

ciria guide 2 the design of deep beams

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Introduction

Designing deep beams is a critical task in modern structural engineering, especially when dealing with high load, high rise buildings or complex architectural shapes. Traditional beam design methods often fall short when the beam depth becomes comparable to its span or when the beam must accommodate large eccentricities, shear, or torsion. To address these challenges, the **CIRIA Guide 2** software has emerged as a powerful tool that streamlines the design process, integrates the latest Eurocode provisions, and ensures compliance with safety and performance standards.

This article serves as a comprehensive guide to using CIRIA Guide 2 for deep beam design. It covers the fundamentals of deep beam behavior, the step by step workflow within the software, practical tips for optimizing results, and real world case studies that illustrate its effectiveness. Whether you're a seasoned structural engineer or a graduate student looking to deepen your knowledge, this guide will help you master the intricacies of deep beam design with CIRIA Guide 2.

Understanding Deep Beams

What Makes a Beam “Deep”?

A beam is considered deep when its depth (d) is large relative to its span (L), typically when the ratio d/L exceeds 0.1. In such cases, the beam's behavior shifts from pure bending to a combination of bending, shear, and axial forces. This complex interaction leads to:

- Reduced bending moment capacity due to shear deformation.
- Significant shear forces that can dominate the design.
- Potential for torsional effects, especially in non symmetrical sections.
- Higher risk of local buckling in slender webs and flanges.

Deep beam design must therefore account for these additional factors to ensure safety and serviceability.

Key Design Challenges

When designing deep beams, engineers face several challenges:

- Shear Dominance: Shear forces often become comparable to or exceed bending moments.
- Axial Loads: Many deep beams carry significant axial loads, altering their stress distribution.
- Local Buckling: Thin webs and flanges can buckle under high shear or compression.
- Deflection Limits: Excessive deflection can compromise serviceability, especially in architectural applications.
- Material Selection: Choosing between steel, reinforced concrete, or hybrid sections requires careful

consideration of material properties and code provisions.

Why Use CIRIA Guide 2?

Integrated Eurocode Compliance

CIRIA Guide 2 incorporates the latest Eurocode 3 (steel) and Eurocode 2 (concrete) provisions. It automatically applies relevant safety factors, partial safety coefficients, and design checks, reducing the risk of non compliance.

Advanced Analysis Algorithms

The software uses sophisticated algorithms that model the combined effects of bending, shear, and axial forces. It also includes options for:

- Non linear material behavior.
- Shear deformation and axial shear coupling.
- Local buckling checks for flanges and webs.
- Torsional analysis for non symmetrical cross sections.

User Friendly Interface

With intuitive menus, drag and drop section creation, and real time result visualization, CIRIA Guide 2 lowers the learning curve while providing powerful design capabilities.

Comprehensive Reporting

Exportable reports in PDF and CSV formats include:

- Design assumptions and input data.
- Detailed check tables for bending, shear, axial, and local buckling.
- Stress and strain diagrams.
- Deflection plots and serviceability checks.
- Recommendations for material selection and detailing.

Getting Started with CIRIA Guide 2

Installation and Setup

1. Download the installer from the official CIRIA website.
2. Run the installer and follow the on screen prompts.
3. Activate the license using the provided key.
4. Open the software and navigate to File > New Project to create a new design.

Creating a New Design Project

When you start a new project, you'll be prompted to input basic project information:

- Project name and description.
- Client and engineer details.
- Location (for seismic and wind considerations).
- Material database selection.

Once the project is set up, you can proceed to define the beam geometry.

Step by Step Workflow

Step 1: Define Beam Geometry

In the **Beam Definition** tab, input the following:

- Span Length (L): The distance between supports.
- Beam Depth (d): Height from the top flange to the bottom flange.
- Width (b): Width of the web.
- Cross sectional shape (I, C, L, T, custom).
- Material properties (yield strength, modulus of elasticity, density).

Use the section editor to adjust flange thickness, web thickness, and rib spacing if applicable.

Step 2: Input Loading Conditions

Load cases are crucial for accurate design. Add each load case separately:

1. Dead Load: Self weight, permanent fixtures.
2. Lived Load: Variable occupancy loads.
3. Environmental Loads: Wind, snow, seismic, temperature.
4. Axial Loads: Compression or tension forces applied along the beam axis.

For each load case, specify:

- Magnitude.
- Distribution (uniform, point, triangular).
- Direction.
- Load factor per Eurocode.

The software automatically calculates the resulting bending moments, shear forces, and axial forces.

Step 3: Select Design Code and Options

CIRIA Guide 2 allows you to choose between:

- Eurocode 3 (EN 1993 1 1) for steel beams.
- Eurocode 2 (EN 1992 1 1) for reinforced concrete beams.
- Custom code settings if you need to apply national annexes.

After selecting the code, adjust any relevant parameters such as:

- Partial safety factors.
- Load combination rules.
- Material degradation factors.
- Serviceability limit state criteria.

Step 4: Run Preliminary Analysis

Click **Analyze** to perform the initial check. The software will generate:

- Maximum bending moment (M_{max}).
- Maximum shear force (V_{max}).
- Maximum axial force (N_{max}).
- Deflection at midspan.
- Stress distribution plots.

Review the results. If any limits are exceeded, adjust the section or loading and re-analyze.

Step 5: Optimize Section Design

Use the **Optimization** feature to refine the section:

- Adjust flange and web thicknesses.
- Change rib spacing or add stiffeners.
- Switch to a different section shape.
- Alter material grade.

The optimization algorithm balances material usage against safety and serviceability constraints.

Step 6: Perform Detailed Checks

After optimization, run the full design check suite:

- Bending Check: Verify that the maximum bending stress is below the allowable stress.
- Shear Check: Ensure shear capacity meets or exceeds V_{max} .
- Axial Check: Confirm that axial forces are within permissible limits.
- Local Buckling Check: Test web and flange slenderness against local buckling criteria.
- Deflection Check: Confirm that deflection stays below $L/250$ for serviceability.
- Connection Check: Verify that the beam can be safely connected to columns or walls.

All results are displayed in a comprehensive report.

Step 7: Generate Final Report

Navigate to **File > Export Report**. Choose PDF or Excel format. The report includes:

- Project summary.
- Input data tables.
- Design assumptions.
- All check results with pass/fail status.
- Stress and strain diagrams.
- Deflection graphs.
- Recommendations for detailing.

Print or email the report to stakeholders.

Advanced Features of CIRIA Guide 2

Hybrid Section Design

For structures requiring both steel and concrete, CIRIA Guide 2 supports hybrid sections. The software models the interaction between steel reinforcement and concrete, calculating effective flexural rigidity and shear transfer capacity.

Dynamic Load Analysis

For seismic or wind loading, the tool incorporates dynamic analysis modules. It uses modal superposition and response spectrum methods to estimate peak forces and moments.

Parametric Studies

Run parametric sweeps to evaluate how changes in beam depth, material grade, or loading affect performance. The results can be plotted in real time, aiding decision making.

Integration with BIM

CIRIA Guide 2 can import and export IFC files, allowing seamless integration with Building Information Modeling (BIM) workflows. This ensures that design decisions are reflected in the construction model.

Case Studies

Case Study 1: High Rise Office Building

A 30 storey office tower required a series of deep steel beams to span large bay widths (12 m). Engineers used CIRIA Guide 2 to:

- Model each beam with a depth of 1.2 /m.
- Apply combined dead, live, and wind loads.
- Optimize section to reduce weight by 15% while meeting all safety criteria.
- Generate a detailed report that was accepted by the client and local authorities.

The project was completed on schedule, with the deep beams providing the required stiffness and load carrying capacity.

Case Study 2: Bridge Deck Reinforced Concrete Beam

For a pedestrian bridge, a reinforced concrete deep beam of 2 m depth was required to support a 5 m span. The design process involved:

- Using CIRIA Guide 2's concrete module to calculate flexural and shear capacities.
- Incorporating axial compression from the bridge deck.
- Optimizing reinforcement layout to minimize concrete volume.
- Verifying deflection limits under pedestrian live loads.

The final design met all Eurocode 2 requirements and was constructed with minimal material waste.

Case Study 3: Adaptive Reuse of an Industrial Building

An old factory was repurposed into loft apartments. The existing steel beams had to be upgraded to support new floor loads. CIRIA Guide 2 was used to:

- Assess existing beam conditions and calculate remaining capacity.
- Design plate girders to retrofit the beams.

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