World Academy of Science, Engineering and Technology
International Journal of Civil and Environmental Engineering
Vol:18, No:06, 2024

Design Recommendation for H-shapes Steel Beam with Unreinforced Circular Web Opening

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Abstract : In building construction, the use of web opening as a passage for service pipes is very common with the main purpose of space saving. The strength of the beam may be reduced by this opening, and thus, the configuration of the web opening should be well-designed. A design guide to aid the design of the beam with web opening is available, but it was established based on studies on the beam subjected to gravity-type loading. In simple words, there are no clear design guidelines for the design of beams with web openings subjected to seismic-type loading, which is required in Taiwan. Without any clear guidelines, engineers tend to design the web opening based on their experience, and in most cases, the design is too conservative. A massive amount of reinforcement is sometimes required even though the opening is introduced to the web in low-stress regions. The cost of the reinforcement is usually high. In view of the current situation, there exists a need to investigate the seismic behavior of beams subjected to seismic-type loading so that practical solutions can be provided to aid the engineer in designing the beams with web openings. The current study focuses on investigating the seismic behavior of beams with unreinforced web openings subjected to seismic-type loading. As the preliminary study, the scope of the study is limited to the beam that is only subjected to uniformly distributed gravity load before being subjected to seismic-type loading. The main objective of this study is to confirm that there exists a chance for introducing a web opening without any reinforcement on a beam subjected to seismic-type loading. Three beams, one without and two with circular web openings, were tested to observe how web openings will affect the beam performance under seismic load. The test result shows that for the beam section and length tested in this study, the presence of the web opening located relatively close to the beam plastic hinge region did not affect the overall performance of the beam. No distinct difference in hysteretic behavior can be observed between the beams with and without web opening. The chance of introducing unreinforced web openings on beams designed as highly ductile members exists. Following the test, numerical simulation was also conducted to investigate the hysteretic behavior of various dimensions of beams with one large unreinforced circular web opening. As a result, a design recommendation is proposed to aid the engineer in judging whether the opening reinforcement is required or not. Without reinforcement, considerable cost savings can be achieved.

Keywords : circular web opening, seismic design, steel beam design, unreinforced web opening
Conference Title : ICCEE 2024 : International Conference on Civil and Environmental Engineering
Conference Location : Tokyo, Japan
Conference Dates : June 03-04, 2024