
Postgraduate Certificate in Structural Steel Design

Steel Seismic Design

Steel Seismic Design: Key Terms and Vocabulary

When it comes to steel seismic design, there are several key terms and vocabulary that are critical to understand. In this explanation, we will cover some of the most important terms and provide examples and practical applications to help illustrate their meaning.

- 1. Seismic Design Forces:** Seismic design forces are the forces that are applied to a structure during an earthquake. These forces are determined based on the structure's location, the expected ground motion, and the structure's properties. In steel seismic design, the seismic design forces are used to determine the size and shape of the steel members and connections.
- 2. Seismic Coefficient:** The seismic coefficient is a factor used to determine the seismic design forces. It is a measure of the expected ground motion and is based on the structure's location and the type of soil at the site. The seismic coefficient is typically expressed as a decimal value between 0 and 1.
- 3. Ductility:** Ductility is the ability of a material to deform under stress without breaking. In steel seismic design, ductility is a critical property because it allows the structure to absorb energy during an earthquake and helps prevent brittle failure.
- 4. Capacity Design:** Capacity design is a method used in steel seismic design to ensure that the structure has sufficient ductility and energy-absorbing capacity. It involves designing the structure so that the plastic hinges form in the beam-column connections rather than in the columns or beams themselves.
- 5. Plastic Hinge:** A plastic hinge is a region in a steel member where the material has yielded and can no longer support the applied loads. In steel seismic design, plastic hinges are intentionally created in the beam-column connections to allow the structure to deform and absorb energy during an earthquake.
- 6. Overstrength Factor:** The overstrength factor is a factor used to account for the increased strength of a steel member due to factors such as strain hardening and residual stresses. It is typically expressed as a decimal value greater than 1.
- 7. Redundancy:** Redundancy is the ability of a structure to withstand damage to one or more of its members without collapsing. In steel seismic design, redundancy is achieved by providing multiple paths for load transfer and by ensuring that the structure can redistribute loads in the event of damage.
- 8. System Strength:** System strength is the total strength of a steel structure, including the strength of all of its members and connections. In steel seismic design, system strength is a critical factor because it determines the structure's ability to resist seismic forces.
- 9. Steel Grade:** Steel grade is a measure of the strength and ductility of a particular type of steel. In steel seismic design, the steel grade is an important consideration because it determines the size and shape of the steel members and connections.
- 10. Connection Design:** Connection design is the process of designing the connections between steel members to ensure that they can transfer the required loads. In steel seismic design, connection design is critical because it ensures that the structure can deform and absorb energy during an earthquake without failing.

11. Seismic Joint: A seismic joint is a structural detail that allows for differential movement between adjacent parts of a structure during an earthquake. Seismic joints are typically used in buildings with long spans or irregular shapes.

12. Base Isolation: Base isolation is a seismic design technique that involves separating the structure from the ground using flexible bearings or other devices. This allows the structure to move independently of the ground during an earthquake, reducing the forces on the structure.

13. Supplemental Damping: Supplemental damping is a seismic design technique that involves adding damping devices to a structure to reduce the forces on the structure during an earthquake. Supplemental damping can be achieved using a variety of devices, including fluid dampers and viscoelastic dampers.

14. Capacity Protection: Capacity protection is a seismic design technique that involves protecting critical components of a structure from damage during an earthquake. This is typically achieved by providing additional reinforcement or by locating the critical components in areas of the structure with reduced seismic forces.

15. Risk-Targeted Design: Risk-targeted design is a seismic design approach that involves designing a structure to achieve a specific level of risk. This approach considers the consequences of a structural failure and the likelihood of that failure occurring, and uses that information to determine the appropriate design criteria.

Examples and Practical Applications:

* When designing a steel structure for seismic forces, the seismic design forces are calculated based on the seismic coefficient, the structure's location, and the structure's properties. These forces are then used to determine the size and shape of the steel members and connections.

* Capacity design is used to ensure that the structure has sufficient ductility and energy-absorbing capacity. This is achieved by designing the structure so that the plastic hinges form in the beam-column connections rather than in the columns or beams themselves.

* Plastic hinges are intentionally created in the beam-column connections to allow the structure to deform and absorb energy during an earthquake. However, it is important to ensure that the plastic hinges do not form in the columns or beams themselves, as this can lead to brittle failure.

* The overstrength factor is used to account for the increased strength of a steel member due to factors such as strain hardening and residual stresses. This factor is typically expressed as a decimal value greater than 1, and is used to determine the size and shape of the steel members and connections.

* Redundancy is achieved by providing multiple paths for load transfer and by ensuring that the structure can redistribute loads in the event of damage. This is important because it ensures that the structure can withstand damage to one or more of its members without collapsing.

* System strength is a critical factor in steel seismic design because it determines the structure's ability to resist seismic forces. The system strength is determined by the strength of all of the members and connections in the structure.

* Connection design is critical in steel seismic design because it ensures that the connections between steel members can transfer the required loads. This is particularly important in areas with high seismic forces, as the connections may be subjected to significant loads during an earthquake.

* Seismic joints are used in buildings with long spans or irregular shapes to allow for differential movement between adjacent parts of the structure during an earthquake. This helps to reduce the forces on the

structure and prevent damage.

- * Base isolation is a seismic design technique that involves separating the structure from the ground using flexible bearings or other devices. This allows the structure to move independently of the ground during an earthquake, reducing the forces on the structure.
- * Supplemental damping is a seismic design technique that involves adding damping devices to a structure to reduce the forces on the structure during an earthquake. This can be achieved using a variety of devices, including fluid dampers and viscoelastic dampers.
- * Capacity protection is a seismic design technique that involves protecting critical components of a structure from damage during an earthquake. This is typically achieved by providing additional reinforcement or by locating the critical components in areas of the structure with reduced seismic forces.
- * Risk-targeted design is a seismic design approach that involves designing a structure to achieve a specific level of risk. This approach considers the consequences of a structural failure and the likelihood of that failure occurring, and uses that information to determine the appropriate design criteria.

Challenges:

- * One of the challenges in steel seismic design is ensuring that the structure has sufficient ductility and energy-absorbing capacity. This requires careful consideration of the plastic hinge locations and the use of capacity design principles.
- * Another challenge is ensuring that the connections between steel members can transfer the required loads. This requires careful design and testing of the connections to ensure that they can withstand the expected loads.
- * Seismic joints and base isolation are effective techniques for reducing the forces on a structure during an earthquake, but they can be expensive and complex to implement. As such, they may not be feasible for all structures.
- * Risk-targeted design is a powerful approach for achieving specific levels of risk, but it requires careful consideration of the consequences of a structural failure and the likelihood of that failure occurring. This can be challenging, particularly for complex structures with multiple failure modes.

Conclusion:

Steel seismic design is a critical aspect of ensuring the safety and resilience of steel structures in seismically active regions. By understanding the key terms and vocabulary associated with steel seismic design, engineers can design structures that are capable of withstanding the forces of an earthquake and protecting the safety of the occupants. Examples and practical applications can help illustrate the importance of these concepts, while challenges such as ensuring ductility, connection strength, and risk-targeted design can provide opportunities for further study and exploration.