

# Steel Design - LRFD

## AISC Steel Manual 13th edition

### Beam Limit States

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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,  $\phi M_n$  must be determined for the trial beam selected. Once  $\phi M_n$  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  $\phi M_n$  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*,  $\lambda$ . 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  $\phi M_n$  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  $\phi M_n$ , one for each limit state, are obtained. The *smallest* value of  $\phi M_n$  governs and indicates the factored nominal moment capacity of the beam which is compared to  $M_u$ .

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



**Figure I** —  $M_n$  vs  $\lambda$

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