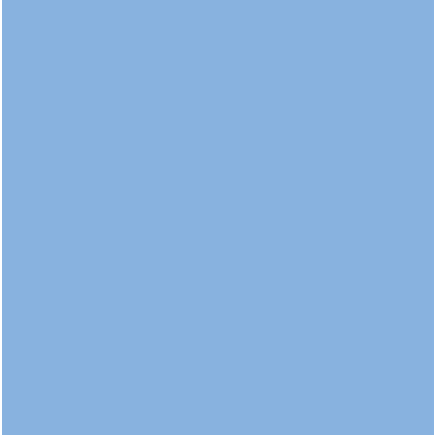




Executive Summary

Following the September 11, 2001, attacks on New York City's World Trade Center (WTC), the Federal Emergency Management Agency (FEMA) and the Structural Engineering Institute of the American Society of Civil Engineers (SEI/ASCE), in association with New York City and several other Federal agencies and professional organizations, deployed a team of civil, structural, and fire protection engineers to study the performance of buildings at the WTC site.

The events following the attacks in New York City were among the worst building disasters in history and resulted in the largest loss of life from any single building collapse in the United States. Of the 58,000 people estimated to be at the WTC Complex, 2,830 lost their lives that day, including 403 emergency responders. Two commercial airliners were hijacked, and each was flown into one of the two 110-story towers. The structural damage sustained by each tower from the impact, combined with the ensuing fires, resulted in the total collapse of each building. As the towers collapsed, massive debris clouds consisting of crushed and broken building components fell onto and blew into surrounding structures, causing extensive collateral damage and, in some cases, igniting fires and causing additional collapses. In total, 10 major buildings experienced partial or total collapse and approximately 30 million square feet of commercial office space was removed from service, of which 12 million belonged to the WTC Complex.

The purpose of this study was to examine the damage caused by these events, collect data, develop an understanding of the response of each affected building, identify the causes of observed behavior, and identify studies that should be performed. The immediate effects of the aircraft impacts on each tower, the spread of fires following the crashes, the fire-induced reduction of structural strength, and the mechanism that led to the collapse of each tower were studied. Additionally, the performance of buildings in the immediate vicinity of the towers was studied to determine the effects of damage from falling debris and fires. Recommendations are presented for more detailed engineering studies, to complete the assessments and produce improved guidance and tools for building design and performance evaluation.

As each tower was struck, extensive structural damage, including localized collapse, occurred at the several floor levels directly impacted by the aircraft. Despite this massive localized damage, each structure remained standing. However, as each aircraft impacted a building, jet fuel on board ignited. Part of this fuel immediately burned off in the large fireballs that erupted at the impact floors. Remaining fuel flowed across the floors and down elevator and utility shafts, igniting intense fires throughout upper portions of the buildings. As these fires spread, they further weakened the steel-framed structures, eventually leading to total collapse.

The collapse of the towers astonished most observers, including knowledgeable structural engineers, and, in the immediate aftermath, a wide range of explanations were offered in an attempt to help the public understand these tragic events. However, the collapse of these symbolic buildings entailed a complex series