WORKSHOP ON
BEST PRACTICES FOR REDUCING POTENTIAL FOR PROGRESSIVE COLLAPSE IN BUILDINGS

Organized by

Structural Engineering Institute

National Institute of Standards and Technology

Workshop on Progressive Collapse Mitigation

INTRODUCTION

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National Institute of Standards and Technology

Events Stimulated Interest In Progressive Collapse

- Ronan Point Tower collapse in U.K. in 1968.
- Terrorist attack on the Alfred P. Murrah building in Oklahoma City in 1995.
- Terrorist attacks on the World Trade Center towers and the Pentagon in 2001.
- Other terrorist attacks on U.S. facilities worldwide.

Current Activities

- ASCE/SEI Technical Committee on “Progressive Collapse”
- Harmonize UFC and GSA Guidelines
- Code change proposal for IBC
- Joint ad hoc committee

What Is Progressive Collapse ?

ASCE 7 – "Spread of an *initial local failure* from *element to element* resulting in, eventually, the collapse of an entire structure or a disproportionately large part of it."

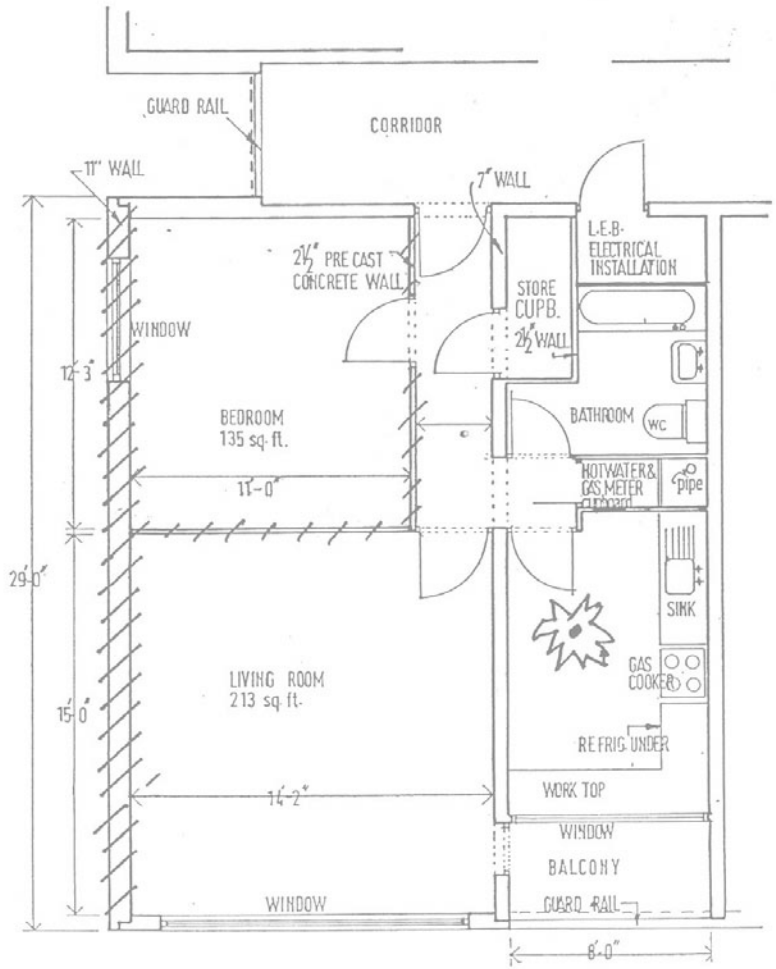
Key distinguishing features:

- Propagation of local structural damage
- Chain reaction of failures
- Extensive partial or total collapse

RONAN POINT
(1968)

- 24 story tower (60 ft x 80 ft)
- Precast concrete panel construction
- Gas explosion on 18th floor
- Progressive collapse of one corner

Floor Plan Of Flat 90



STRUCTURAL DEFICIENCIES

- Lack of structural continuity
- Absence of alternate load paths

RECOMMENDATIONS

- Changes in building regulations
- Design to prevent progressive collapse
- Introduce continuity at connections
- Provide alternative load paths

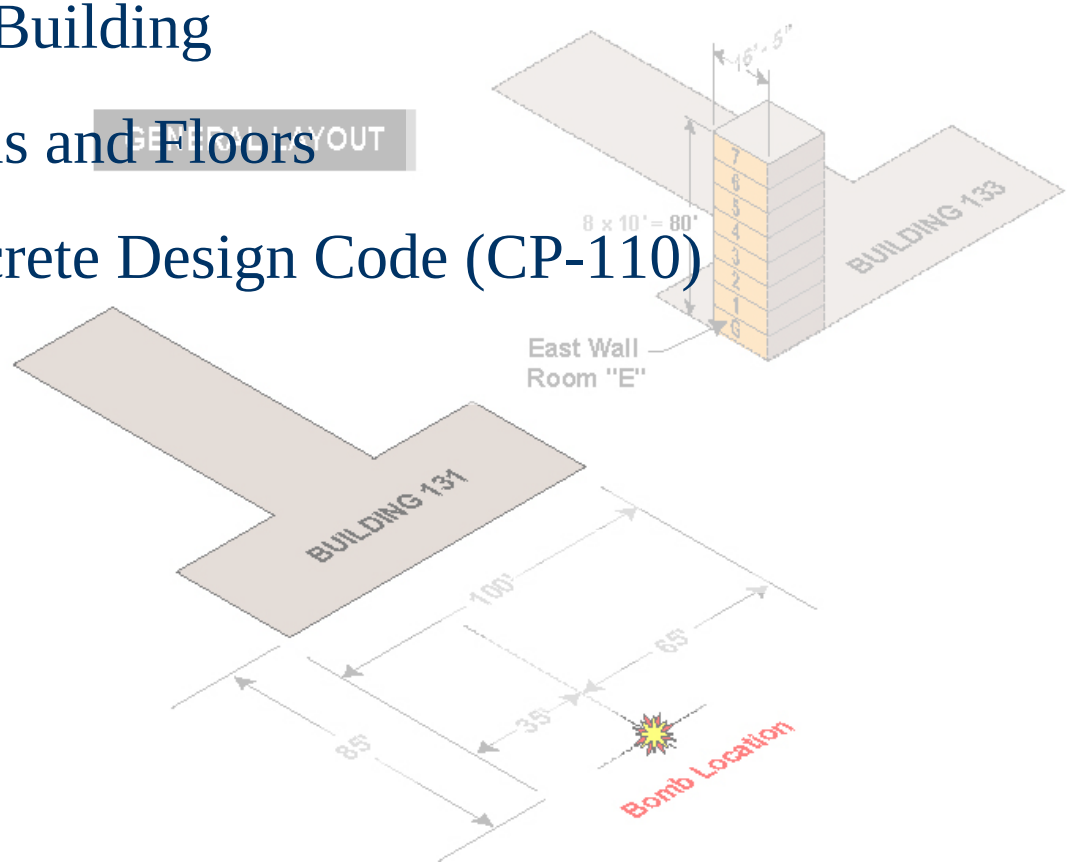
DESIGN METHODS

- Tying structural members
  - Provide vertical and horizontal ties
- Bridging over failed members
  - Notional removal of members
- Key element design
  - Design members to resist 5 psi (720 psf)

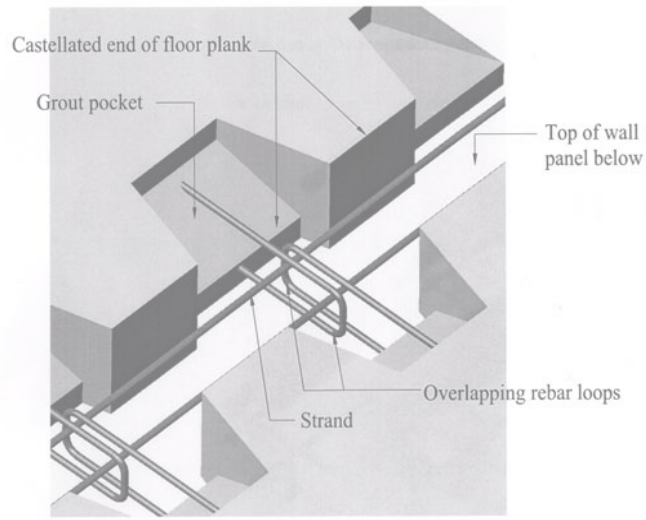
KHOBAR TOWERS
(1996)

General Layout

- Eight Story Building
- Precast Walls and Floors
- British Concrete Design Code (CP-110)

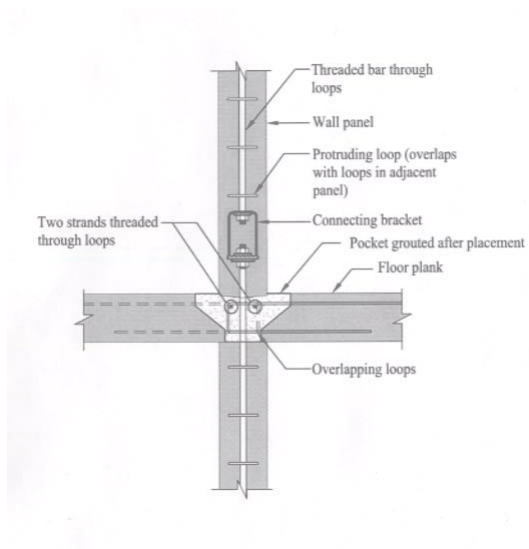


Typical Construction



Interlocking floor plank detail

Two 0.43” dia 270 ksi steel strand threaded through overlapping loops embedded in panel



Connection at floor plank and wall intersection

Steel bars threaded through protruding loops and attached, from level to level, with nuts inside connecting brackets

OBSERVED DAMAGE

- Crater – 55 ft diameter and 16 ft deep
- Destroyed façade facing blast
- Damaged interior wall and floor panels
- Widespread glass damage

Post-Blast Crater

Post-Blast Damage

POST-BLAST DAMAGE
Interior Wall Panel

OBSERVATIONS

- Precast concrete system designed with continuous ties provide enough ductility to resist extraordinary event.
- Precast panels designed with sufficient ductility can limit extent of damage.

DESIGN REQUIREMENTS

- U.S.
  - DoD Unified Facility Criteria (2005)
  - GSA Progressive Collapse Analysis and Design Guidelines (2003)
  - ASCE/SEI 7-05
  - ACI 318 (2005)
  - NYC Building Code (1973)

DESIGN REQUIREMENTS

- UK
  - British Standards
  - Code of Practice documeents
- Eurocode
- National Building Code of Canada
- Swedish Design Regulations

Current State of Code and Standard Provisions on Progressive Collapse

- No unified definition of progressive collapse in quantitative terms.
  - Disproportionate collapse
- Lack of specific structural integrity requirements for robustness.
  - Degree of redundancy
  - Requirements for structural details
- Lack of quantitative requirements for design events.

NIST PROGRAM ON PROGRESSSIVE COLLAPSE MITIGATION

- Objective
  - To develop and implement
    - Performance criteria for codes and standards
    - Analytical tools for design professionals
    - Practical guidelines

- Timeline

  2005 - 2011

PRINCIPAL OUTPUTS

- **Best Practice Guide for new and existing buildings**.
- Analytical tools for design professionals.
- Guide for progressive collapse vulnerability assessment.
- Guide for design of new buildings to resist progressive collapse.
- Guide for retrofitting of existing buildings to resist progressive collapse.
- Pre-standard for design of new buildings to resist progressive collapse.
- Pre-standard for rehabilitation of existing buildings to resist progressive collapse.

WORKSHOP CONTENT

- Introduction
- Acceptable risk
- Means for risk reduction
- Practical design approaches
- Case studies
- Q & A

PURPOSE OF WORKSHOP

- To present “Best Practices” guides
- To obtain input from design professionals

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Questions & Comments