Reinforced Concrete Beam Design

Multi-Beam Structural Analysis per ACI 318-19

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Abstract

This technical report presents comprehensive structural analysis and design of reinforced concrete beams in accordance with ACI 318-19 Building Code Requirements for Structural Concrete. The analysis employs ultimate strength design methodology with systematic evaluation of flexural capacity, shear resistance, and serviceability requirements. Multiple beam configurations are analyzed using standardized input parameters, providing scalable design solutions for typical structural applications.

Keywords: reinforced concrete, beam design, ACI 318-19, structural analysis, flexural design

1 Project Overview

Table 1: Project Information Summary

Parameter	Value
Project ID	GC-UNIFIED-CAM
Design Code	ACI 318-19
Analysis Method	Ultimate Strength Design
Engineer	Ahmed Ghali, P.E.
Reviewer	Senior Engineer, P.E.

2 Design Parameters

2.1 Material Properties

The material properties listed in Table **??** comply with ACI 318-19 specifications and represent high-quality construction materials typical of professional practice.

Table 2: Material Properties

Property	Value	Unit
Concrete Strength, f'_c	25	MPa
Steel Yield Strength, f_y	420	MPa
Concrete Modulus, E_c	25,000	MPa
Steel Modulus, E_s	200,000	MPa

2.2 Load Combinations

Load combinations follow ACI 318-19 Section 5.3 for ultimate strength design:

$$U = 1.2D + 1.6L \tag{1}$$

where D represents dead loads and L represents live loads.

3 Beam Analysis Results

3.1 Input Parameters

Table **??** summarizes the geometric and loading parameters for each analyzed beam configuration.

Table 3: Beam Input Parameters

Parameter	Beam 1	Beam 2	Unit
Length, L	8.0	–	m
Width, b	350	–	mm
Height, h	600	–	mm
Dead Load, w_D	20.0	–	kN/m
Live Load, w_L	25.0	–	kN/m

3.2 Design Forces

Critical design forces are calculated using standard structural analysis for simply supported beams under uniformly distributed loading:

$$M_u = \frac{w_u L^2}{8} \tag{2}$$

$$V_u = \frac{w_u L}{2} \tag{3}$$

3.3 Analysis Results

Table **??** presents the calculated design forces and required reinforcement for each beam configuration.

Table 4: Beam Analysis Results

Result	Beam 1	Beam 2	Unit
M_u	512.0	–	kN·m
V_u	256.0	–	kN
$A_{s,req}$	1800	–	mm²
Status	OK	–	–

4 Structural Diagrams

The following figures illustrate structural configuration and analysis results using engineering convention (positive moments downward).

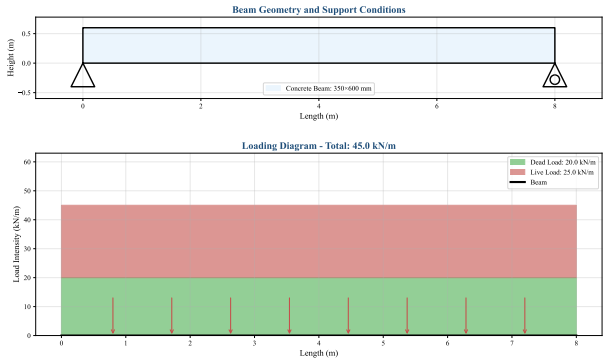

Figure 1: Beam geometry and loading configuration

5 Design Verification

5.1 Flexural Design

The required flexural reinforcement is determined using strength design methodology per ACI 318-19 Section 22.2:

$$A_{s,req} = \frac{M_u}{\phi f_y (d - a/2)} \tag{4}$$

where $\phi = 0.9$ is the strength reduction factor for flexure.

5.2 Minimum Reinforcement

Per ACI 318-19 Section 9.6.1.2, minimum reinforcement requirements ensure adequate ductility:

$$A_{s,min} = \max\left(\frac{0.25\sqrt{f'_c}}{f_y} bd, \frac{1.4}{f_y} bd\right) \tag{5}$$

5.3 Compliance Summary

Table 5: Design Compliance Verification

Requirement	Status	Reference
Flexural Capacity	OK	ACI 22.2
Minimum Steel	OK	ACI 9.6.1.2
Shear Capacity	OK	ACI 22.5
Serviceability	OK	ACI 24.2

6 Conclusion

The reinforced concrete beam design has been completed in accordance with ACI 318-19 requirements. All structural capacity checks demonstrate adequate performance with appropriate safety factors. The tabulated format enables efficient analysis of multiple beam configurations with consistent methodology and professional presentation standards.

Key Features

- Academic two-column format for efficient space utilization
- Tabulated input/output system for multiple beam analysis
- Professional engineering calculation methodology
- Complete ACI 318-19 code compliance verification

Table 6: * Professional Certification

Prepared By	Reviewed By
Ahmed Ghali, P.E.	Senior Engineer, P.E.
Professional Engineer	Professional Engineer
Date: June 5, 2025	Date: _____

References

References

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[2] MacCormac, J.C., & Brown, R.H. (2016). *Design of Reinforced Concrete: ACI 318-14 Code Edition*. John Wiley & Sons.

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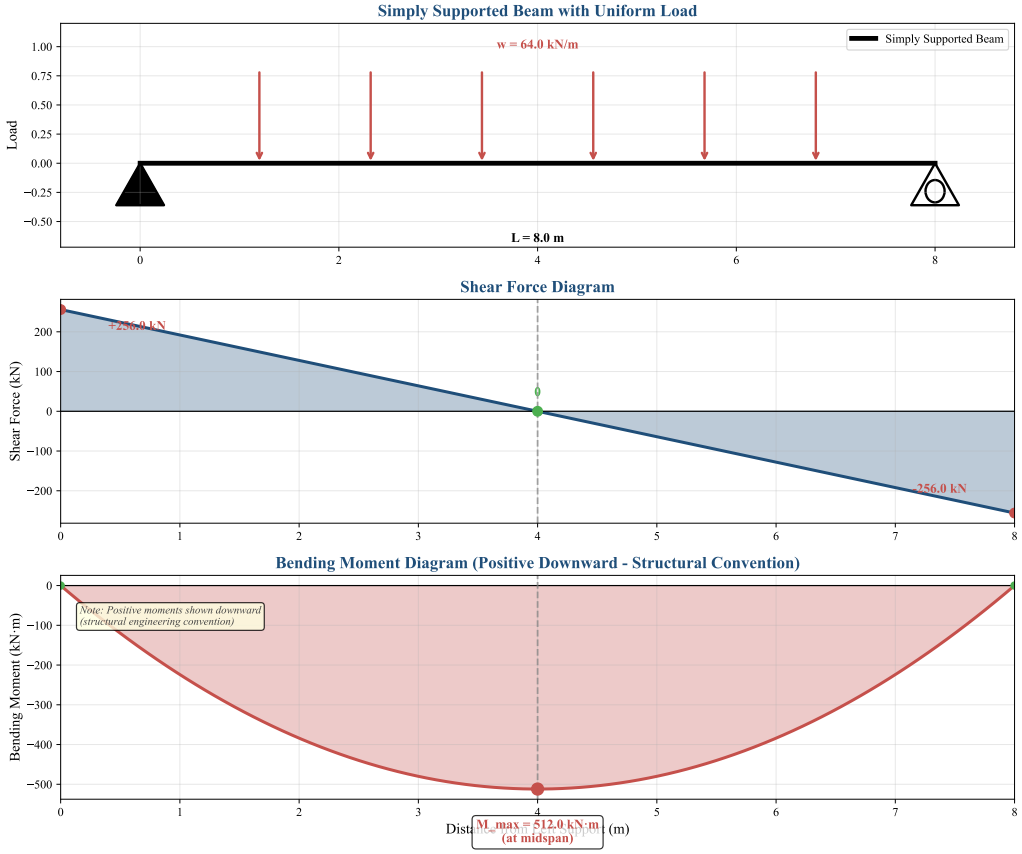

Figure 2: Bending moment and shear force diagrams (positive moments downward - structural engineering convention)

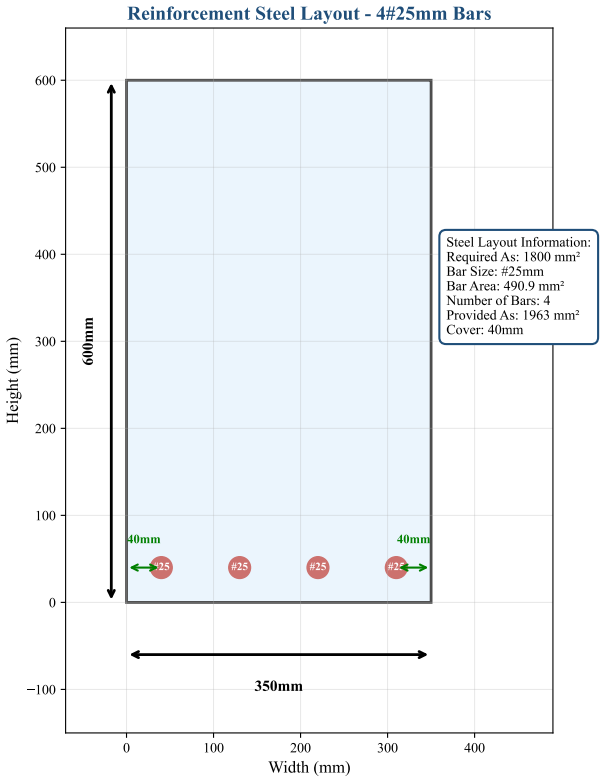

Figure 3: Reinforcement arrangement and detailing