

SEW/C2002

ABSTRACTS

Structural
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Northridge Earthquake: Statistical Analysis of Damage to Residential Wood Structures

Key findings are presented of the following five statistical studies of residential wood structures damaged in the Northridge Earthquake, based on LA City data of damaged and existing buildings:

- *General Study* (all red and yellow tagged buildings)
- *Sample Study* (1230 buildings, randomly selected)
- *Focus Study: Apartments with Tuck-under Parking* (42 buildings near Northridge Meadows)
- *Focus Study: Expensive Repair* (based on rapid screening estimates of 60% or > damage)
- *Focus Study: Demolished Buildings* (based on LA demolition permit records)

The study used 18 categories: 2 types (single family [SFD] and multifamily dwellings [MFD]), 3 vintages (built 0-40, 41-76, 77-93), and 3 PGA intensities (<30, 30-60, >60). All findings are relative, correlate damage to existing stock, presented in graphs and maps. Key findings are:

- ***Performance vs. Vintage***

Multifamily dwellings (MFD) built 77-93 performed worse than older ones (graphs 1-7); contrary to what should be expected, since 1976 UBC changes require more conservative seismic design. Poor performance may be due to inadequate construction observations by design professionals.

- ***Damage Correlation with PGA vs. PGV***

Damage patterns correlate better with PGA (Peak Ground Acceleration) than PGV (Peak Ground velocity) (maps 1&2, SFD built 77-93, are compelling examples). While this differs from a study by Dr. Boatwright, low-rise structures may correlate better with PGA due to short periods. The stock of existing homes in this example is rather uniform, hence damage is defined by seismic intensity, rather than existing home density.

- ***Demolished SFD vs. Height***

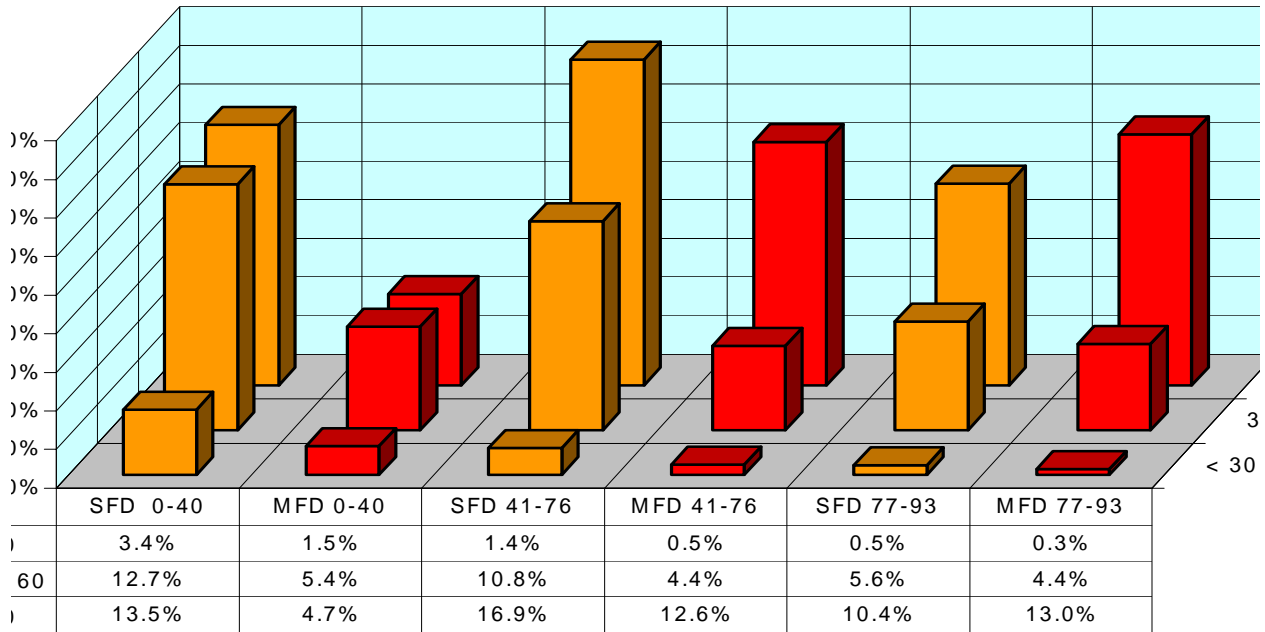
As pro-mill of existing, most demolished SFD had two stories (graph 8). Their resonant periods of about 0.2 seconds correlates with the dominant ground period of about 0.2 seconds of the Northridge Earthquake and appears to be a major factor for their failure.

- ***Other findings include:***

- Apartment buildings with tuck-under parking with pin columns did cost seven times more to repair than those with moment frame of the same vintage (graph 5).
- 59% demolished SFD are on hillsides, likely rock sites, while only 16% existed on rock sites.
- 31% demolished MFD are on hillsides, likely rock sites, while only 8% existed on rock sites.
- 88% of demolished MFD and 84% of demolished MFD were red-tagged.
- In MFD, shear walls are the most frequently damaged and the most costly item to repair.
- In SFD, footings are the most costly items to repair, while in SFD built before 1977, chimneys are the most frequently damaged items.
- In expensive repair buildings, non-structural items are most frequently damaged.
- Several collapsed buildings had tuck-under parking (soft-story).
- Roof diaphragm failure at intersection of irregular configurations caused major damage.

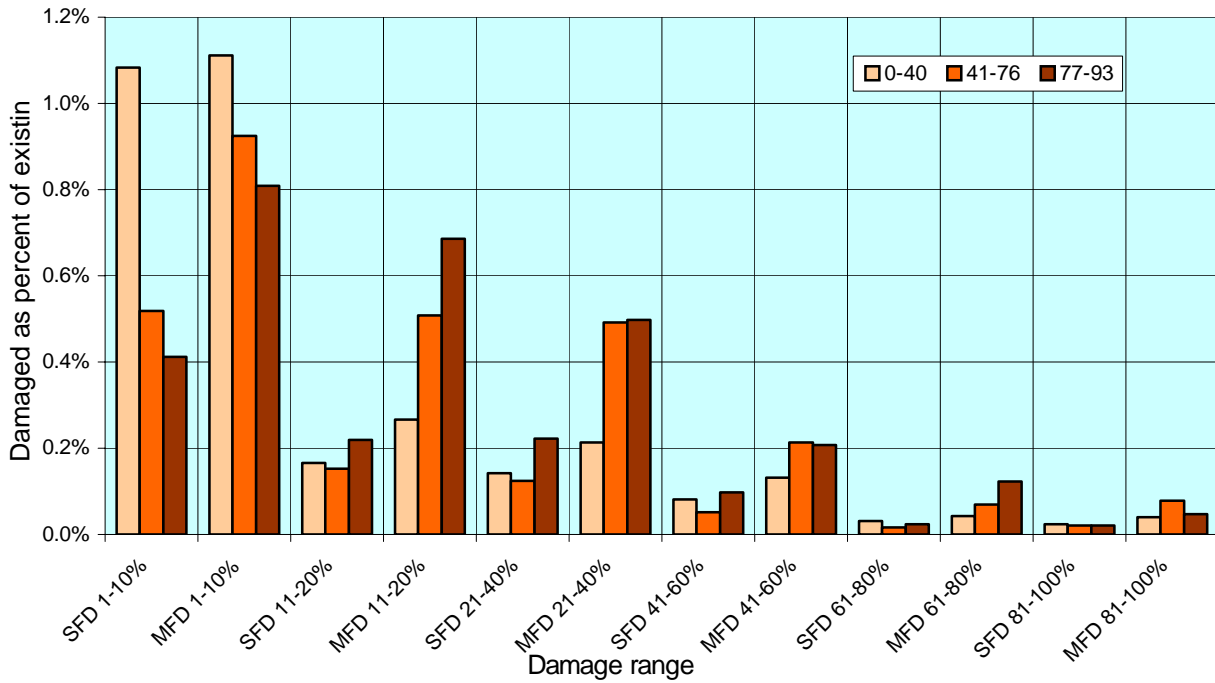
Conclusions and recommendations regarding the findings will be included in the paper.

Graph 1: Damaged Projects as Percent of Existing

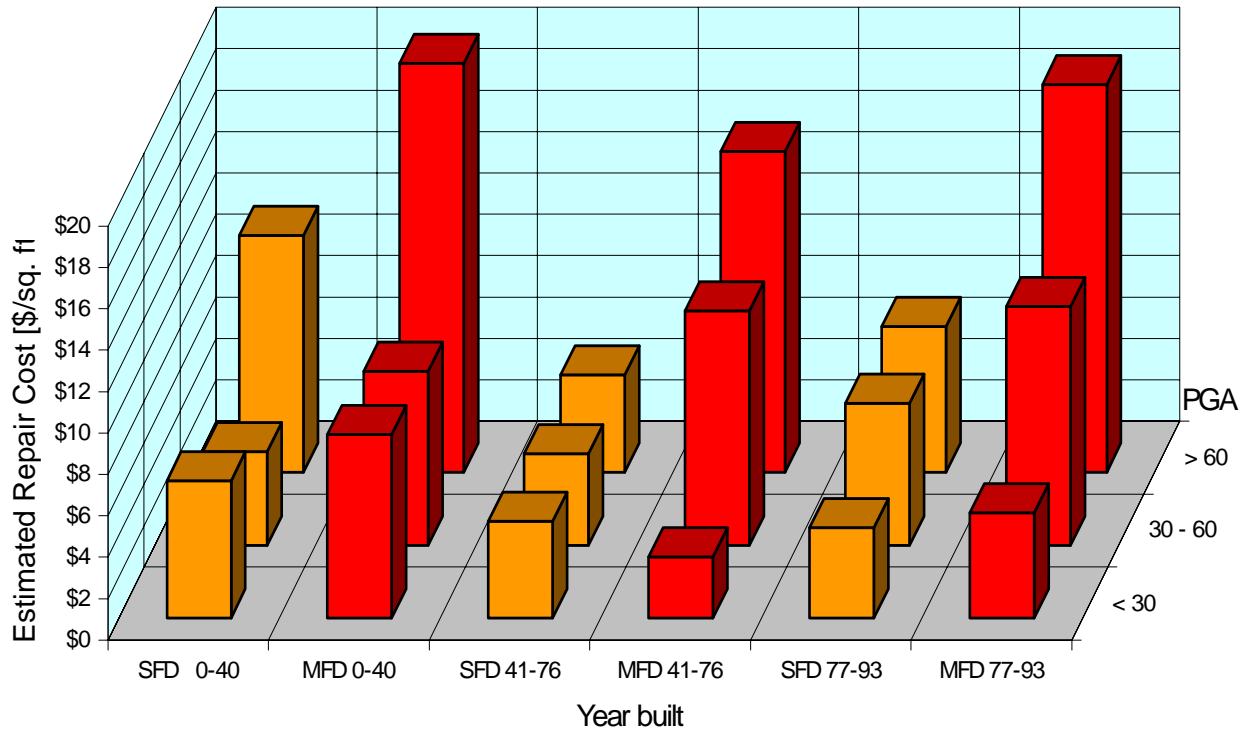


Year built / data table

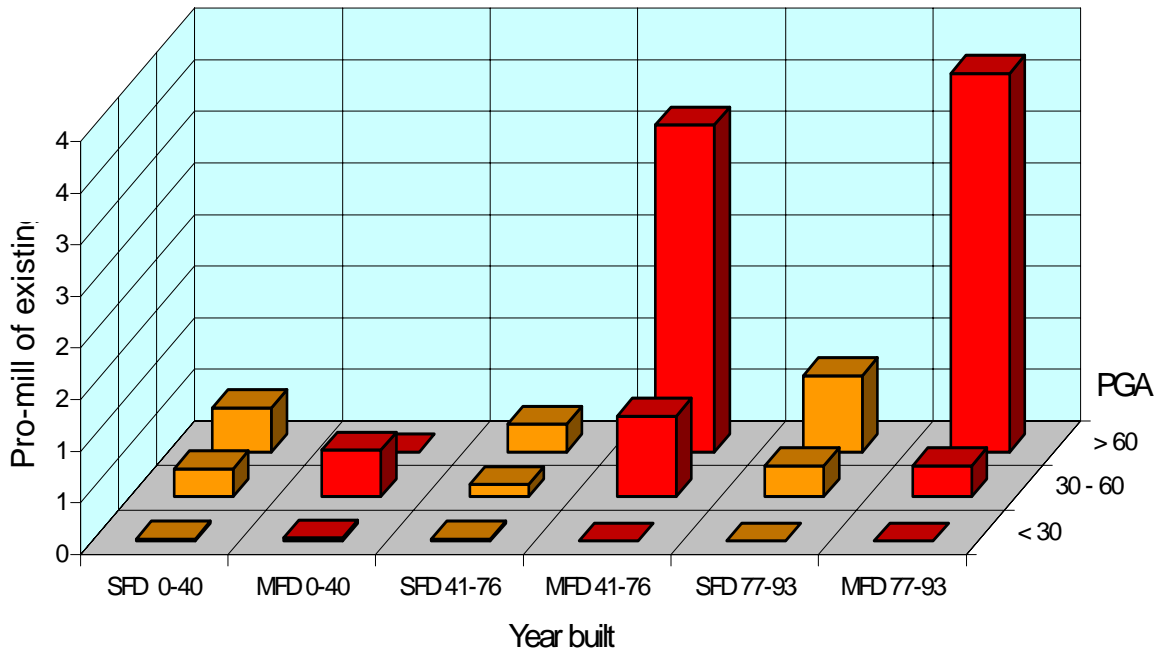
Graph 2: Damage Range by Year Built



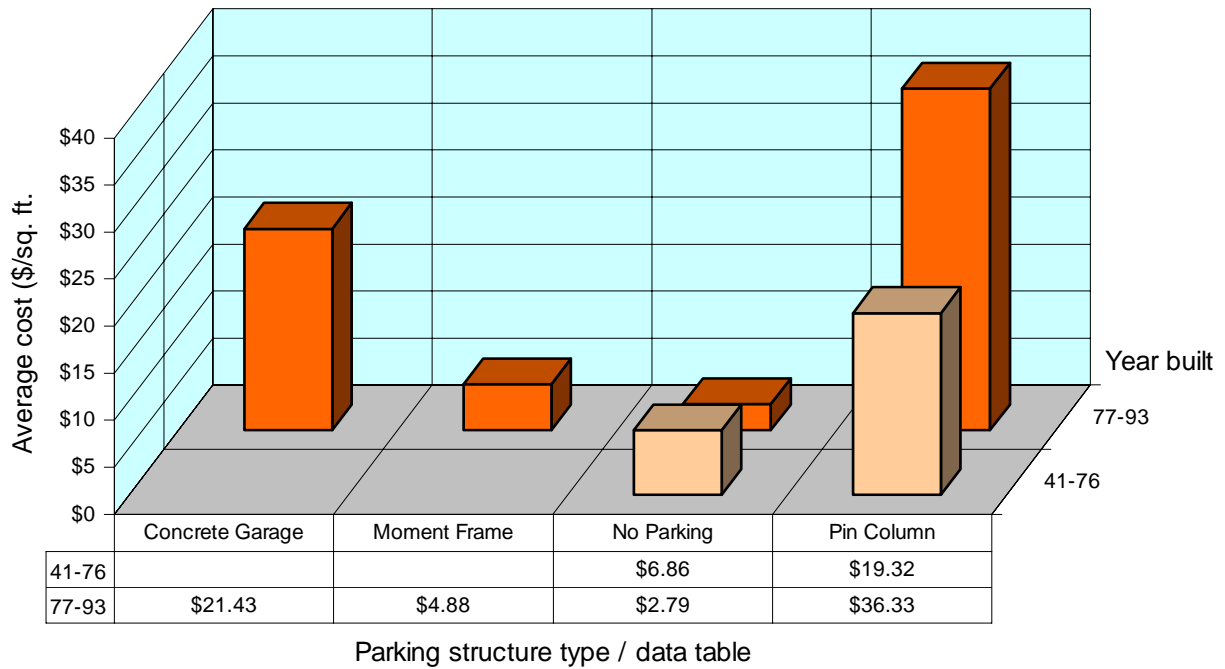
Graph 3: Average Estimated Repair Cost per Square Foot



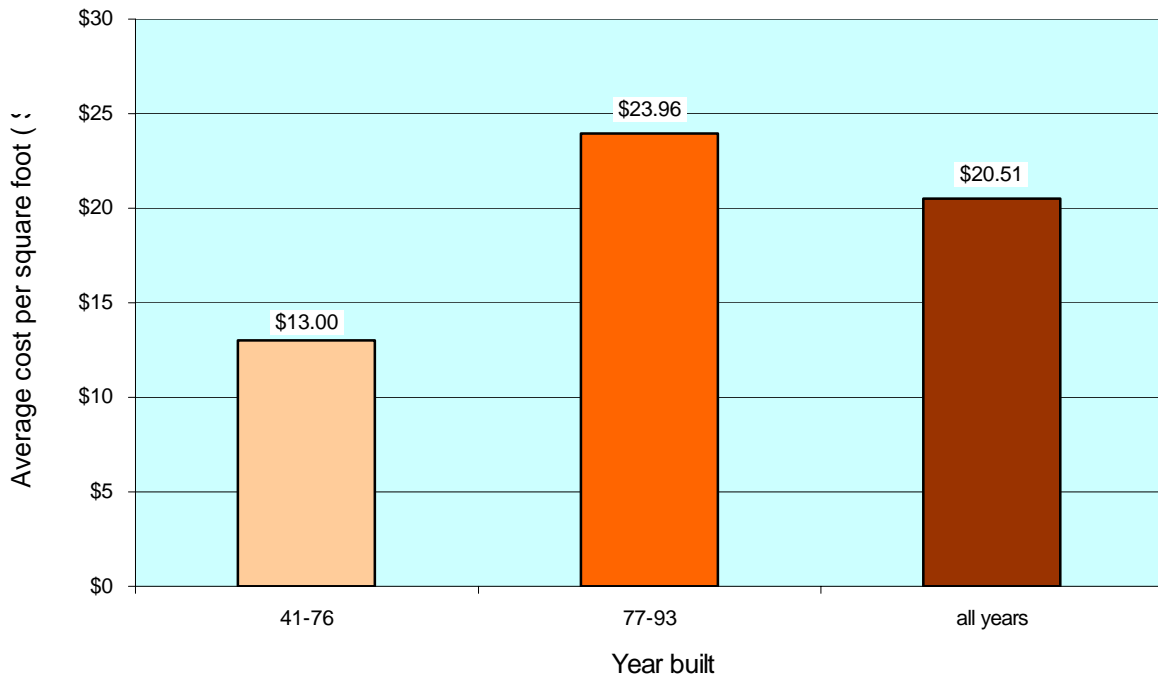
Graph 4: Expensive Repair Projects as Pro-mill of Existing



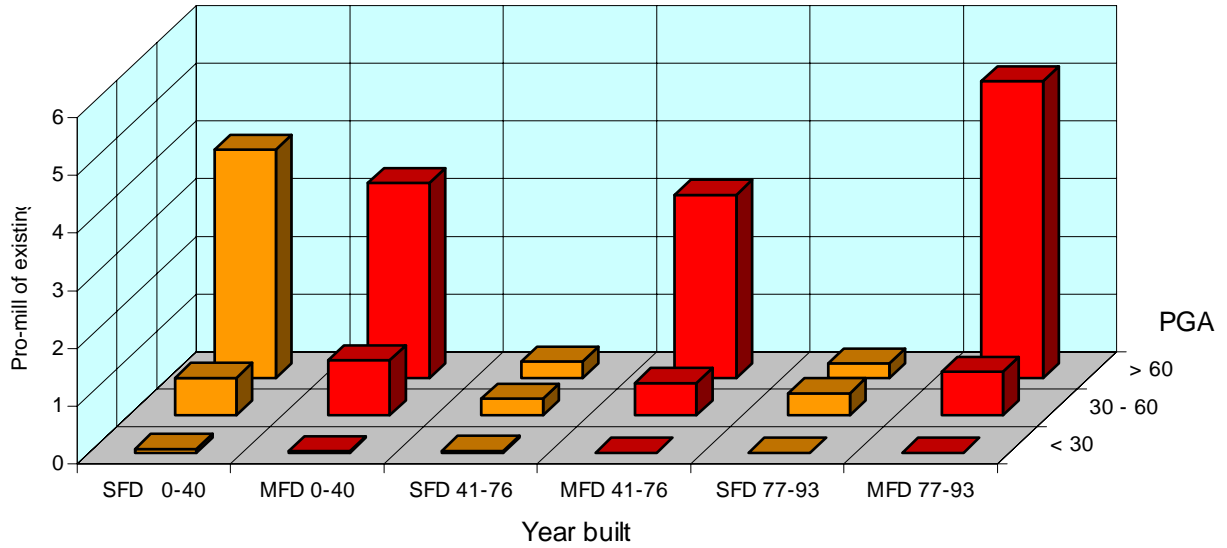
Graph 5: Repair Cost by Type of Parking Structure and Year Built



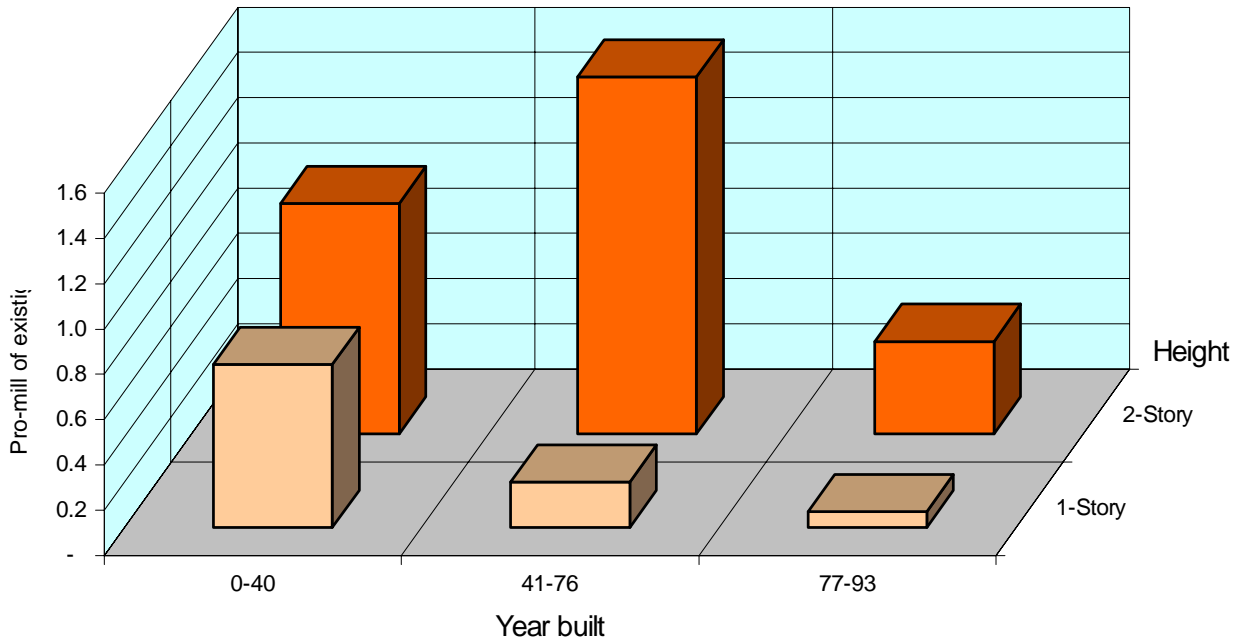
Graph 6: Repair Cost of Apartments with Tuck-under parking by Year Built

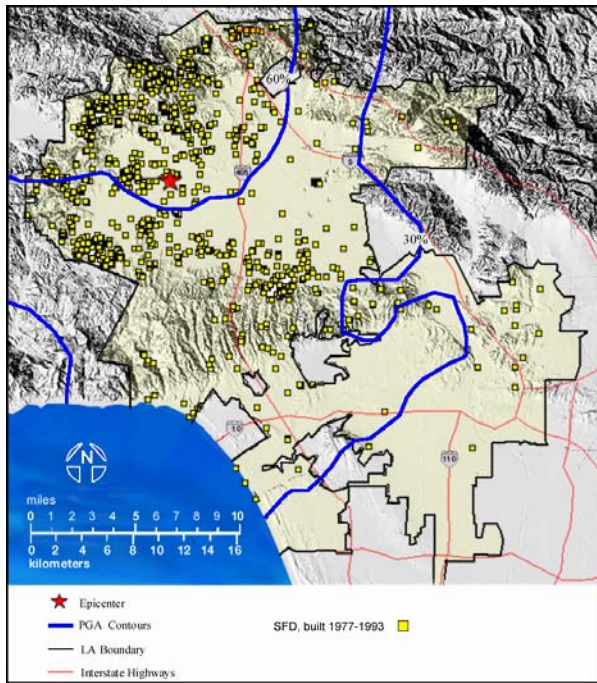


Graph 7: Demolished Projects as Pro-mill of Existing

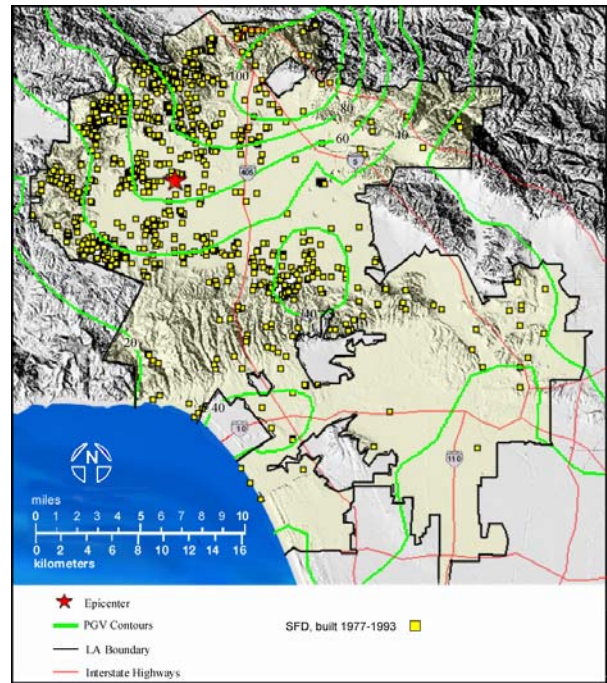


Graph 8: Demolished SFD as Pro-mill of Existing by Height and Year Built





Map 1: Damaged SFD at PGA Contours



Map 2: Damaged SFD at PGV Contours



Fig. 1: Collapsed Tuck-under Parking



Fig. 2: T-Configuration Failure