

Steel Design - LRFD

AISC Steel Manual 13th edition

Beam Limit States

Professor Louie L. Yaw

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1 Moment Limit State

In steel design it is often necessary to design a beam to resist bending moments. In order to design the beam according to LRFD, ϕM_n must be determined for the trial beam selected. Once ϕM_n is determined it can then be compared to the factored moment M_u to evaluate the adequacy of the selected beam. This is often an iterative process. Hence, in order to determine ϕM_n three bending limit states must be considered:

- A. Lateral Torsional Buckling (LTB).
- B. Flange Local Buckling (FLB).
- C. Web Local Buckling (WLB).

For each of the above limit states beams will, if loaded to failure, fail in one of three failure modes:

- 1. Failure by yielding (material failure), $\lambda \leq \lambda_p$.
- 2. Failure by inelastic buckling, $\lambda_p < \lambda \leq \lambda_r$.
- 3. Failure by elastic buckling, $\lambda_r < \lambda$.

For example, if loaded to failure, a beam failing according to limit state "A" will fail by failure mode 1, 2, or 3. The failure mode for the limit state "A" can be determined by calculating a *slenderness parameter*, λ . This slenderness parameter will indicate if the mode of failure occurs in the *material*, *inelastic*, or *elastic* range (see **Figure I**). Based on the mode of failure the value of ϕM_n for limit state "A" can be calculated.

This same procedure must be followed for limit state "B" and for limit state "C". By this process three values of ϕM_n , one for each limit state, are obtained. The *smallest* value of ϕM_n governs and indicates the factored nominal moment capacity of the beam which is compared to M_u .

In what follows a procedure to calculate ϕM_n for each limit state is given. For each limit state the procedure provides all of the information needed to calculate ϕM_n . In each case



Figure I — M_n vs λ

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