LESSONS FROM SICHUAN EARTHQUAKE: FAILURE AND STRUCTURAL INTEGRITY

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Summary The Failure was extensive to residential and commercial buildings and lifelines after the 12 May 2008 Sichuan earthquake. This work presents post-earthquake field investigations, features failure modes in the different damaged structures and the cause of the damage to the effects of the loading during the ground motion. It is noticed that structural failure during earthquake is often associated with a small number of post-yield stress reversals and large cyclic deformations with local buckling or plastic damage. It should be considered in seismic Integrity and reliability analyses that focus on very low cycle damage. Finally, the paper briefly discuss the extraneous effects on the mechanisms of very low cycle fatigue, the possible use of collapsed building waste to produce concrete for rebuilding.

INTRODUCTION

The 2008 Sichuan earthquake (also known as the Wenchuan earthquake), which measured at 8.0 Ms according to China Seismological Bureau, occurred on 12 may in Sichuan province of China. The earthquake occurred in the Longmen Mountain Fault which slipped along a plane of 240 km long by 20 km deep. Along this line the ground was displaced horizontally as much as 5 meters (Fig.1). The total disaster zone covering an area of 440 000 square kilometers. The earthquake destroyed 5.3 million and damaged 21 million rooms, and left about 4.8 million people homeless. Some 90000 people were counted as dead or missing. More than 80% earthquake-related deaths are caused by the collapse of man-made structures and the building construction play a tremendous role in the death toll of the earthquake.

a) Dujiangyan b) Pengzhou C) Beichuan

Fig.1 Buildings damaged due to fault propagate

STRUCTURAL PERFORMANCE OF BUILDINGS

Earthquake damage depends on many parameters, including intensity, duration and frequency content of ground motion, geologic and soil condition, quality of construction, etc. Building design must be such as to ensure that the building has adequate strength, high ductility, cyclic load capacity and will remain as one unit, even while subjected to very large deformation. Several factors of building construction determine the structural failure from the earthquake including, the type and age of building, foundation, materials used, seismic code used and construction quality, etc. Field investigation in Mianyang area revealed that 63% of raw-soil buildings, 36% of brick-wood structures, 25% of masonry structures, and 11% of frame structures damaged during the earthquake (Fig.2).

a) raw-soil structure b) brick-wood structure c) masonry structure d) frame structure

Fig.2 Evolution of quake damage for different types of buildings

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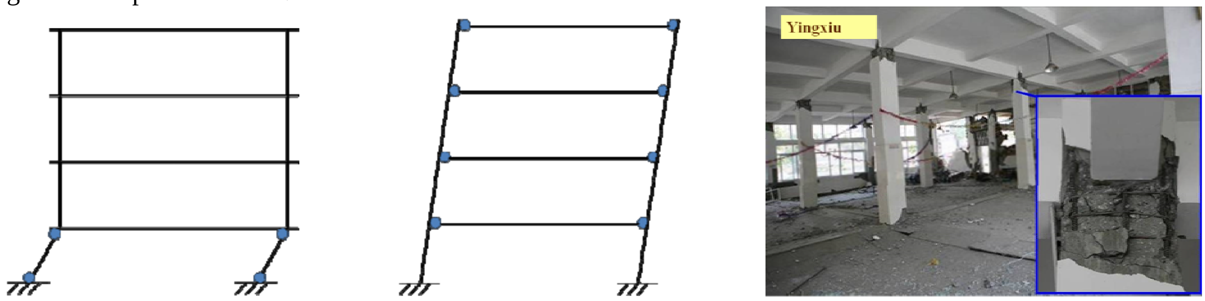
Typically, the RC column fails in flexure just below floor level, with spalling of the concrete and buckling of the reinforcement, leading to global collapse (Fig. 3). If the beams deform plastically at the column face the damage is local and global collapse is avoided.



Strong beam – weak column   Weak beam – strong column   Typical failure in columns

Fig. 3 – Weak beam – strong column failure

Many residential and commercial buildings in the epicenter area experienced severe damage to the first story. Generally, the ground stories of these buildings were used for commercial space or as parking space, and the upper stories were used as residential apartments. These buildings had less, even no infill walls (or other strong and stiff lateral load resisting elements, e.g. shear walls or strong columns) in the first story to increase the parking or commercial spaces. Such an arrangement of tiles infill walls created stiffness discontinuities in these buildings.

Fig. 4 Soft storey failure

Even badly built buildings can resist some up-and-down loads, not side-to-side loads. The structural elements such as walls, beams and columns that were bearing only vertical loads before the earthquake, have now to carry horizontal bending and shearing effects as well. The principal cause of earthquake-induced failure is ground shaking. As the earth vibrates, all buildings on the ground surface will respond to that vibration or cyclic loading (Fig.5). The earthquake loads are dynamic.

Fig. 5 Failure due to horizontal dynamic loading

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