

Collapse of 2000 Commonwealth Avenue

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Outline

- Introduction
- Building description
- Construction
- Collapse
- Causes
- Other cases
- Lessons learned
- Conclusions

Introduction

- Important to study case studies
- 2000 Commonwealth Ave. collapse occurred on January 25, 1971
- Many factors contributed to collapse

Building Description

- Sixteen story high-rise apartment building
- Cast-in-place reinforced concrete
- Flat slab construction
- Central elevator shaft
- Penthouse mechanical room with a five-foot crawl space

Construction

- Excavation began in fall of 1969
- Most of work was subcontracted
- At time of collapse, construction was almost complete
- Brickwork done to 16th floor and work had started in individual apartments

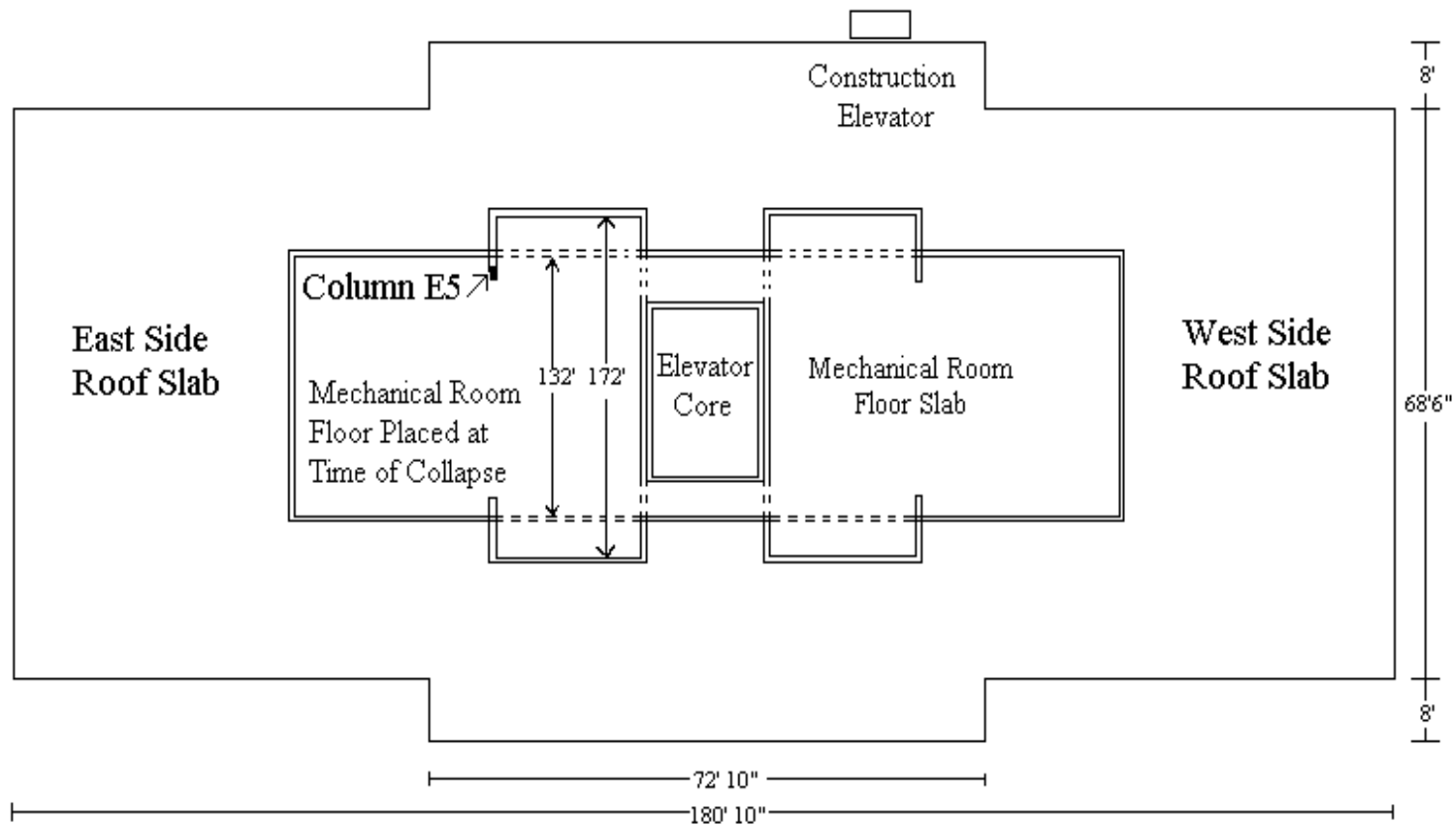
Collapse

- Phase 1: Punching Shear Failure in the Main Roof at Column E5
- Phase 2: Collapse of Roof Slab
- Phase 3: General Collapse

Phase 1: Punching Shear

- About 3:00pm workers take break from placing concrete for the mechanical room floor slab
- Placement started at the west edge and proceeded east
- Shortly after break there was a drop in the floor slab
- Punching shear was noticed around column E5

Floor Plan



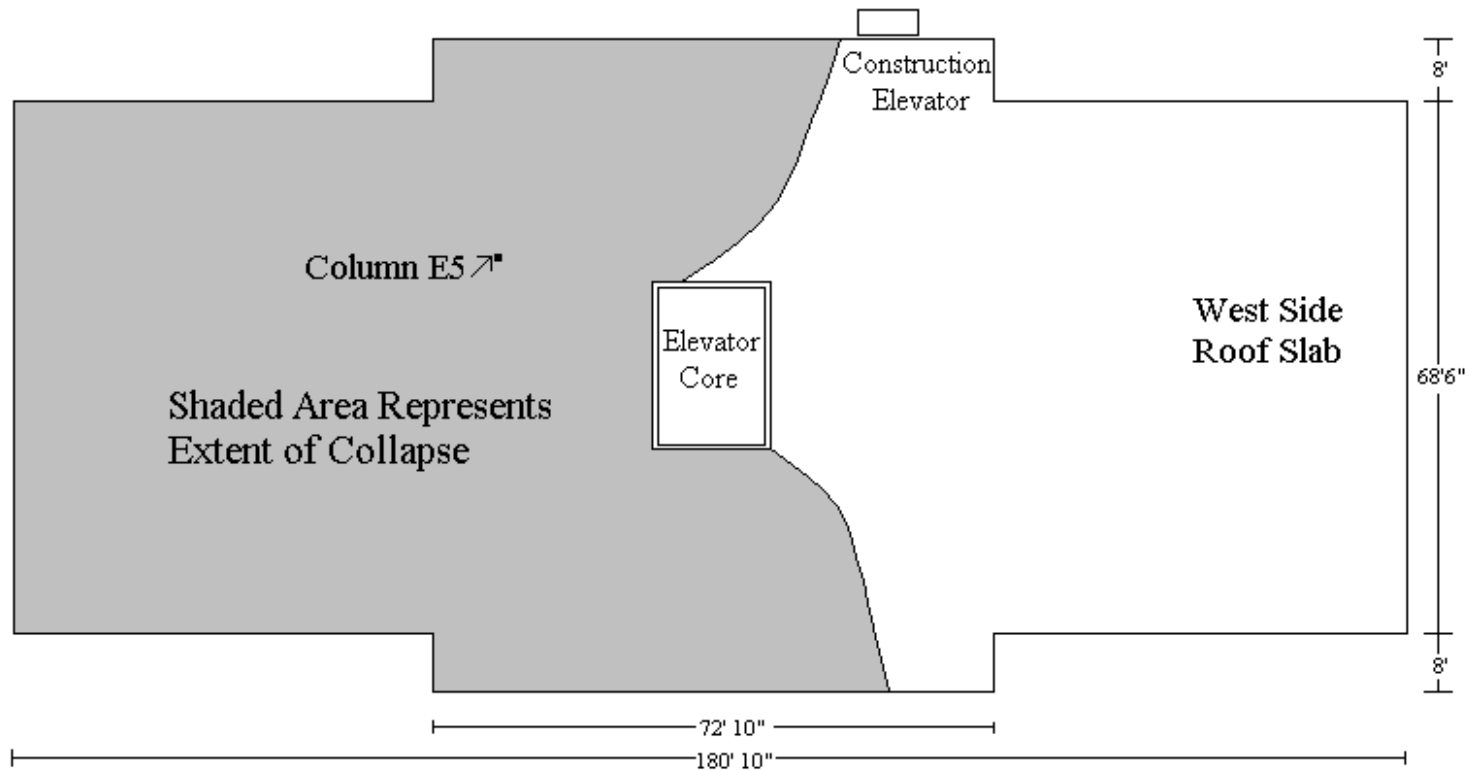
Phase 2: Collapse of Roof Slab

- After hearing a warning, most workers managed to get out of the way
- Roof slab began to form the shape of a belly
- Roof collapsed onto sixteenth floor
- At time, reinforcing steel was being placed, so workers were forced to cross over to the west side of the building

Phase 3: General Collapse

- Progressive collapse occurred 20 minutes after roof collapsed
- Weight of the roof caused the 16th floor to collapse onto 15th and so on down to the ground
- Two thirds of the building was gone
- Four workers died

Extent of Collapse



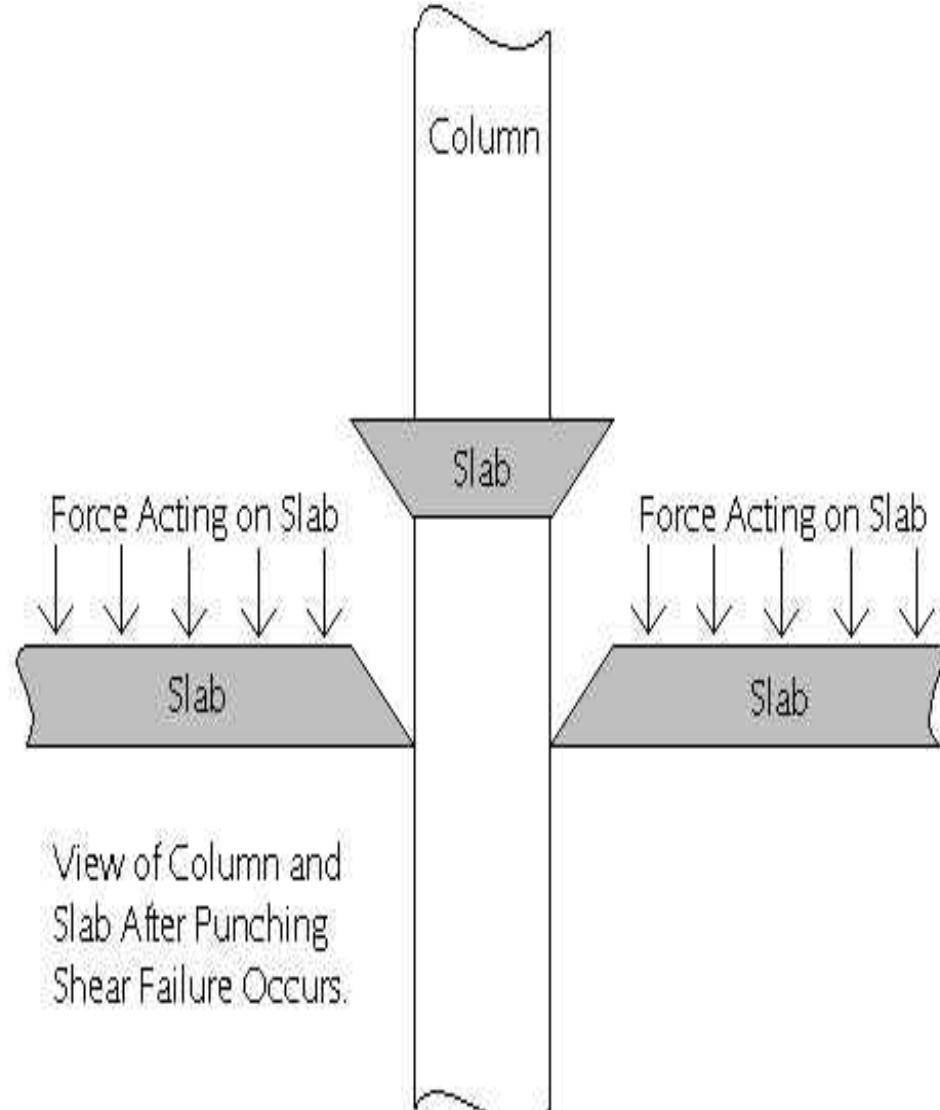
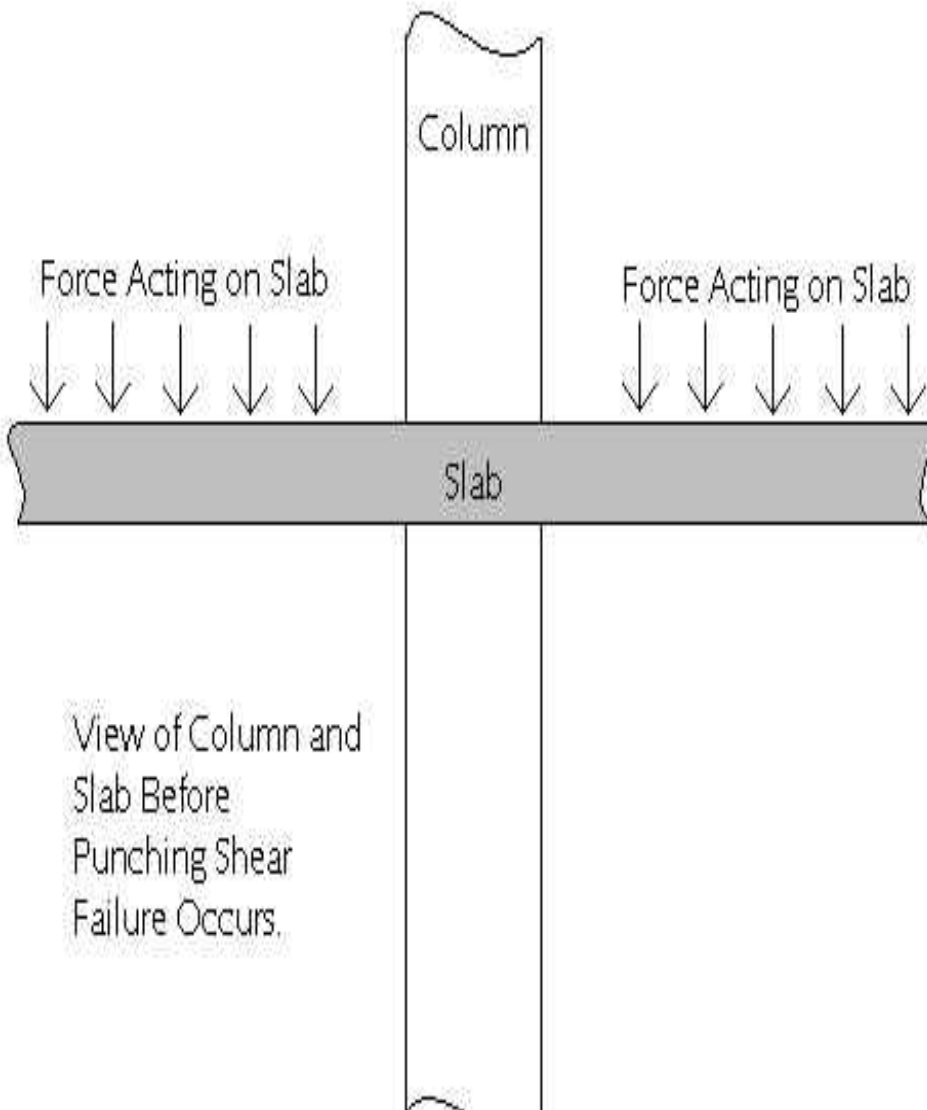
Causes of Failure

- Many factors contributed to collapse:
 - Punching shear failure at column E5
 - Design Flaws
 - Procedural/Construction flaws

What is Punching Shear?

- Happens when floor slab becomes too great for a column to hold
- Added construction loads can cause unbalanced moments
- The dead weight the column cannot hold is transferred to surrounding columns. However, this added weight is often too great and the floor slab fails.

Punching Shear



Causes of Punching Shear

- Concrete strength was well below required 3000 psi
- Inadequate shoring under the roof slab
- Construction equipment and two boilers were on the roof

Design Flaws

- Insufficient length of rebar
 - the bars did not extend enough into columns
- Incorrect placement of bars
 - confusion with deliveries
 - design around columns did not meet ACI codes
 - billet steel vs. rail steel

Procedural/Construction Flaws

- Lack of proper building permit and field inspection
- Premature removal of formwork
- Lack of construction control

Confusion Surrounding Construction

- 11-3-64 first building permit applied for
- 5-24-65 excavation begins
- 8-16-67 permit lapsed due to delay
- 11-20-67 new permit, new building design
- 7-3-68 zoning change obtained
- 12-23-68 ownership changes
- 7-7-69 new permit, new building design
- 8-1-69 excavation continued

Confusion Surrounding Construction (cont.)

- 8-27-69 new permit, ownership change
- 8-29-69 affidavit states plans meet code
- 9-4-69 change in ownership
- 9-5-69 permit granted for 16 story building
- fall '69 construction begins
- fall '69-70 concept changes
- 11-10-70 ownership changes
- 1-25-71 building collapses

Similarities to Other Failures

- Skyline Plaza in Bailey's Crossroads, VA
 - March 2, 1973 collapse while under construction
 - premature removal of shoring and insufficient concrete strength
- Harbour Cay Condominium Building, Cocoa Beach, FL
 - March 27, 1981 collapse while under construction
 - punching shear failure

Lessons Learned

- Twenty eight day cylinder test
- Slump test
- Punching shear
- What happens when shoring and formwork are not properly used

Conclusion

- The collapse of 2000 Commonwealth Avenue could have been avoided
- It is the responsibility of everyone involved in a project to see that all codes and design specifications are being adhered to

Acknowledgements

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- Dr. Delatte for answering all of my questions
- Mom for sending me cool packages

Key References

- City of Boston report