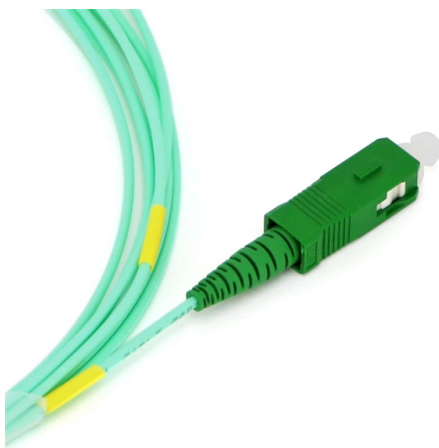


Customization Process for Low-Loss Molded Tapered Beams in Power Systems



Overview

In this paper, an advanced beam-column element is proposed for modeling tapered members with both symmetric and asymmetric variations.

Key Takeaways

The customization of low-loss molded tapered beams involves material selection, geometric optimization, finite element analysis, and vibration testing to ensure minimal electrical and mechanical losses.

Material Selection

Choosing the right material is critical for low-loss performance. Glass fiber-reinforced polymers (GFRP) are commonly used due to their low dielectric constant and high strength-to-weight ratio, which reduces electrical losses and mechanical deformation under load. E-glass is preferred for electrical applications, while S-glass offers higher silica content for enhanced mechanical performance.

The selection process may also consider D-glass for low dielectric applications and A-glass for improved surface finish.

Geometric Design and Tapering

Tapered beams are non-prismatic members with varying cross-sections along their length. The tapering profile—concave, linear, or convex—affects both mechanical stress distribution and modal behavior. Concave tapers can increase modal loss for higher-order modes, which is advantageous for minimizing unwanted vibrations, while convex tapers can reduce nonlinear effects and improve structural stability.

The beam geometry must be tailored to the specific load conditions and spatial constraints of the power system. Finite Element Analysis (FEA) is used to predict the mechanical and electrical performance of the tapered beam before manufacturing. Advanced beam finite elements can handle non-linear taper, pre-twist, bending, torsion-related warping, and eccentric loads, capturing complex stress fields and large displacements.

Modal analysis identifies natural frequencies and vibration modes, which are critical for minimizing resonance and energy losses in power systems.

Comparing FE

A results with experimental data ensures the design meets vibration and structural standards.

Manufacturing and Testing

Once the optimal material and geometry are determined, the beam is molded or fabricated according to the selected lay-up angles and taper profile. Post-manufacturing, FFT analyzer tests or other vibration measurement techniques are conducted to validate the predicted modal behavior and ensure low-loss performance. Adjustments to lay-up angles or taper geometry may be made iteratively to achieve the desired electrical and mechanical characteristics.

Optimization Considerations

Dielectric properties: Minimize electrical losses by selecting materials with low dielectric constants. Mechanical stiffness: Ensure the beam can withstand operational loads without excessive deflection. Vibration control: Optimize natural frequencies to avoid resonance with system excitations.

Thermal stability: Consider temperature effects on material properties and beam geometry. By integrating material science, geometric design, and computational analysis, the customization process ensures that tapered beams in power systems achieve low-loss, high-efficiency performance while maintaining structural integrity.

Article Content

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In this paper, an advanced beam-column element is proposed for modeling tapered members with both symmetric and asymmetric variations. Unlike the stepped element model, only

Design of Tapered Single-Span Beam According to Eurocode 3

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(PDF) Design of tapered beam-columns

The report covers all major aspects of the design of tapered frames; from total frame analysis to stress analysis of individual members - to the development of tapered design formulas.

Design of Tapered Beam-Columns | PDF | Buckling | Bending

The document discusses the design of tapered beam-columns, highlighting their popularity due to high strength-to-weight ratios and the lack of established design codes in North America.

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Present work proposes an optimum design approach of such sandwich tapered beam with laminated composite face layer and MR fluid core undergoing the supersonic flow excitation. The

Aisc Steel Design Guide 25 Tapered Beams

It provides a comprehensive understanding of tapered beam theory, design considerations, and practical applications, offering a valuable resource for structural engineers, architects, and students.

Timoshenko-EFEA model for tapered beams and its application

This study develops an enhanced EFEA model for tapered beams based on Timoshenko beam theory (Timoshenko-EFEA), which accounts for both bending and shear effects.

Application of AISC Design Provisions for Tapered Members

Other standard methods of structural analysis based on either the flexibility or stiffness approach, such as moment distribution, can be readily adapted to tapered frame assemblies (stiffness and carry-over

Analytical and Numerical Evaluation of Additional Deflection in

This study presents an analytical formulation for predicting the additional elastic deflection of tapered steel beams with variable-diameter circular web openings, a configuration that

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In this paper, we present a novel symbolic MEMS modeling methodology for devices with tapered beam geometries. Such beams are very common in piezoelectric energy harvesters. While a closed-form

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The axial compressive and flexural resistances as well as their interaction of general tapered beam-columns are investigated and proposed.

Bending and buckling of tapered steel beam structures

This paper describes an efficient finite element method of analysing the elastic in-plane bending and out-of-plane buckling of indeterminate beam structures whose members may be

Tapered Beams in MEMS: A Symbolic Modeling

In this monograph, the authors take a fundamental, physics-based approach to the modeling of tapered beams in MEMS that is based on a rigorous perturbation

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In this study, a direct design method for a continuous web tapered beam is investigated by using a conjugate system to estimate the value of ultimate load by the finite element method.

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