11 WCEE

Published by Elsevier Science Ltd 1996
Paper No. 2143. (quote when citing this article)
Eleventh World Conference on Earthquake Engineering
ISBN: 0 08 042822 3

DAMAGE TO STEEL BUILDINGS OBSERVED IN THE 1995 HYOGOKEN-NANBU EARTHQUAKE

MASAYOSHI NAKASHIMA

Disaster Prevention Research Institute, Kyoto University
Gokasho, Uji, Kyoto 611 JAPAN

ABSTRACT

Japan is an earthquake-prone country, having received large earthquakes chronically. For the first time in the 1995 Hyogoken-Nanbu (colloquially called the Hanshin/Awaji or simply Kobe) Earthquake, reported was the extensive damage to steel building structures. Among the damaged steel buildings, the vast majority was concentrated in steel buildings more than 35 years old, built before the major economic growth of the post-war era. These old buildings used light-gauge sections for their columns and beams that seriously lacked in earthquake resistance because of the then premature seismic design and construction technologies, and also because of material deterioration, etc. Renewal and rehabilitation of such old buildings, which form a very large proportion of building stock in many large cities throughout Japan, are no doubt most urgent.

From the survey conducted by the Steel Committee of the AIJ's Kinki Branch, 988 modern steel buildings were found to have sustained damage, and the following vulnerable spots were identified. They were: (1) fractures of beam-to-column welded connections, (2) fractures of column base metals and welded splices, (3) fractures of brace-to-column and brace-to-beam connections, and (4) damage to column base connections

The damage may also be classified as follows in light of previous awareness and the difficulty of providing solutions. TYPE-I is the damage that can be described as, "We knew they were seismically vulnerable; but we did not take action, and they failed." The extensive damage to old steel buildings mentioned above falls into this category. TYPE-II is the damage that can be described as, "We did not know they were so bad (because their weaknesses were hidden); upon seeing the damage, we could locate reasons." This type of damage was closely associated with quality control in building design and construction. Examples of this type of damage are fractures of steel beam-to-column connections which were fillet-welded of very small size, and our quality control is in question. TYPE-III is the damage that can be described as "They were designed and constructed according to present practice; nevertheless they failed." Here, our present design and construction practice is called into question, and action by researchers and engineers has to be initiated. TYPE-III may be classified further into TYPE-III-a, stated as "After examining the damage, we located the true reasons and now know how to improve," and TYPE-III-b stated as, "After one year, we still debate." Damage to column base connections and brace-to-column and brace-to-beam connections may be categorized as TYPE-III-a, whereas fractures of jumbo columns and cold-formed square tube columns and fractures of beam-to-column connections are TYPE-III-b. Furthermore, it should be noted that cases of fractures to beam-to-column connections outnumber those of column failures.

Various types and degrees of damage to steel buildings observed in the 1994 Hyogoken-Nanbu Earthquake have revealed that much effort is still needed to upgrade the design, fabrication, and construction of Japanese steel buildings.

KEYWORDS

Hyogoken-Nanbu Earthquake; steel buildings; damage; columns; connections; braces; column bases; fractures