, the load capacity, the stiffness, or the lifespan. The goal is to optimize one or more of these properties by maximizing or minimizing their values.

Generally, the idea is to utilize the construction material as efficiently as possible while avoiding overloaded and underloaded areas. Since almost every technical component for functional reasons exhibits changes in section and, hence, notches, minimizing notch stress is especially important in structural optimization. In classic structural optimization, the notch shape factor, i.e. the stress concentration factor on the notch, is reduced by selecting the largest possible radius of curvature for the notch or by utilizing the mutual interaction of notches and adding relief notches. The shapes of the notches are not changed by this procedure. The use of other notch shapes (Baud curves, ellipses, logarithmic spirals, etc.) was suggested as early as in the 1930s. But they are not widely applied in technology and are only used occasionally.

Computer-based biomimetic optimization tools, such as Computer Aided Optimization (CAO) and the Soft Kill Option (SKO), modify the shape and topology of the component, respectively, and thus homogenize the stresses using the finite element analysis (FEA). Such tools have been available since 1990 and are used in industry. The need to use FEA for optimization in this case limits the number of possible users, though, because a powerful computer, special software, and an expert are needed for its operation. The demand for even simpler and faster methods that cannot only be used by specialists to optimize components, but also by design engineers, led to the development of the “Method of Tensile Triangles”. Although development of this method began in 2006 only, it is already being used for verified applications because it is easy to understand and apply. The wide range of applications of biomimetic optimization methods together with the relative ease with which users are able to understand and apply the methods enables users to perform component optimization early in the design process. In the case of the Tensile Triangle Method, this is possible simply by implementing the method in CAD systems.

As every optimization means specialization for the selected cases of load, service loading can be well known. Other unconsidered loading conditions might even result in higher stresses in a component.

# Biomimetics — Biomimetic structural optimization

## 1 Scope

The International Standard specifies the functions and scopes of biomimetic structural optimization methods. They consider linear structural problems under static and fatigue loads. The methods described in this International Standard are illustrated by examples.

Based on the biological model of natural growth and by use of the FEM optimization methods for technical components, computer-based biomimetic optimization tools are described as Computer Aided Optimization (CAO), Soft Kill Option (SKO), and Computer Aided Internal Optimization (CAIO). The purpose of these methods is an optimal materials application for weight reduction or enhanced capability and lifespan of the components.

Additionally, a simpler and faster "Method of Tensile Triangles" is described that can be used by every design engineer. The wide range of applications of biomimetic optimization methods together with the relative ease with which users are able to understand and apply the methods enables users to perform component optimization early in the design process.

The purpose of this International Standard is to familiarize users with biomimetic optimization methods as effective tools for increasing the lifespan, reducing the weight of components, and promoting the widespread use of these methods in support of sustainable development.

This International Standard is intended primarily for designers, developers, engineers, and technicians, but also for all persons entrusted with the design and evaluation of load-bearing structures.



## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 18458, *Biomimetics — Terminology, concepts and methodology*

ISO 2394, *General principles on reliability for structures*

ISO 4866, *Mechanical vibration and shock — Vibration of fixed structures — Guidelines for the measurement of vibrations and evaluation of their effects on structures*

ISO 13823, *General principles on the design of structures for durability*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**3.1**
**mechanical adaptive growth**
appropriate reaction of biological structures, such as trees and bones, to changing conditions (e.g. mechanical loads) by locally adding material to high-stress areas or removing material from low-stress areas

EXAMPLE Thicker annual rings.

**3.2**
**algorithm**
precisely described procedure to complete a task in a finite number of steps