

# COMPLETE BEAM ENGINEERING REPORT

## Worked Example: IS 456 Beam (Annex G)

|                          |                              |
|--------------------------|------------------------------|
| Project number           | Not specified                |
| Client                   | Not specified                |
| Location                 | Not specified                |
| Responsible engineer     | Not specified                |
| Design standard          | IS 456:2000                  |
| Calculation units        | SI canonical calculations    |
| Minimum stirrup diameter | 10 mm / #3                   |
| Report status            | Ready for engineering review |
| Generated                | 2026-09-04T07:01:19.229359Z  |

NOTE: flexural design, shear, torsion, and straight-bar anchorage/development length on this report follow IS 456:2000. Hooked-bar development length and curtailment/cutoff extension lengths remain ACI 318-19-only regardless of the selected design code (no IS 456:2000 equivalent is implemented for Beam yet). Engineering review of those values is required before use.

### 1. Executive engineering narrative

This report records the complete CIVORA reinforced-concrete beam workflow. Beam geometry and loading were defined, the structural analysis was completed, flexural and shear reinforcement were designed, longitudinal reinforcement was selected, and the final detailing, drawings and bar bending schedule were generated.

The report is prepared for engineering review. Straight-bar development length was computed automatically per IS 456:2000 (see Section 2A); cutoff/extension lengths remain ACI 318-19-only regardless of the selected design code.

Nominal continuity bars are detailing reinforcement and are not classified as flexural-demand verified reinforcement.

### 2. Design basis and assumptions

|                            |                                               |
|----------------------------|-----------------------------------------------|
| Structural concrete code   | IS 456:2000                                   |
| Concrete model             | Normal-weight concrete unless noted otherwise |
| Internal calculation units | N, mm, MPa                                    |
| Main reinforcement         | metric                                        |
| Minimum stirrup diameter   | 10 mm / #3                                    |

|                          |                                                                                                         |
|--------------------------|---------------------------------------------------------------------------------------------------------|
| Development length basis | Computed automatically per IS 456:2000 (straight bars; cutoff/extension lengths remain ACI 318-19-only) |
| Drawing status           | Engineering detailing schematic - review before issue                                                   |

## 2A. Engineering Assumptions & Defaults

Declared values used automatically wherever this project was set up in Simple Mode - nothing here is silently decided.

|                                |                                                                                                                                             |
|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Clear cover                    | 38 mm                                                                                                                                       |
| Stirrup diameter               | #3 (10 mm)                                                                                                                                  |
| Compression steel depth d'     | 65 mm                                                                                                                                       |
| Long-term creep factor xi      | 2.0 (5 yr+ sustained load)                                                                                                                  |
| Max aggregate size             | 19 mm                                                                                                                                       |
| Support bearing width          | 230 mm                                                                                                                                      |
| Anchorage & cutoff extensions  | Straight bars: IS 456:2000 Cl 26.2.1. Hooked bars/curtailment extensions: ACI 318-19 Chapter 25 (no IS 456 equivalent implemented for Beam) |
| Side-face (skin) reinforcement | Computed automatically per IS 456:2000 Cl 26.5.1.3 when overall depth D > 750mm                                                             |

## 3. Beam geometry and materials

|                           |         |
|---------------------------|---------|
| Beam name                 | B1      |
| Beam width                | 230 mm  |
| Overall depth             | 450 mm  |
| Effective depth           | 402 mm  |
| Concrete strength         | 25 MPa  |
| Main-steel yield strength | 415 MPa |
| Stirrup yield strength    | 415 MPa |
| Top clear cover           | 30 mm   |
| Bottom clear cover        | 30 mm   |
| Side clear cover          | 30 mm   |
| Preferred bar catalogue   | metric  |

## 4. Spans and supports

| Span |  | Length  |  |
|------|--|---------|--|
| SP1  |  | 5000 mm |  |

| Support | Type   | Physical width | Status   |
|---------|--------|----------------|----------|
| S1      | pinned | 230 mm         | Provided |
| S2      | roller | 230 mm         | Provided |

5. Applied loading

| ID         | Span | Type               | Start | End     | Start value | End value | Unit |
|------------|------|--------------------|-------|---------|-------------|-----------|------|
| w-factored | SP1  | uniformDistributed | 0 mm  | 5000 mm | 37.50       | 37.50     | N/mm |

6. Structural analysis summary

|                   |                          |
|-------------------|--------------------------|
| Stage status      | valid                    |
| Analysis revision | 1                        |
| Primary scenario  | legacy-unfactored        |
| Envelope method   | civora-action-envelope-1 |

| Span   | Maximum positive moment | Maximum negative moment | Maximum absolute shear |
|--------|-------------------------|-------------------------|------------------------|
| Span 1 | 117.19 kN.m             | 0 kN.m                  | 93.75 kN               |

Analysis warnings

- Support "N1" left face lies outside the analyzed beam domain.
- Support "N2" right face lies outside the analyzed beam domain.

7. Flexural design results

| Region | Face   | Critical location | Mu          | As required | As minimum | As governing | Selected bars | Status |
|--------|--------|-------------------|-------------|-------------|------------|--------------|---------------|--------|
| F1     | bottom | 2500 mm           | 117.19 kN.m | 997.67 mm2  | 187.26 mm2 | 997.67 mm2   | Not specified | pass   |

CODE REFERENCE

ACI 318-19 §9.6.1 - Minimum Flexural Reinforcement

As,min = max(0.25 x sqrt(f'c)/fy, 1.4/fy) x bw x d (§9.6.1.2). This prevents a brittle failure if the concrete cracks - the steel must be strong enough to carry at least the moment that caused first cracking. Statistical calibration ensures the reinforced cracked section capacity exceeds the uncracked plain-concrete capacity.

FORMULA - As,min (typical)

$$A_{s,min} = \max(0.25 \times \sqrt{f'c} / f_y, 1.4 / f_y) \times b_w \times d$$

CODE REFERENCE

ACI 318-19 §6.3.2 - Effective Flange Width of T-Beams

For monolithically cast slabs and beams, an effective slab width (overhanging flange) participates in beam flexure. ACI limits the overhang each side to the lesser of: 8 x slab thickness, half the clear distance to the adjacent beam, or one-eighth the beam's clear span. Compressive force in T-beam flanges dramatically increases moment capacity over rectangular sections.

8. Shear design and stirrup schedule

|                  |            |
|------------------|------------|
| Stage status     | valid      |
| Result revision  | 1          |
| Selected stirrup | 10 mm / 10 |
| Selected spacing | 300 mm     |

|                           |             |
|---------------------------|-------------|
| Minimum permitted stirrup | 10 mm / #3  |
| Recommendation status     | Recommended |

**CODE REFERENCE**  
**ACI 318-19 §9.5 - Shear Strength & Stirrup Design**  
Where  $V_u > \phi V_c/2$ , minimum shear reinforcement is required (§9.6.3.1). Stirrups are designed for  $V_s = V_u/\phi - V_c$ . Spacing  $s \leq d/2$  for  $V_s \leq 4 \times \sqrt{f'_c} \times b_w \times d$  and  $s \leq d/4$  for higher shear demands. Maximum stirrup spacing also ensures every potential 45-degree crack is crossed by at least one stirrup leg.

**WHY THIS MATTERS**  
Shear failure in beams is brittle and sudden. Unlike flexural failure (which shows warning cracks), shear failure can occur with no visible warning. The strength reduction factor for shear ( $\phi = 0.75$ ) is lower than for flexure ( $\phi = 0.90$ ) precisely because shear failure is less ductile.

## 8B. Torsion design (ACI 318-19 §22.7)

|                              |                                                                                                   |
|------------------------------|---------------------------------------------------------------------------------------------------|
| Torsion threshold $T_{u,th}$ | 0 kN-m                                                                                            |
| Result                       | $T_u$ is below threshold - torsion effects negligible (ACI 318-19 §22.7.4.1), no design required. |

**CODE REFERENCE**  
**ACI 318-19 §22.7 - Torsion Design**  
Below the threshold  $T_{u,th} = \phi \lambda \sqrt{f'_c} (A_{cp}^2/P_{cp})$ , torsion effects are negligible and no design is required. Above it, closed stirrups ( $A_t/s$ ) plus additional longitudinal bars ( $A_l$ ), distributed around the section perimeter, are required in addition to the shear stirrups above - the two demands add ( $A_v+t/s = A_v/s + 2 \cdot A_t/s$ ), they do not substitute for one another.

**WHY THIS MATTERS**  
Unrestrained torsion twists a beam until the concrete cracks in a spiral pattern, then fails suddenly. This most commonly occurs in edge/spandrel beams supporting an eccentric one-way slab or cantilever, where the slab reaction does not pass through the beam's shear center.

## 9. Longitudinal reinforcement

| Run                   | Face   | Start | End     | Reinforcement | Layers | Classification    |
|-----------------------|--------|-------|---------|---------------|--------|-------------------|
| F1-run                | bottom | 0 mm  | 5000 mm | 3-25          | 1      | Demand-designed   |
| nominal-top-gap-1-run | top    | 0 mm  | 5000 mm | 2-12          | 1      | Nominal detailing |

## 10. Anchorage and development-length verification

| Run    | Required length | Available length | Development status | Overall status |
|--------|-----------------|------------------|--------------------|----------------|
| F1-run | 1007.39 mm      | 2500 mm          | Verified           | Verified       |

## 11. Bar bending schedule

| Mark | Bar | Dia. | Qty | Cut length | Total length | Weight   | Status            |
|------|-----|------|-----|------------|--------------|----------|-------------------|
| B1   | Ø25 | 25   | 3   | 5000 mm    | 15.000 m     | 57.87 kg | Verified          |
| B2   | Ø12 | 12   | 2   | 5000 mm    | 10.000 m     | 8.89 kg  | Nominal Detailing |
| ST1  | Ø10 | 10   | 18  | 1080 mm    | 19.440 m     | 12 kg    | Shear Verified    |

Total Steel Weight: 78.76 kg

## 12. Design warnings and limitations

- Any stale or invalid design stage must be rerun before issue.
- End-support anchorage requires confirmation by the responsible engineer.
- Development and extension lengths are externally verified inputs.
- Nominal continuity bars are detailing steel and are not demand-verified steel.
- Drawings are engineering detailing schematics and require project review.
- No stirrup smaller than 10 mm / #3 may be issued.

Landscape drawing sheets follow at the end of this report.

| <b>CIVORA STRUCTURAL ENGINEERING</b><br>IS 456:2000 Structural Design                           |            |                          | <b>PROJECT:</b> Worked Example: IS 456 Beam (Annex G)<br><b>MEMBER ID:</b> GENERAL NOTES |     |
|-------------------------------------------------------------------------------------------------|------------|--------------------------|------------------------------------------------------------------------------------------|-----|
| <b>ENGINEER:</b> Engineer of Record<br><b>SCALE:</b> NTS                                        |            |                          | <b>DATE:</b> 2026-09-04<br><b>SHEET:</b> D-01 of 4                                       |     |
| REV                                                                                             | DATE       | DESCRIPTION              | BY                                                                                       | CHK |
| 0                                                                                               | 2026-09-04 | Preliminary design issue | -                                                                                        | -   |
| CONCEPTUAL DESIGN ONLY - NOT FOR CONSTRUCTION WITHOUT INDEPENDENT VERIFICATION BY A LICENSED PE |            |                          |                                                                                          |     |

## SHEET D-01: GENERAL NOTES

Reinforced Concrete Beam Design - design code references, material specifications, and general construction notes for the drawing sheets that follow.

### 1. Design Code References

- IS 456:2000 - Building Code Requirements for Structural Concrete.
- IS 456:2000 governs the flexural, shear, torsion, and straight-bar anchorage design on the following sheets. Hooked-bar development length and curtailment/cutoff extensions follow ACI 318-19 regardless of the selected design code.

### 2. Material Specifications

- Refer to the calculation report preceding this drawing set for material properties.

### 3. General Construction Notes

- Verify all span lengths, support conditions, and levels on site before fabrication.
- Reinforcement detailing (bar marks, cut lengths, and bend shapes) is given on the Bar Bending Schedule sheet.

## CIVORA STRUCTURAL ENGINEERING

IS 456:2000 Structural Design

ENGINEER: Engineer of Record

SCALE: NTS

PROJECT: Worked Example: IS 456 Beam (Annex G)

MEMBER ID: BEAM REINFORCEMENT ELEVATION

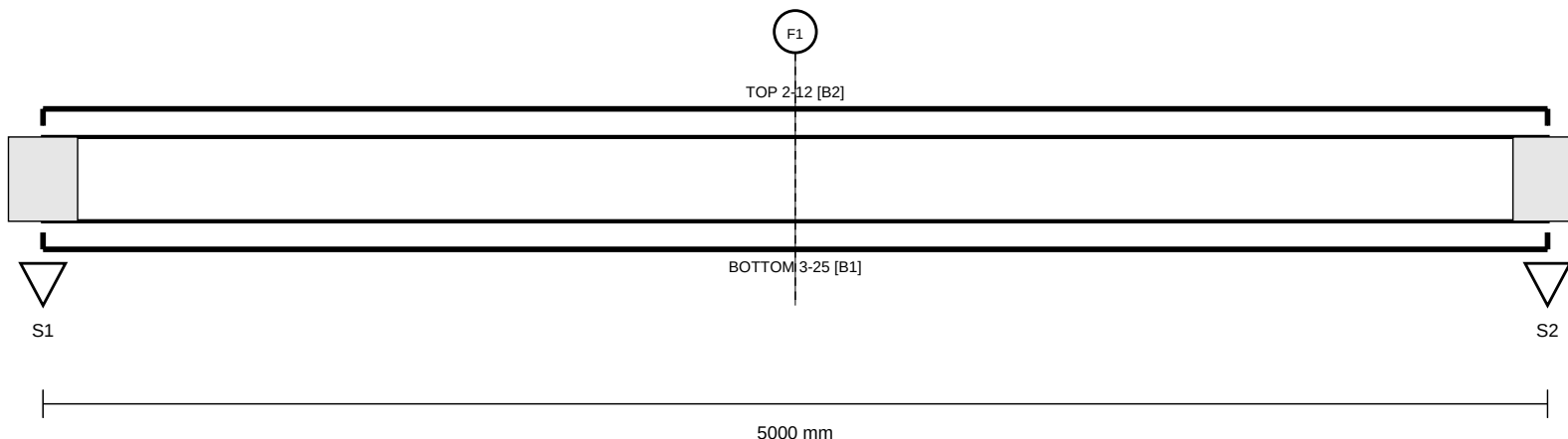
DATE: 2026-09-04

SHEET: D-02

| REV | DATE       | DESCRIPTION              | BY | CHK |
|-----|------------|--------------------------|----|-----|
| 0   | 2026-09-04 | Preliminary design issue | -  | -   |

CONCEPTUAL DESIGN ONLY - NOT FOR CONSTRUCTION WITHOUT INDEPENDENT VERIFICATION BY A LICENSED PE

## COMPLETE BEAM REINFORCEMENT ELEVATION

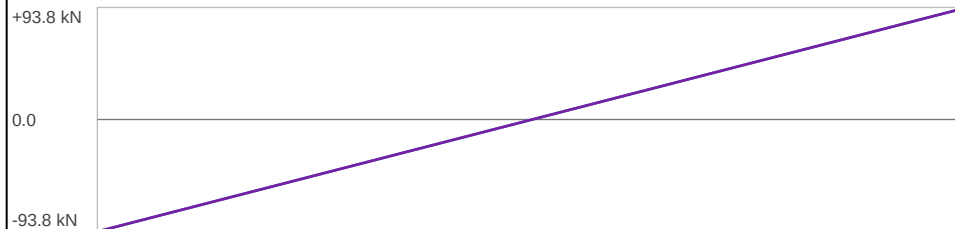


Nominal continuity bars are detailing reinforcement.

## BENDING MOMENT DIAGRAM (envelope, kN.m)



## SHEAR FORCE DIAGRAM (envelope, kN)



NOTES: Dimensions are in millimetres. Verify all dimensions against approved project drawings. Nominal continuity bars are detailing reinforcement.

MINIMUM STIRRUP: 10 mm / #3

CIVORA STRUCTURAL ENGINEERING

IS 456:2000 Structural Design

ENGINEER: Engineer of Record

SCALE: NTS

PROJECT: Worked Example: IS 456 Beam (Annex G)

MEMBER ID: GOVERNING REINFORCEMENT SECTIONS

DATE: 2026-09-04

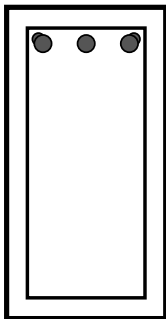
SHEET: D-03

| REV | DATE       | DESCRIPTION              | BY | CHK |
|-----|------------|--------------------------|----|-----|
| 0   | 2026-09-04 | Preliminary design issue | -  | -   |

CONCEPTUAL DESIGN ONLY - NOT FOR CONSTRUCTION WITHOUT INDEPENDENT VERIFICATION BY A LICENSED PE

GOVERNING REINFORCEMENT SECTIONS

F1-section



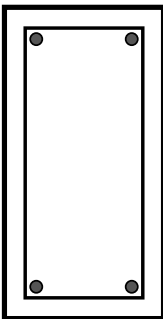
**TOP**  
2-Ø12 (NOMINAL)

**BOTTOM**  
3-Ø25 (DESIGN)

**LINK**  
Ø10 @ 300 mm c/c

230 x 450 mm  
Cover 30 mm; stirrup 10 mm

nominal-top-gap-1-section



**TOP**  
2-Ø12 (NOMINAL)

**BOTTOM**  
2-Ø12 (NOMINAL)

**LINK**  
Ø10 @ 300 mm c/c

230 x 450 mm  
Cover 30 mm; stirrup 10 mm

|                                                                       |                                                                                                                         |
|-----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| <b>CIVORA STRUCTURAL ENGINEERING</b><br>IS 456:2000 Structural Design | <b>PROJECT:</b> Worked Example: IS 456 Beam (Annex G)<br><b>MEMBER ID:</b> BAR BENDING SCHEDULE AND REINFORCEMENT NOTES |
| <b>ENGINEER:</b> Engineer of Record<br><b>SCALE:</b> NTS              | <b>DATE:</b> 2026-09-04<br><b>SHEET:</b> D-04                                                                           |

| REV | DATE       | DESCRIPTION              | BY | CHK |
|-----|------------|--------------------------|----|-----|
| 0   | 2026-09-04 | Preliminary design issue | -  | -   |

CONCEPTUAL DESIGN ONLY - NOT FOR CONSTRUCTION WITHOUT INDEPENDENT VERIFICATION BY A LICENSED PE

| Mark | Bar | Dia. | Qty | Cut length | Total length | Weight   | Status            |
|------|-----|------|-----|------------|--------------|----------|-------------------|
| B1   | Ø25 | 25   | 3   | 5000 mm    | 15.000 m     | 57.87 kg | Verified          |
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| ST1  | Ø10 | 10   | 18  | 1080 mm    | 19.440 m     | 12 kg    | Shear Verified    |

Total Steel Weight: 78.76 kg

|                                                                                                                                                     |                                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| NOTES: Dimensions are in millimetres. Verify all dimensions against approved project drawings. Nominal continuity bars are detailing reinforcement. | <b>MINIMUM STIRRUP: 10 mm / #3</b> |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|

Fabrication notes

- 1. Verify all dimensions against approved project drawings.
- 2. Development and anchorage lengths require engineer confirmation.
- 3. Nominal continuity bars are detailing steel, not demand-verified steel.
- 4. No stirrup smaller than 10 mm / #3 shall be used.