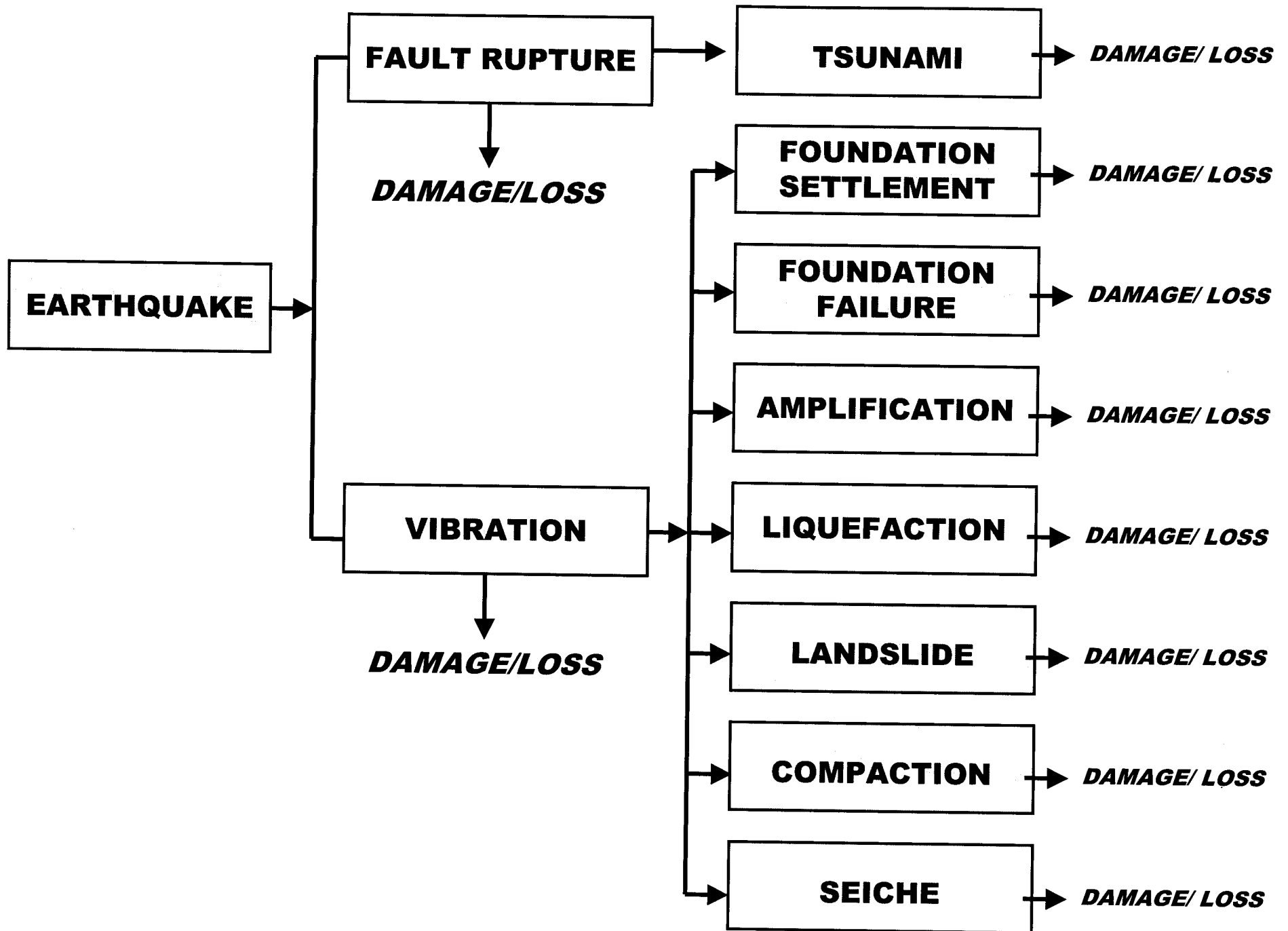


**MANAGING EARTHQUAKE  
RISKS IN THE 21ST CENTURY**

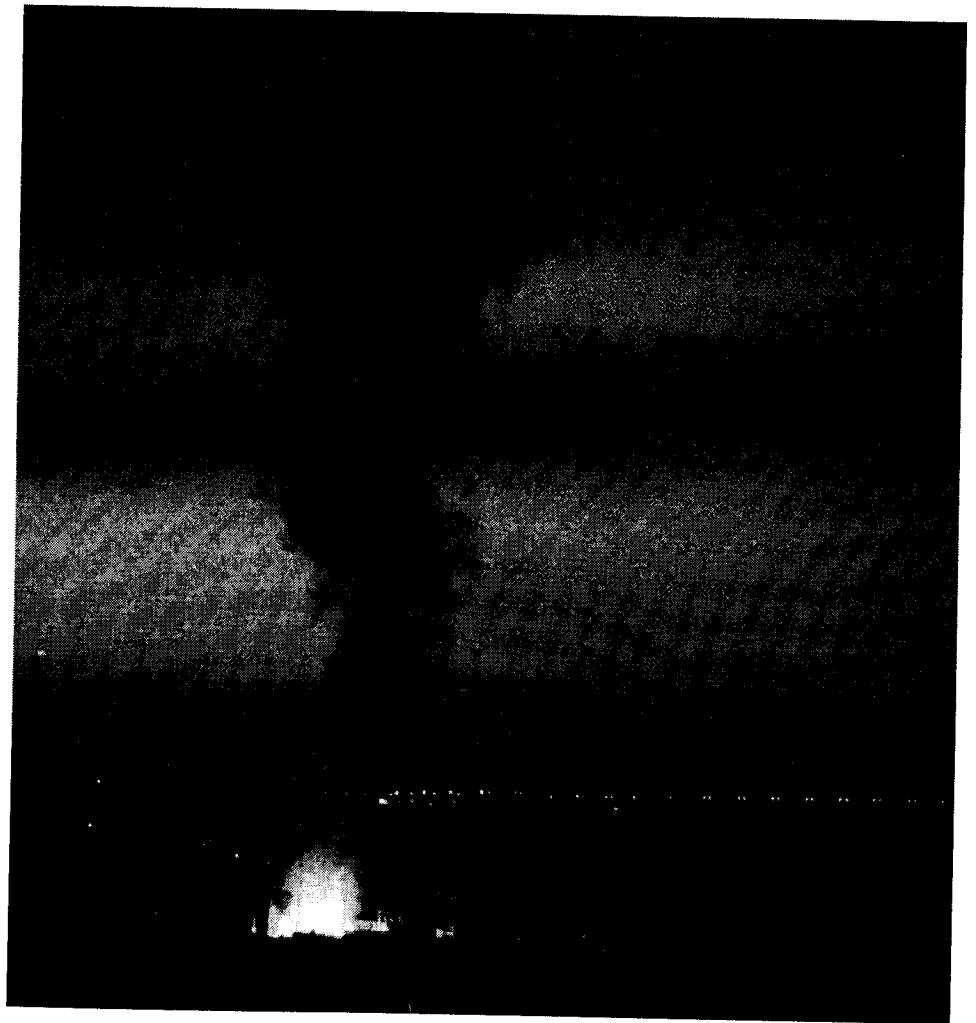
**WALTER W. HAYS**

**AMERICAN SOCIETY OF  
CIVIL ENGINEERS**

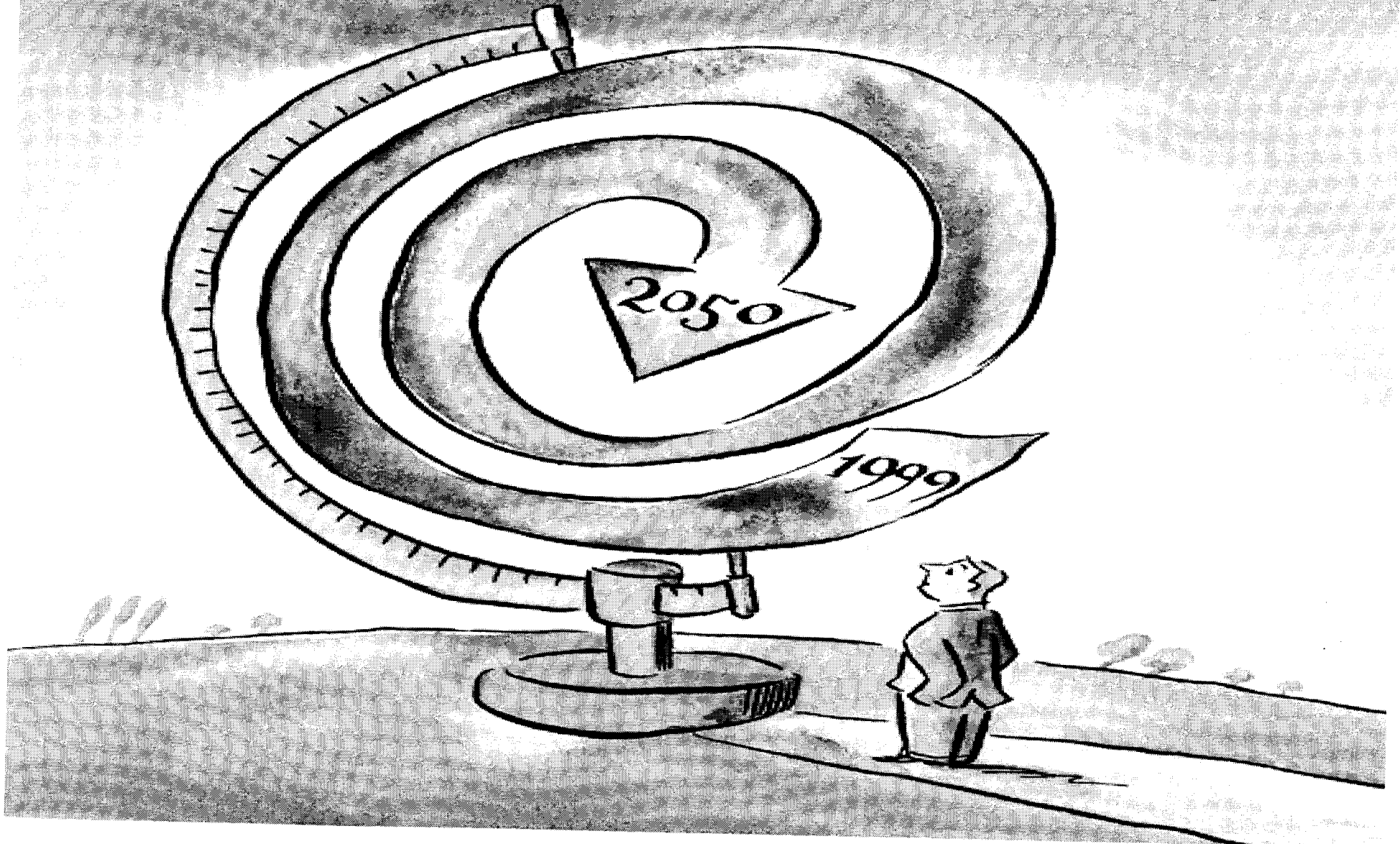


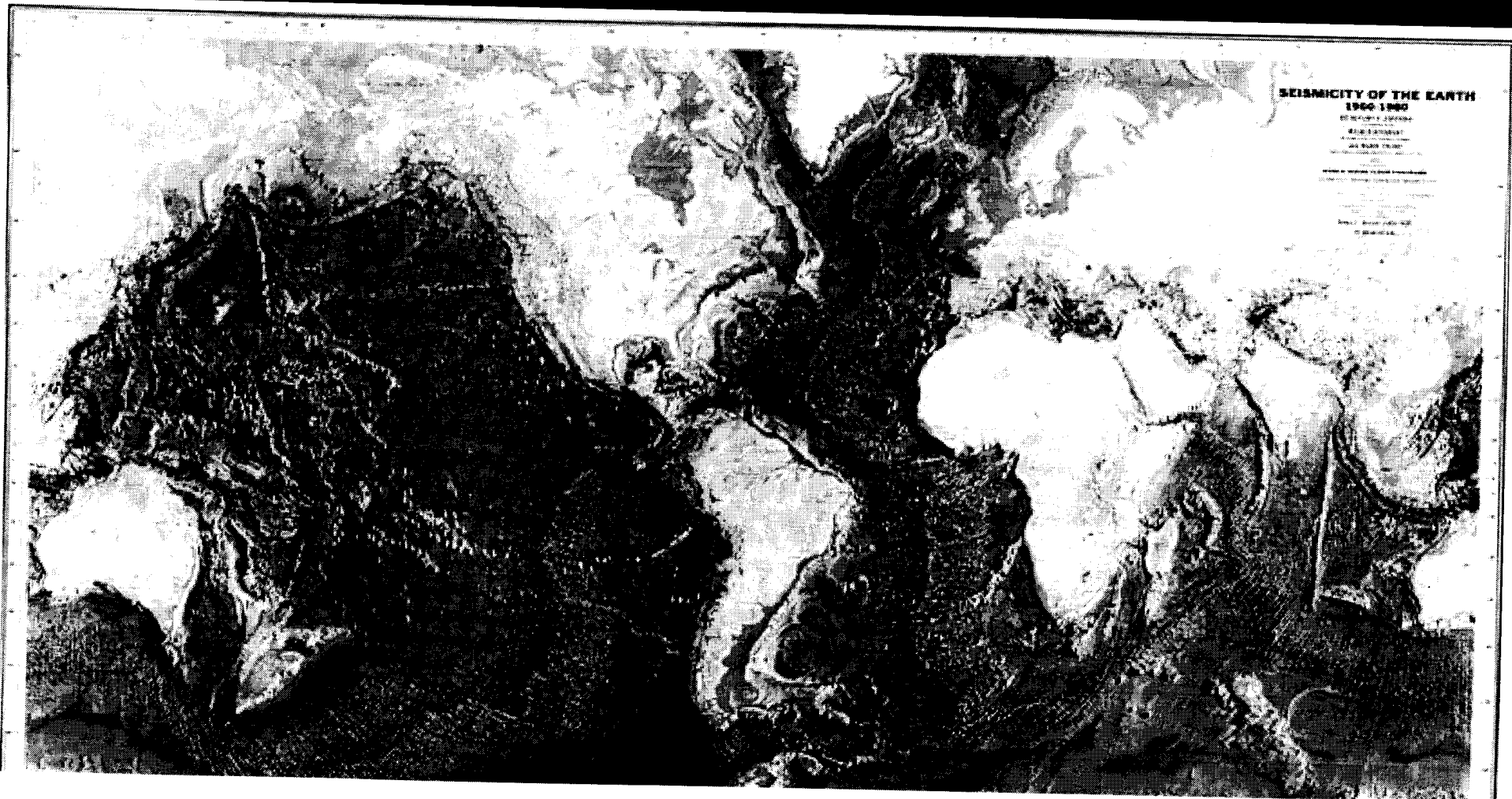
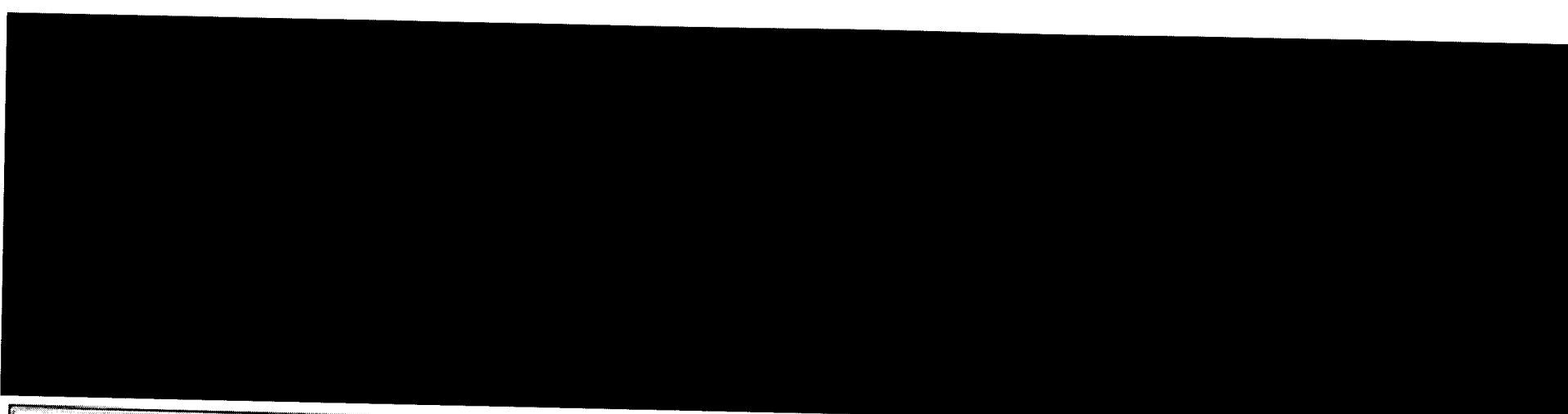
# MANAGING RISKS TO THE INSURANCE ENTERPRISE

- CHOOSING *WHERE*  
AND *WHEN* TO  
RETAIN RISKS
- CHOOSING *WHERE*  
AND *WHEN* TO  
TRANSFER RISKS
- CHOOSING *WHERE*  
AND *WHEN* TO  
AVOID INSURING



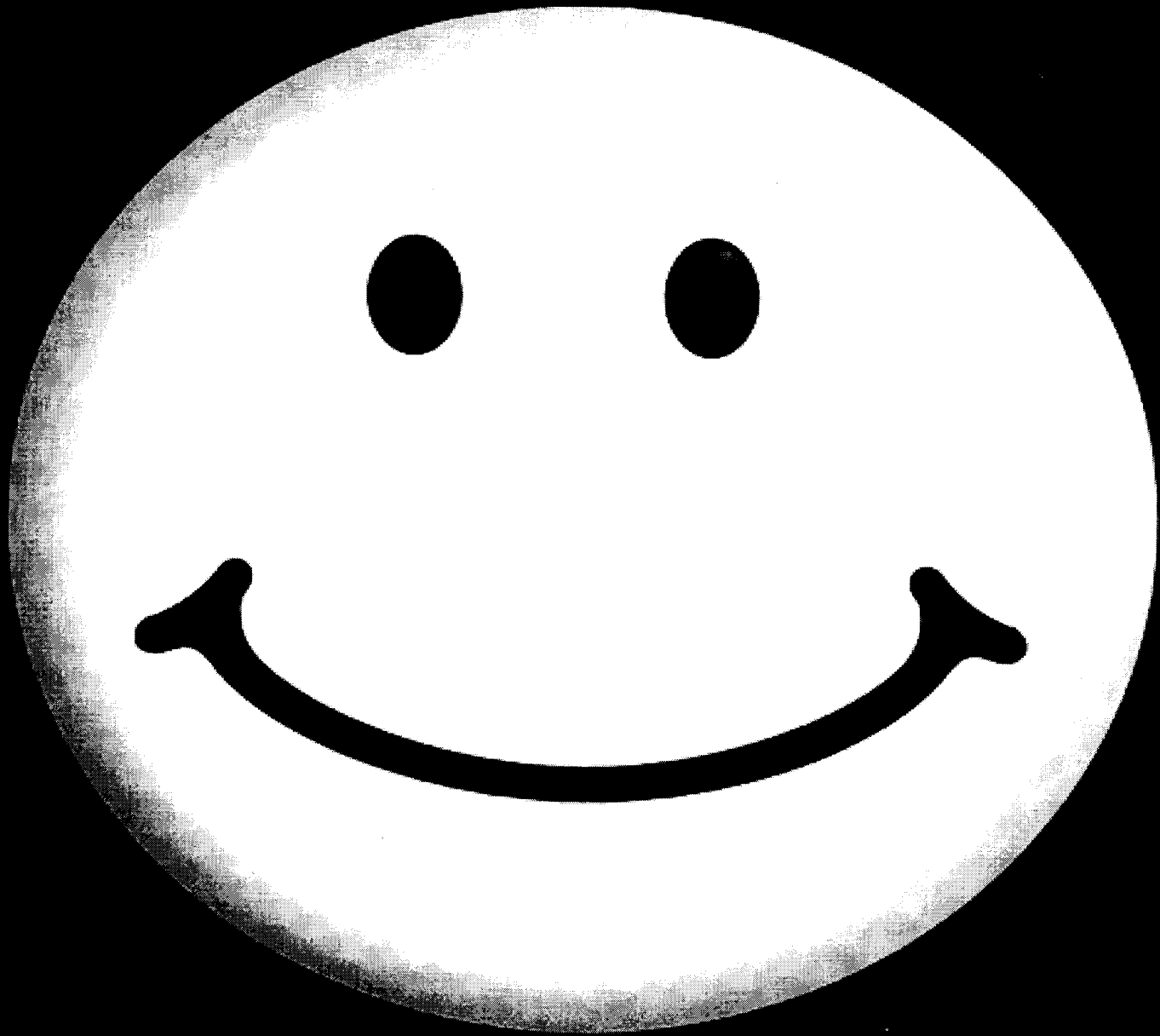
# The road to 2050



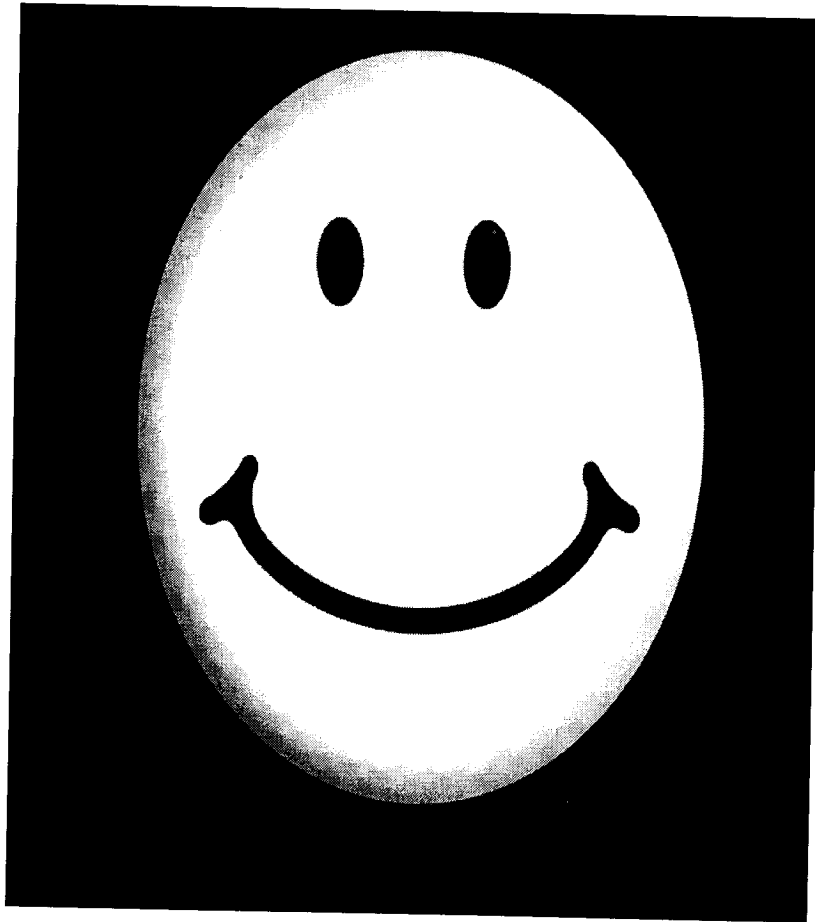


# **INSURANCE ENTERPRISE OBJECTIVES**

- **ACTUARIES AND UNDERWRITERS “GET THE EARTHQUAKE FACTS RIGHT”**
- **THE NEEDS OF THE INSURED ARE MET WITHOUT PAYING MORE THAN THE CONTRACT CALLS FOR**



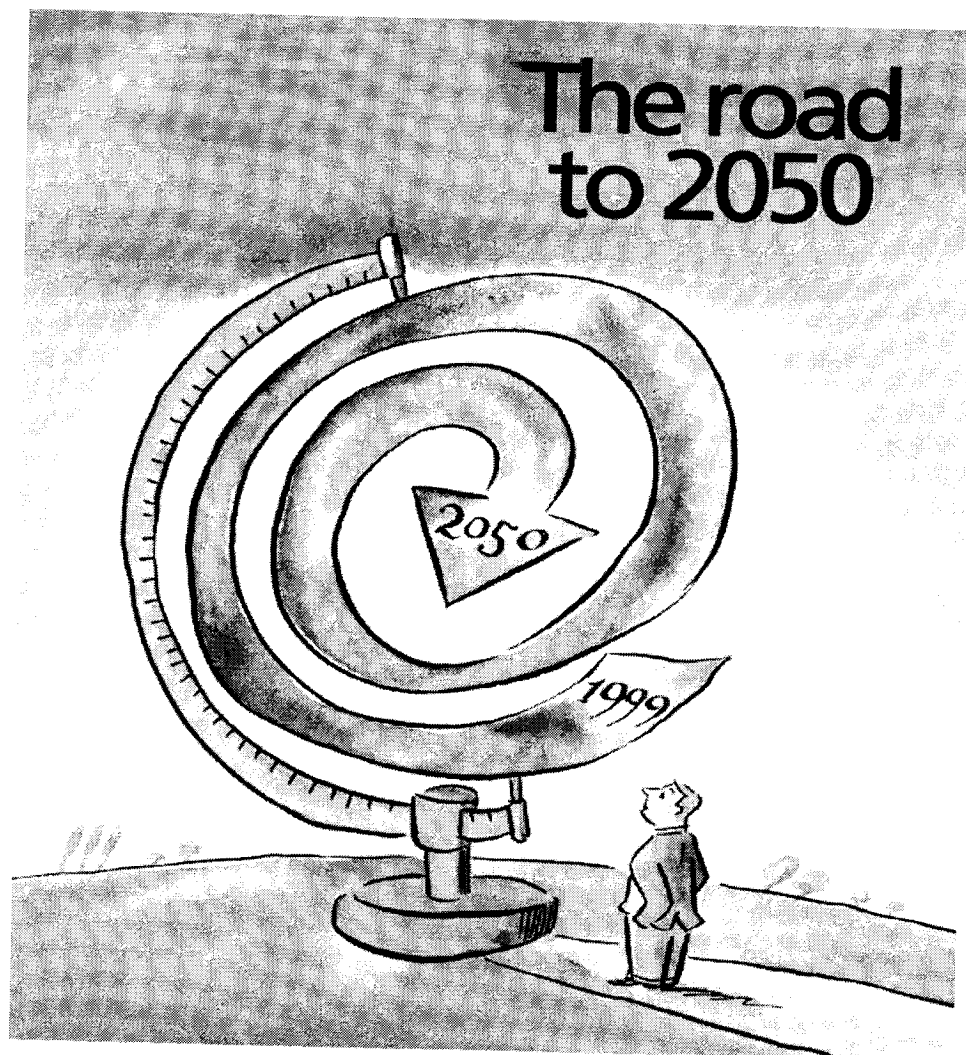
# **INSURER'S MOST WANTED SOLUTIONS**



- **ROOF SYSTEMS**
- **BUILDING ENVELOPE**
- **STRUCTURAL SYSTEM**
- **FOUNDATION**
- **FIRE RESISTANCE**
- **NON-STRUCTURAL**
- **FLOOD PROTECTION**
- **FREEZE PROTECTION**

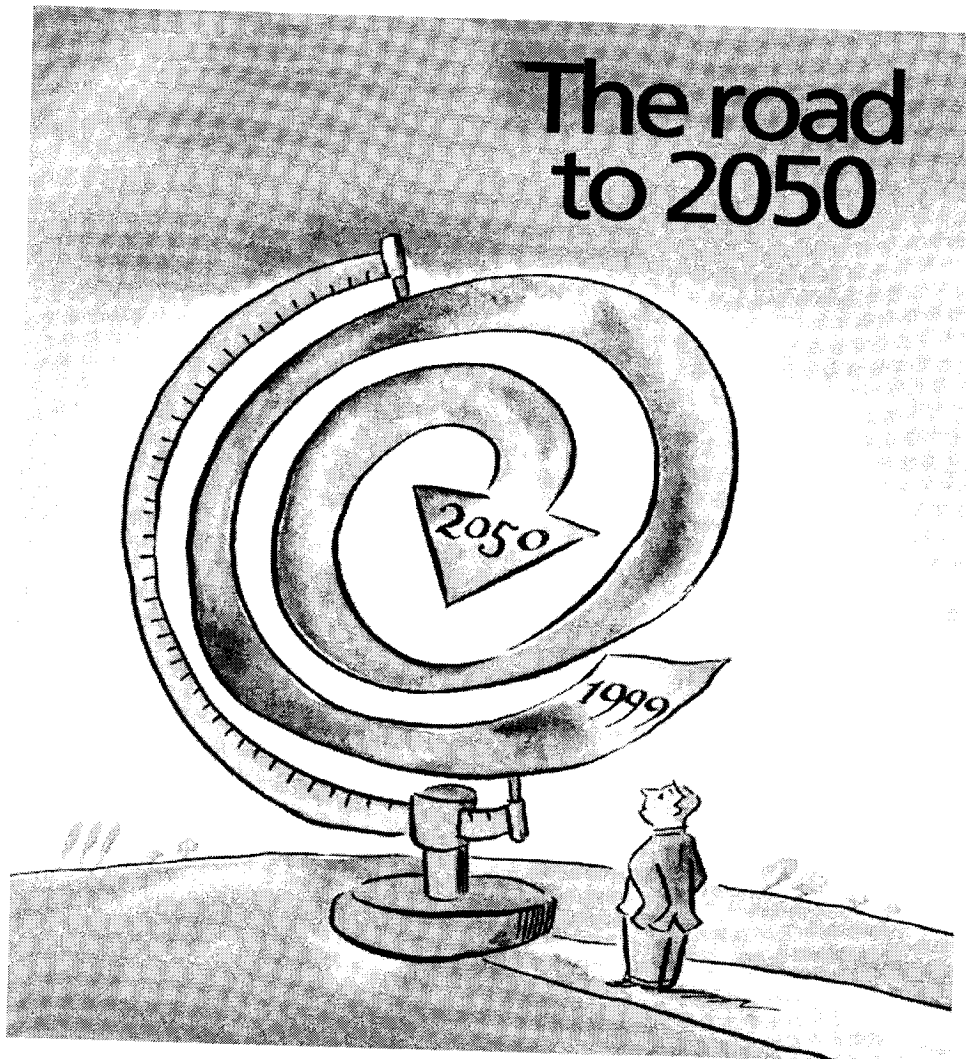


# WHAT CAN INSURERS DO TO MANAGE THEIR RISKS?

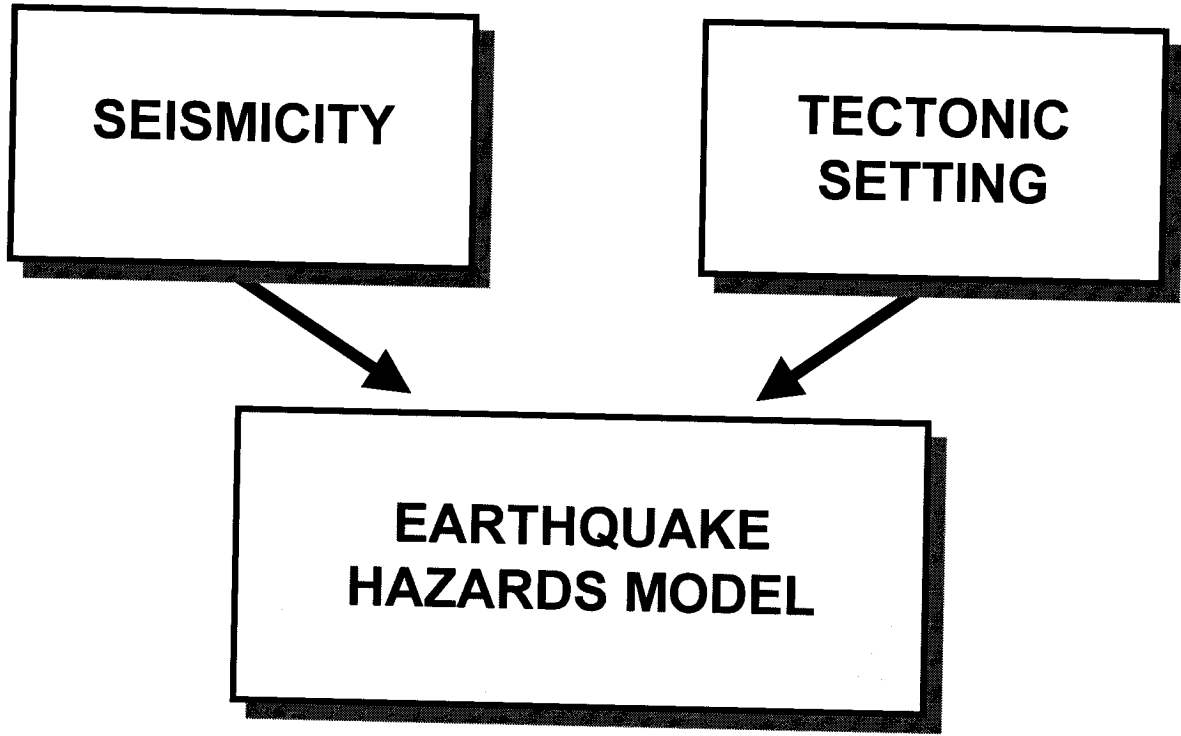


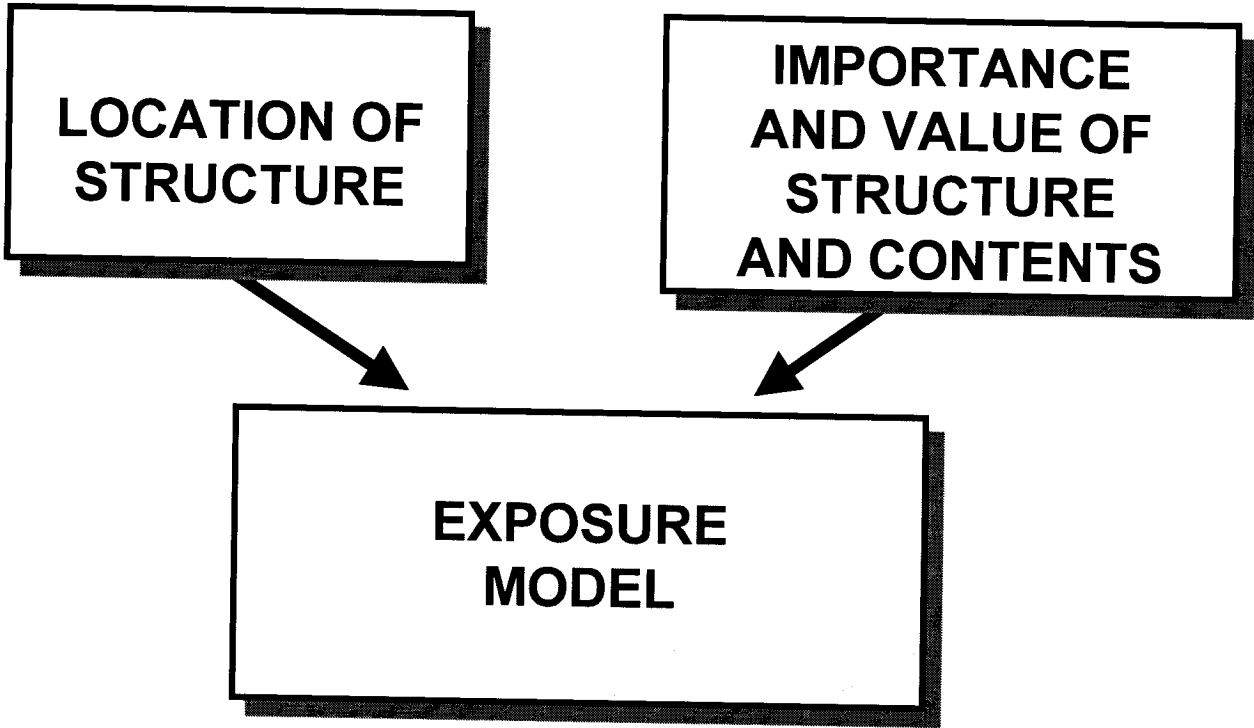
- A TRUSTED LEADER
- A CATALYST FOR THE INTELLIGENT USE OF MONEY
- AN ADVOCATE FOR MITIGATION TO “BULLET PROOF” RISKS
- OUTREACH

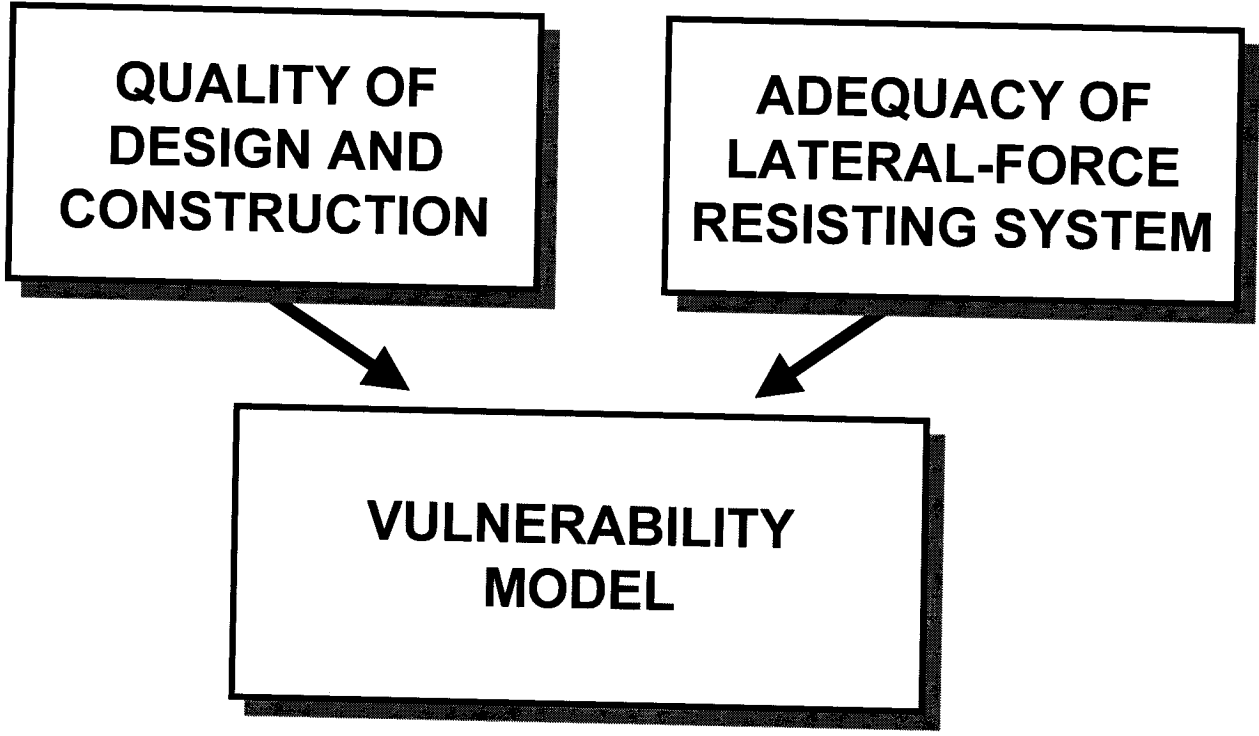
# WHAT CAN INSURERS DO TO MANAGE THEIR RISKS?



- **INTEGRATE CAT MODELS INTO UNDERWRITING PROCESS**
- **ASSESS RISK IN NEW MADRID, PACIFIC NORTHWEST, AND CALIFORNIA**
- **SECUTITIZATION**







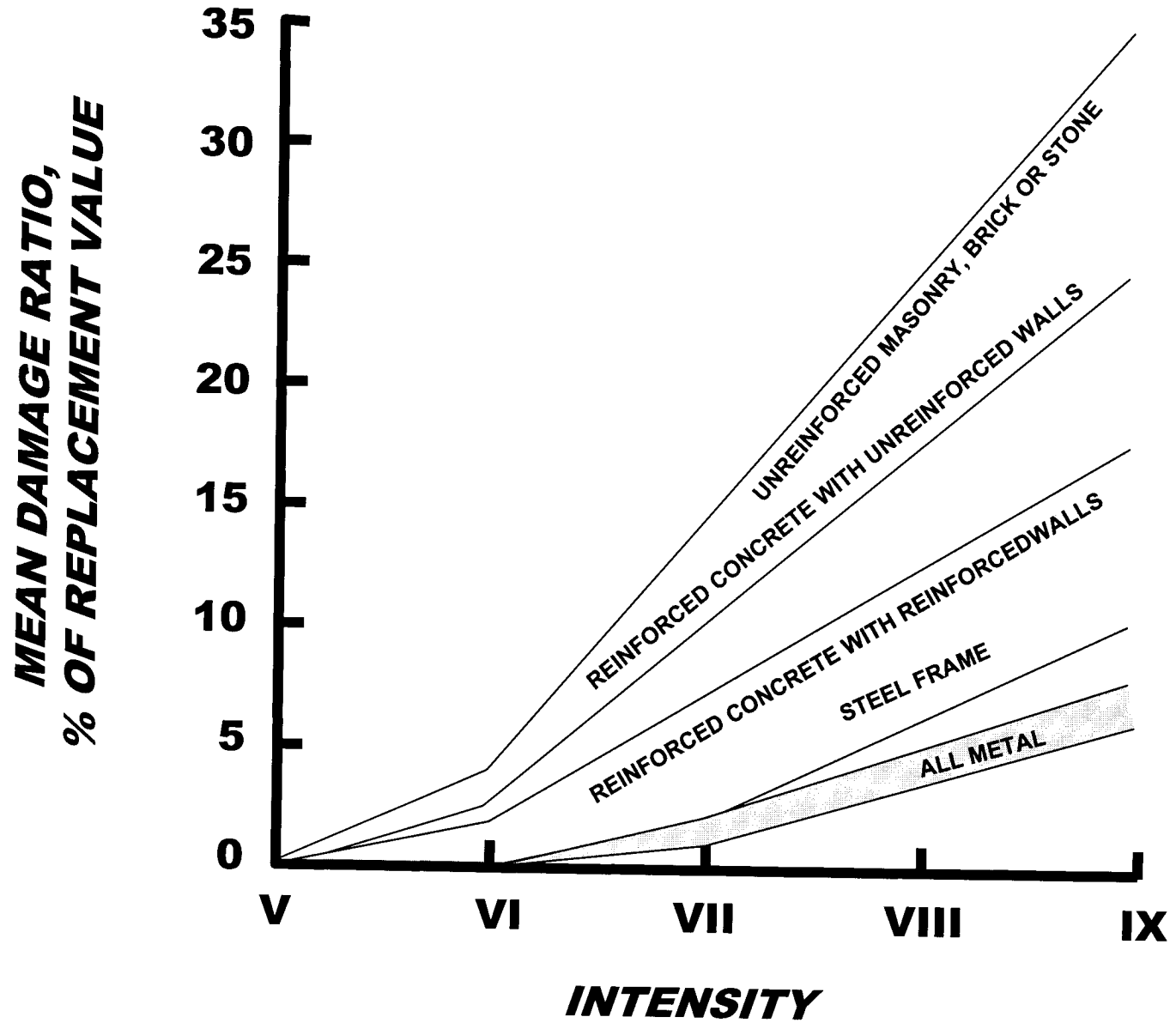
# NEW MADRID SEISMIC ZONE



# NEW MADRID SEISMIC ZONE

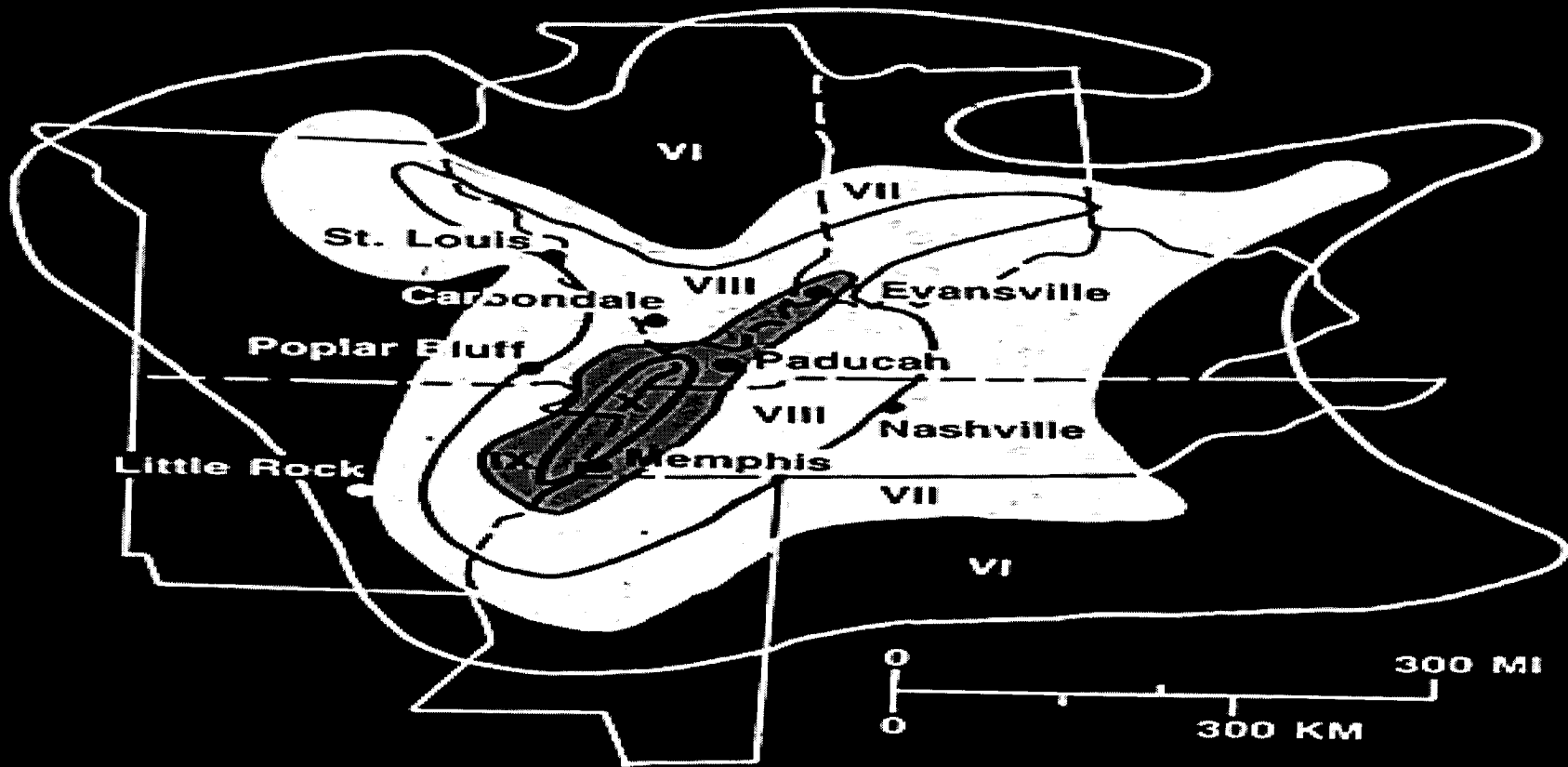


# VULNERABILITY





# HYPOTHETICAL INTENSITY MAP--1811-1812 SIZE EARTHQUAKES









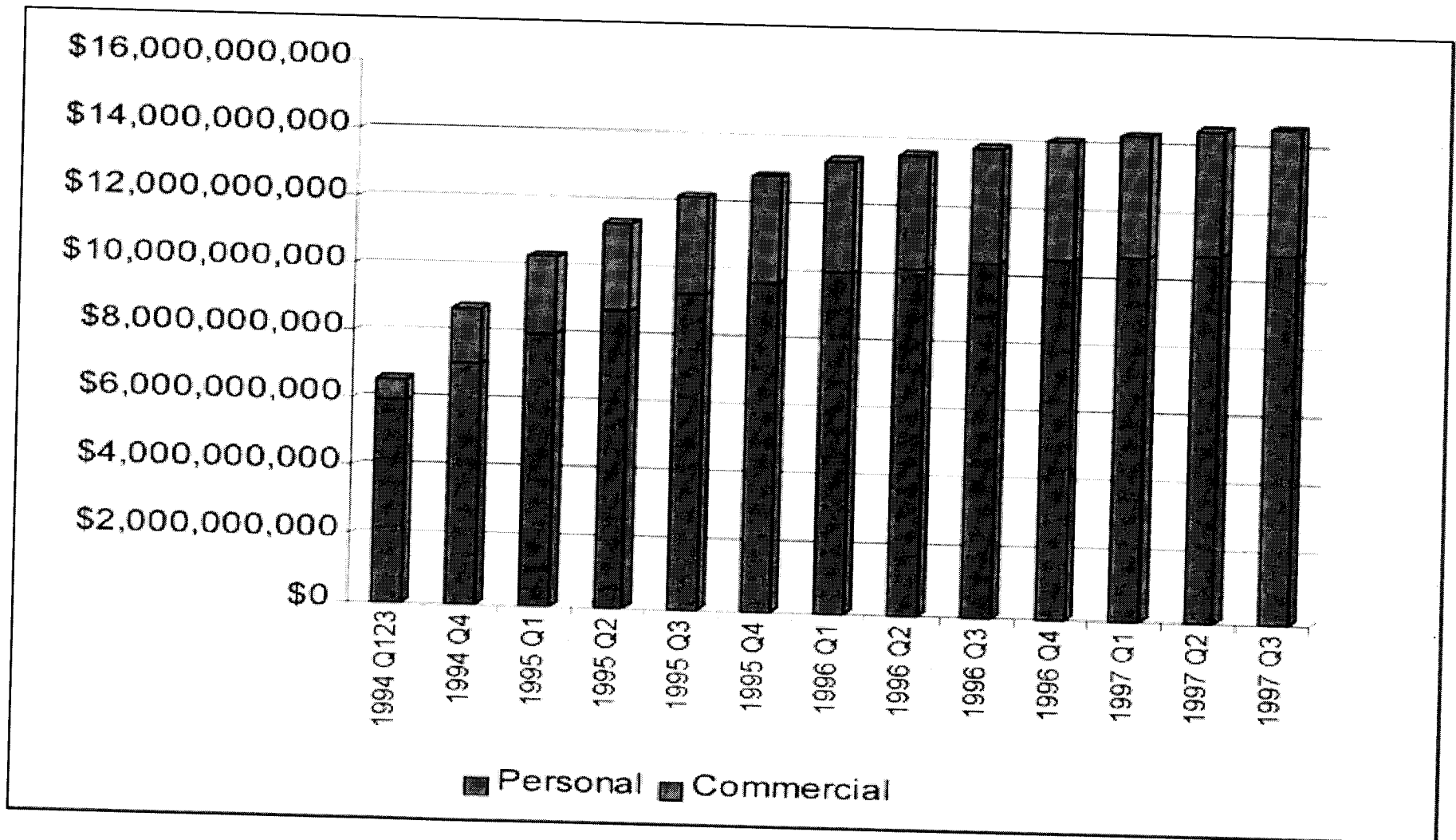


# **EXPERIENCE IS A GREAT TEACHER, BUT THE PRICE IS HIGH**

- INSURERS, LIKE NATIONS,  
COMMUNITIES, BUSINESSES, AND  
CITIZENS CAN'T BE STUPID FOREVER**
- EACH NEEDS TO DEVISE AND  
IMPLEMENT STRATEGIES THAT  
RETAIN, AVOID, TRANSFER,  
CONTROL, AND MITIGATE RISKS  
FROM A HOLISTIC VIEWPOINT**



# INSURED LOSSES: NORTHRIDGE





\$16,000,000,000

\$14,000,000,000

\$12,000,000,000

\$10,000,000,000

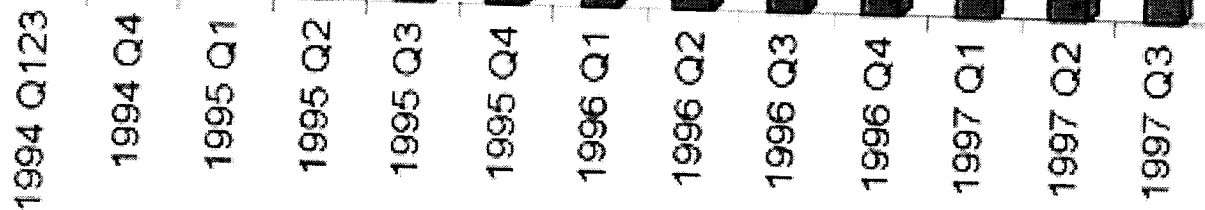
\$8,000,000,000

\$6,000,000,000

\$4,000,000,000

\$2,000,000,000

\$0



■ Building ■ Contents □ Time ■ Other

# EARTHQUAKE LOSSES

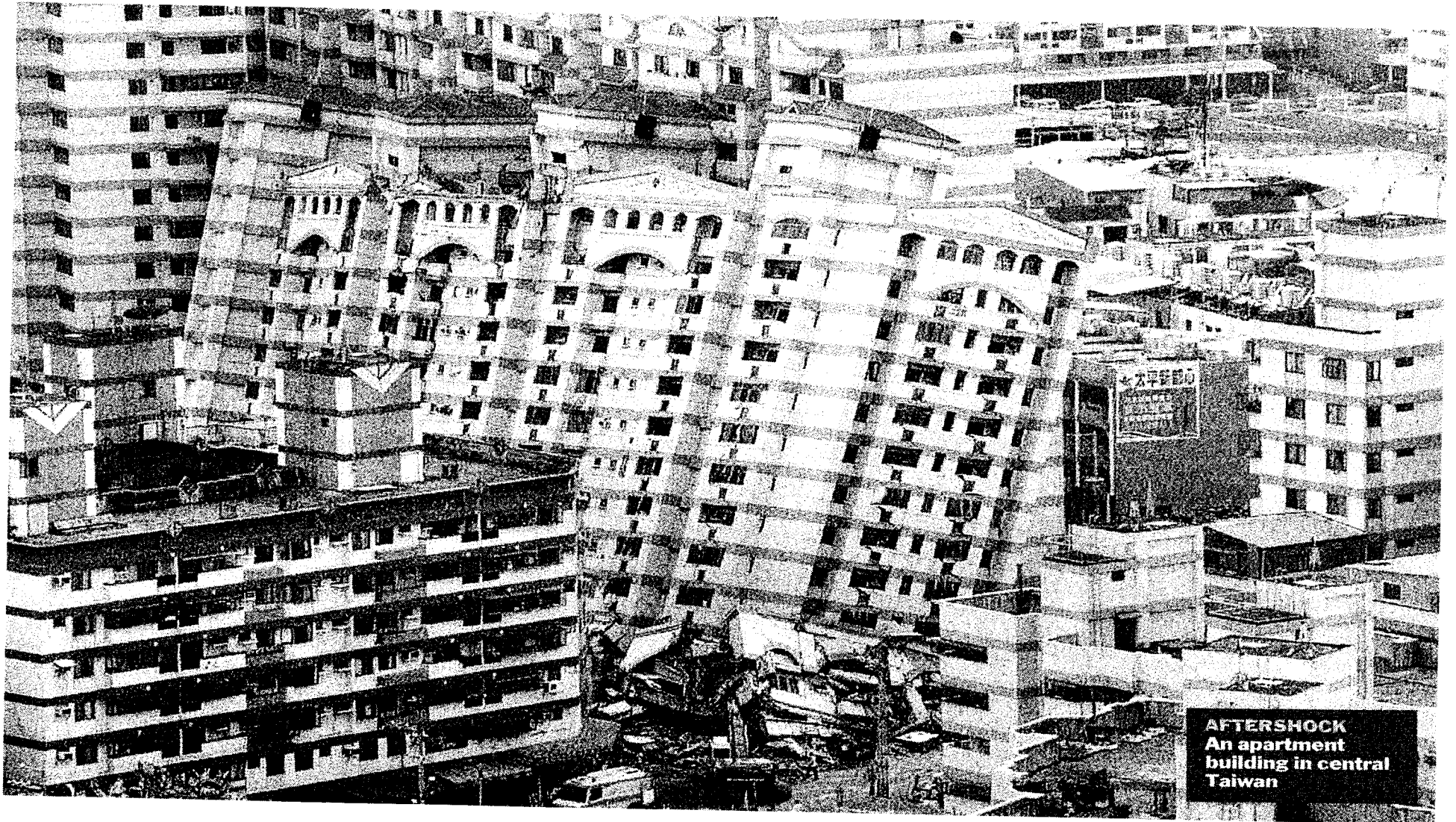
## NATURAL DISASTER REDUCTION



# PERSONAL LINES

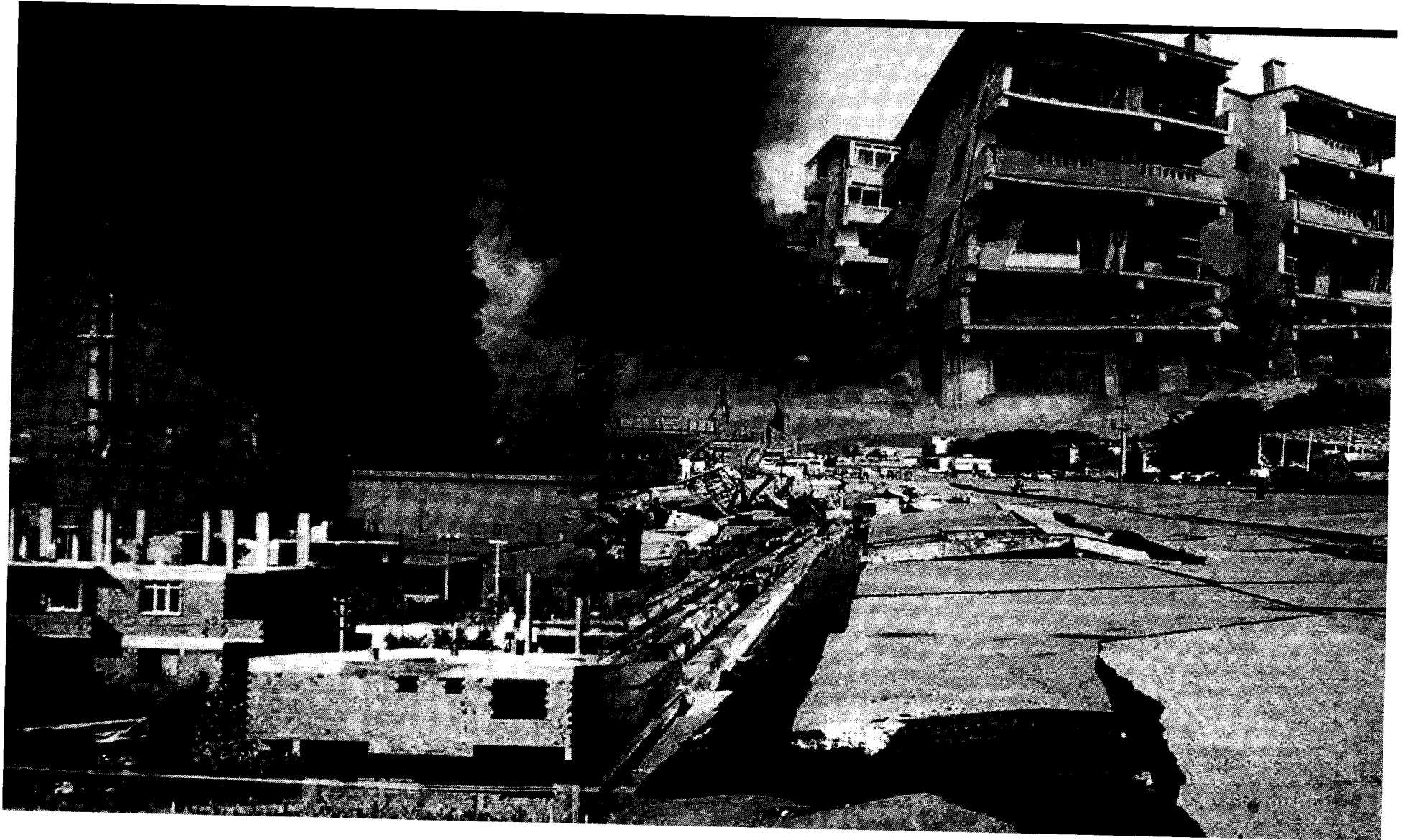


# COMMERCIAL LINES

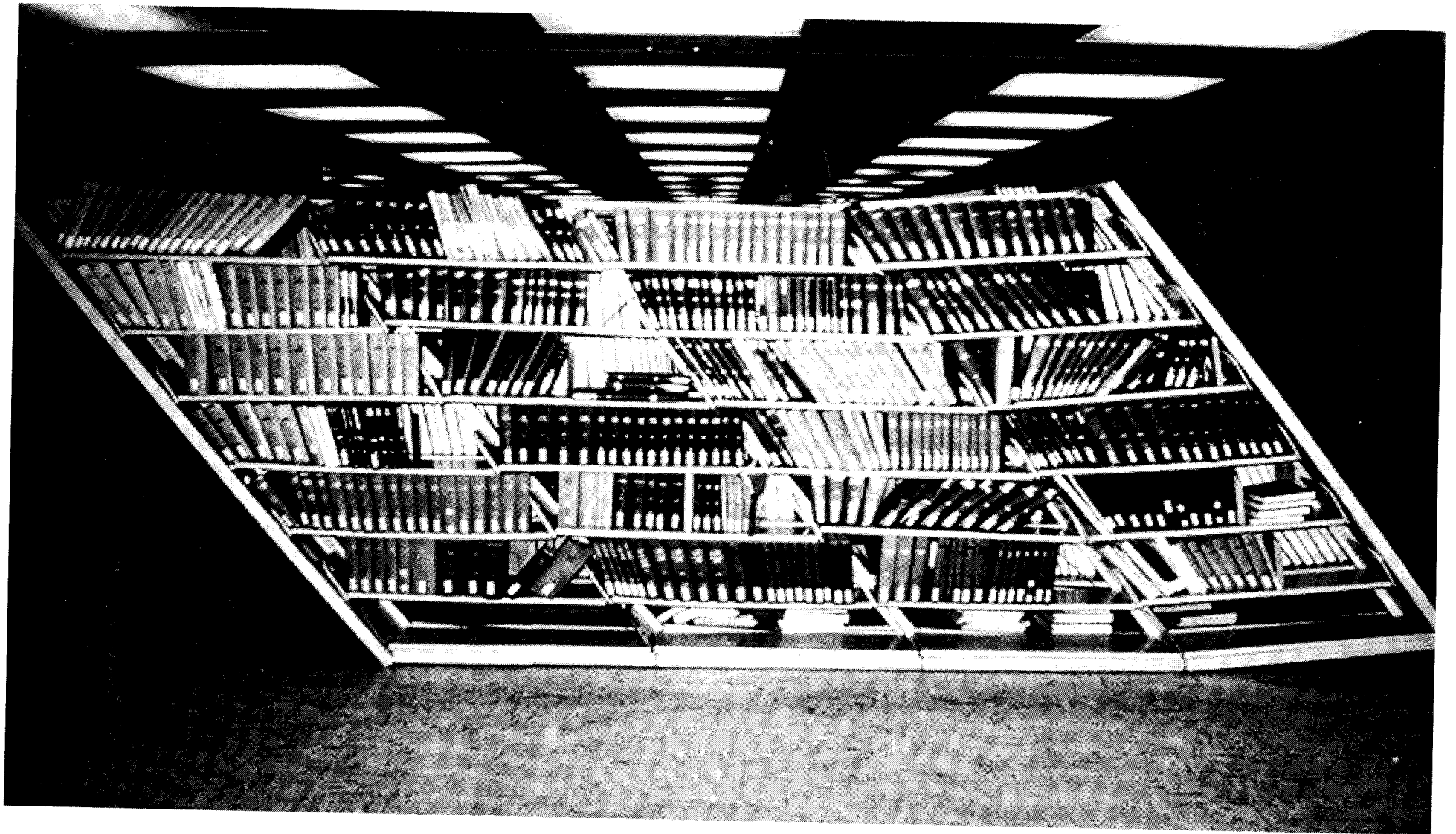


**AFTERSHOCK**  
An apartment  
building in central  
Taiwan

# LOCAL, REGIONAL, AND NATIONAL DISRUPTION



# CONTENTS



# CONTENTS



# CONTENTS





# INFRASTRUCTURE



# INFRASTRUCTURE:

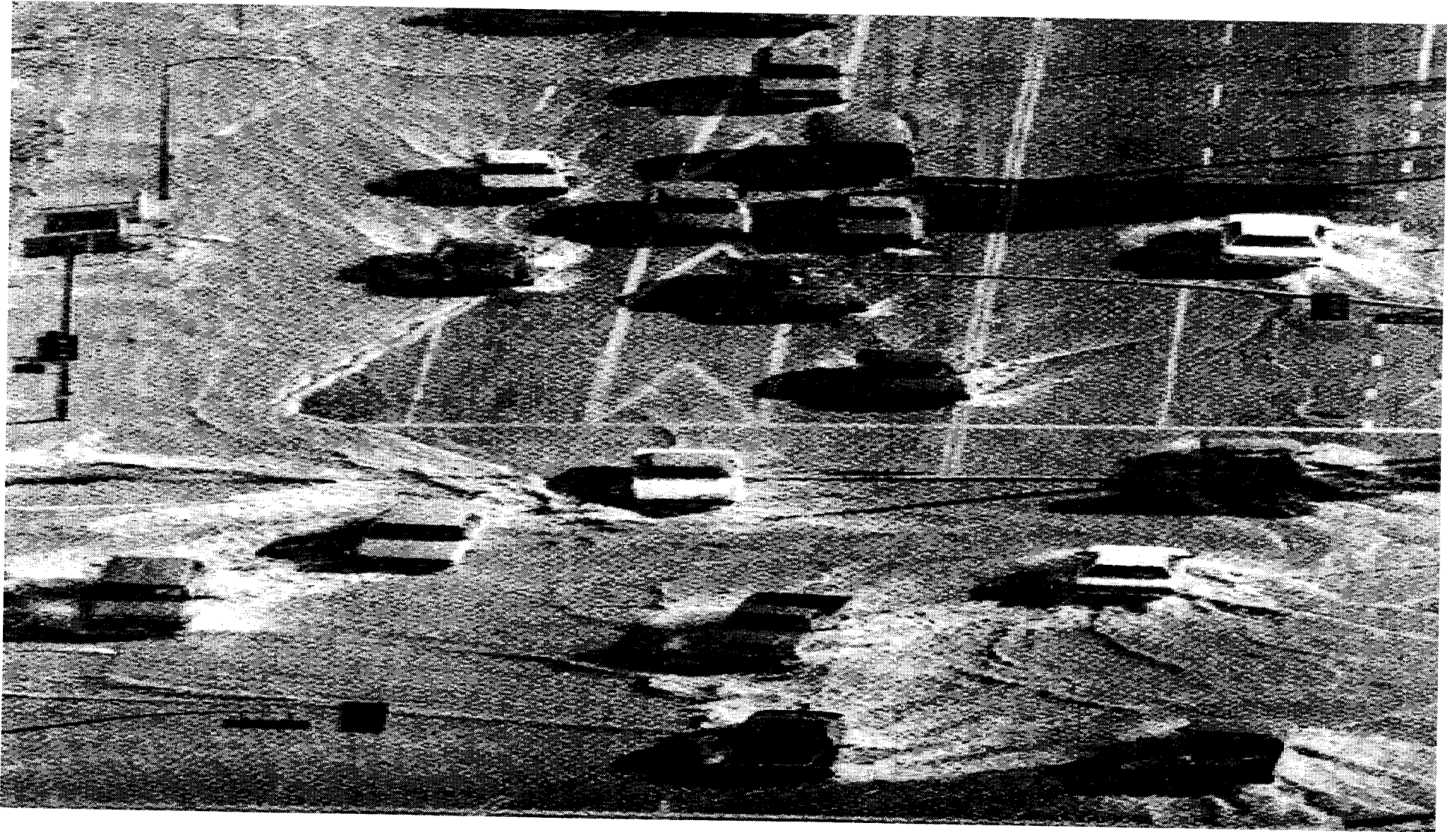


**Sudden collapse:**  
*The quake crippled  
bridges and roads*

# INFRASTRUCTURE

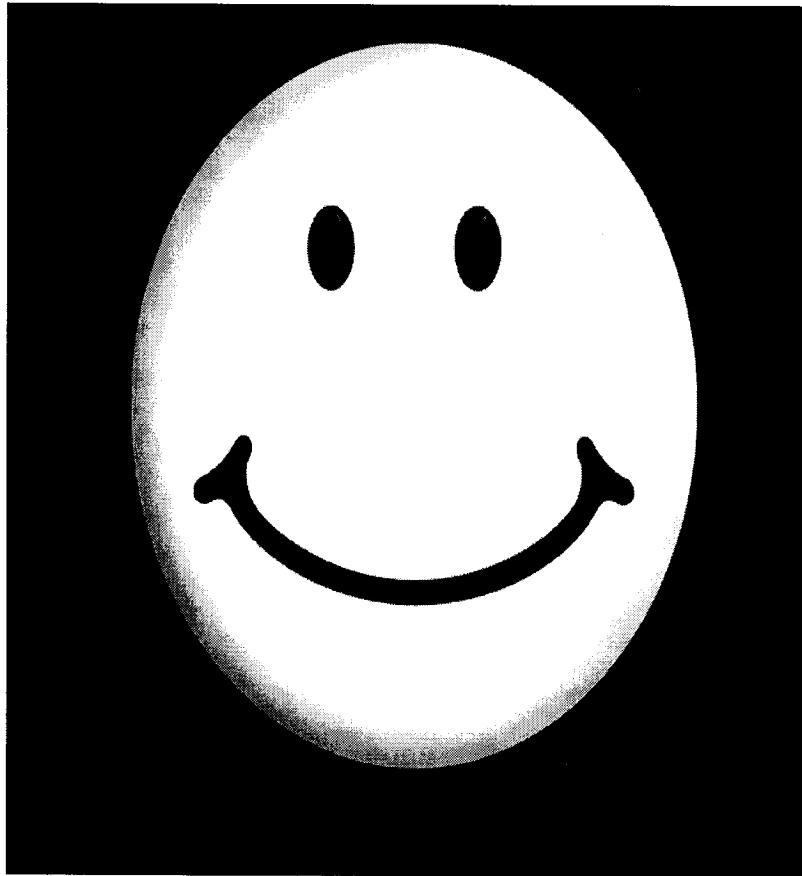


# INFRASTRUCTURE



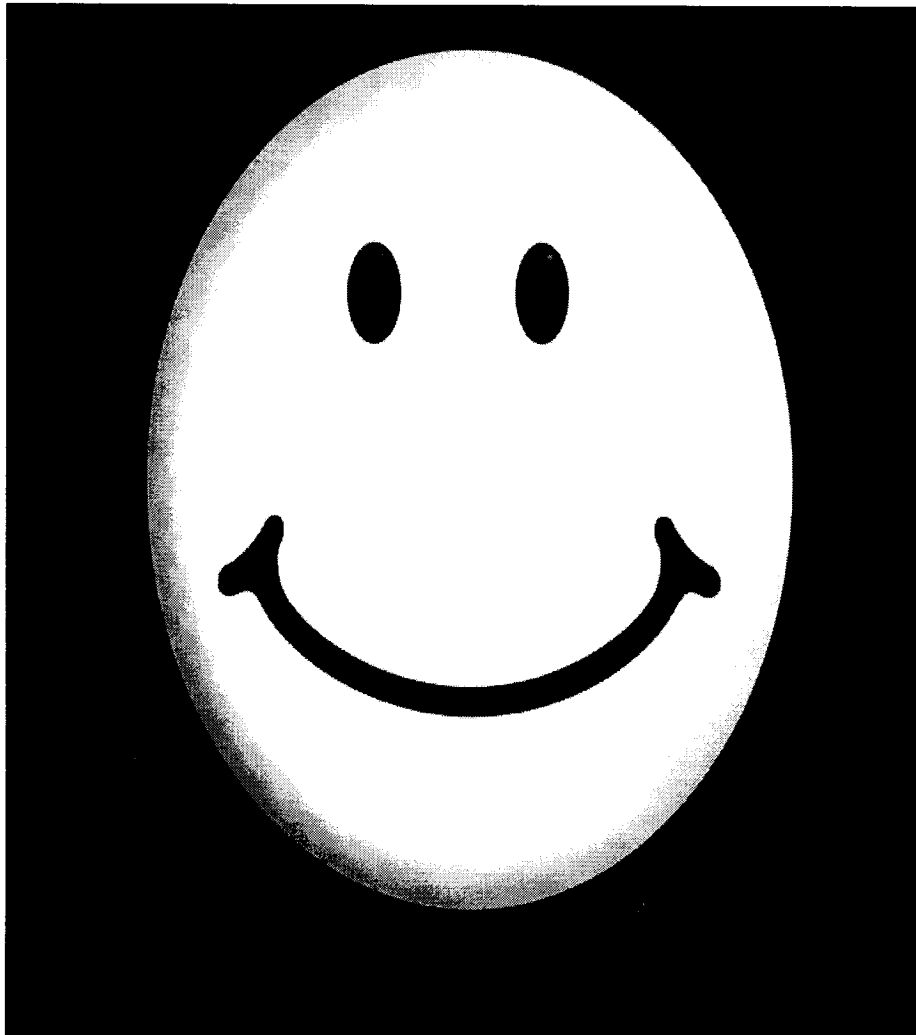
# QUESTIONS AND ANSWERS

# FIVE STRATEGIES FOR MANAGING RISKS



- **ALLIANCES**
- **PROJECTS**
- **BLUEPRINTS**
- **DATABASES**
- **CENTERS OF EXCELLENCE**

# THE COMMUNITY OF NATION'S MOST WANTED SOLUTIONS



- **REDUCE SOCIAL  
VULNERABILITES**
- **REDUCE  
PHYSICAL  
VULNERABILITIES**

**ASSESSING PHYSICAL  
VULNERABILITY DURING THE  
UNDERWRITING PROCESS**



# ANALYSIS OF VULNERABILITY

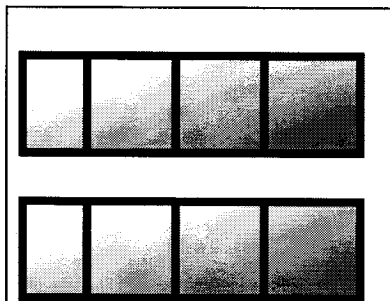
**BUILDING  
ELEVATION**

**LOCATIONS OF  
POTENTIAL FAILURE**

**RELATIVE  
VULNERABILITY**  
*[1 (Best) to 10 (Worst)]*

None, if attention given to foundation and non structural elements. Rocking may crack foundation and structure.

**1-2**



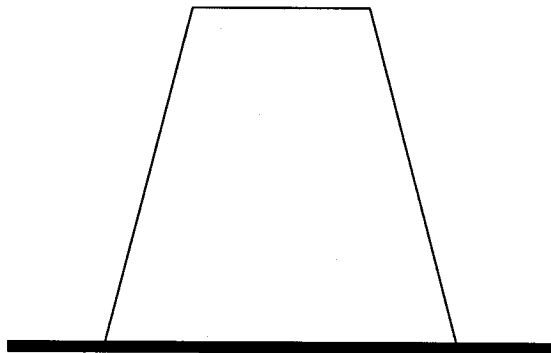
Box

# ANALYSIS OF VULNERABILITY

**BUILDING  
ELEVATION**

**LOCATIONS OF  
POTENTIAL FAILURE**

**RELATIVE  
VULNERABILITY**  
*[1 (Best) to 10 (Worst)]*



Pyramid

**1**

None, if attention given to foundation and non structural elements. Rocking may crack foundation.

# ANALYSIS OF VULNERABILITY

***BUILDING  
ELEVATION***

***LOCATIONS OF  
POTENTIAL FAILURE***

***RELATIVE  
VULNERABILITY  
[1 (Best) to 10 (Worst)]***

**4 - 6**

Top heavy,  
asymmetrical structure  
may fail at foundation  
due to rocking and  
overturning.

---

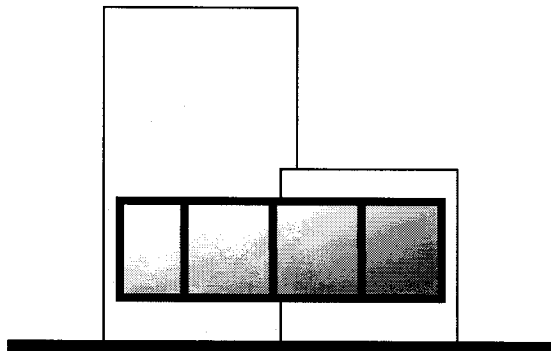
Inverted Pyramid

# ANALYSIS OF VULNERABILITY

**BUILDING  
ELEVATION**

**LOCATIONS OF  
POTENTIAL FAILURE**

**RELATIVE  
VULNERABILITY**  
*[1 (Best) to 10 (Worst)]*



“L”- Shaped  
Building

**5 - 6**

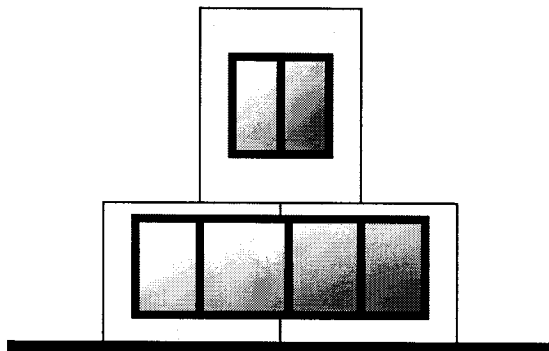
Asymmetry and horizontal transition in mass, stiffness and damping may cause failure where lower and upper structures join.

# ANALYSIS OF VULNERABILITY

**BUILDING  
ELEVATION**

**LOCATIONS OF  
POTENTIAL FAILURE**

**RELATIVE  
VULNERABILITY**  
*[1 (Best) to 10 (Worst)]*



Inverted "T"

**3 - 5**

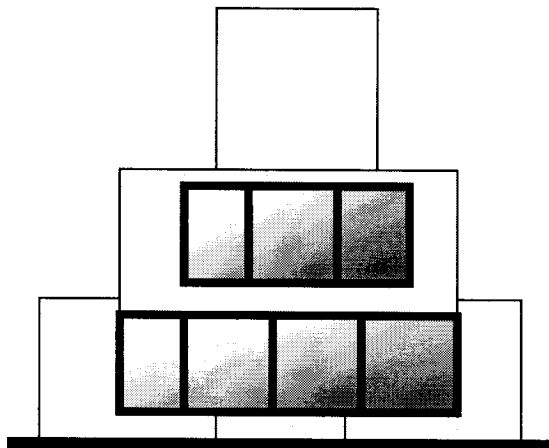
Vertical transition and asymmetry may cause failure where lower part is attached to tower.

# ANALYSIS OF VULNERABILITY

**BUILDING  
ELEVATION**

**LOCATIONS OF  
POTENTIAL FAILURE**

**RELATIVE  
VULNERABILITY**  
*[1 (Best) to 10 (Worst)]*



Multiple Setbacks

**2 - 3**

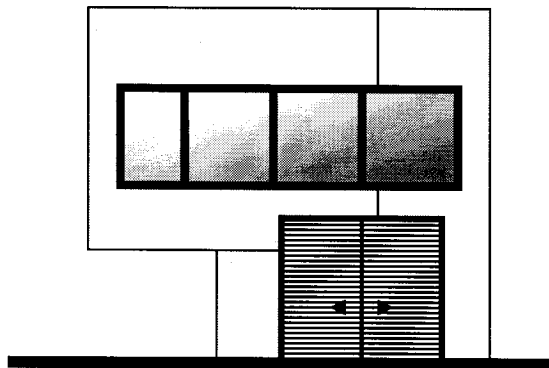
Vertical transition in mass, stiffness, and damping may cause failure at foundation and transition points at each floor.

# ANALYSIS OF VULNERABILITY

**BUILDING  
ELEVATION**

**LOCATIONS OF  
POTENTIAL FAILURE**

**RELATIVE  
VULNERABILITY**  
*[1 (Best) to 10 (Worst)]*



Overhang

**4 - 5**

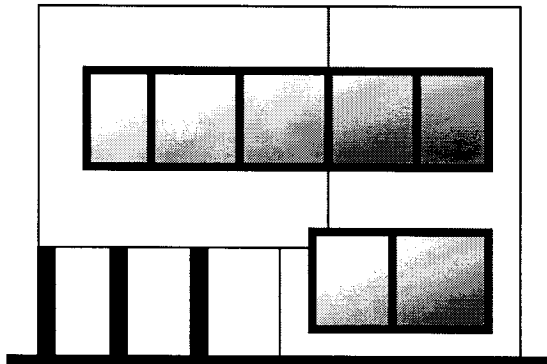
Top heavy  
asymmetrical structure  
may fail at transition  
point and foundation  
due to rocking and  
overturning.

# ANALYSIS OF VULNERABILITY

**BUILDING  
ELEVATION**

**LOCATIONS OF  
POTENTIAL FAILURE**

**RELATIVE  
VULNERABILITY**  
*[1 (Best) to 10 (Worst)]*



Partial "Soft" Story

**6 - 7**

Horizontal and vertical transitions in mass and stiffness may cause failure on soft side of first floor; rocking and overturning.

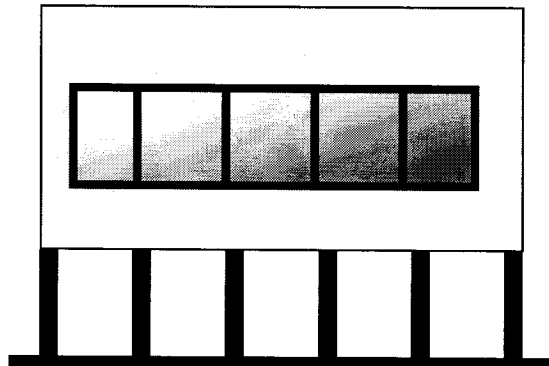


# ANALYSIS OF VULNERABILITY

**BUILDING  
ELEVATION**

**LOCATIONS OF  
POTENTIAL FAILURE**

**RELATIVE  
VULNERABILITY**  
*[1 (Best) to 10 (Worst)]*



“Soft” First Floor

**8 - 10**

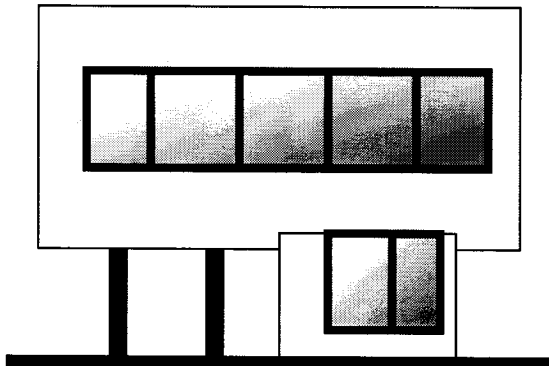
Vertical transitions in mass and stiffness may cause failure on transition points between first and second floors.

# ANALYSIS OF VULNERABILITY

**BUILDING  
ELEVATION**

**LOCATIONS OF  
POTENTIAL FAILURE**

**RELATIVE  
VULNERABILITY**  
*[1 (Best) to 10 (Worst)]*



Combination of  
“Soft” Story and  
Overhang

**9 - 10**

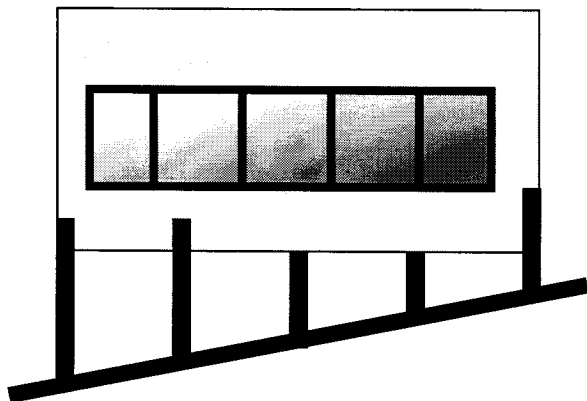
Horizontal and vertical transitions in mass and stiffness may cause failure at transition points and possible overturning.

# ANALYSIS OF VULNERABILITY

**BUILDING  
ELEVATION**

**LOCATIONS OF  
POTENTIAL FAILURE**

**RELATIVE  
VULNERABILITY**  
*[1 (Best) to 10 (Worst)]*



Building on  
Sloping Ground

**10**

Horizontal transition in stiffness of soft story columns may cause failure of columns at foundation and/or contact points with structure.

# ANALYSIS OF VULNERABILITY

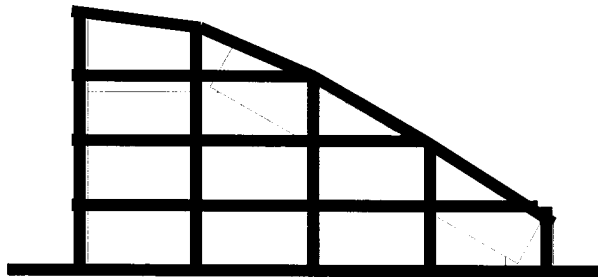
***BUILDING  
ELEVATION***

***LOCATIONS OF  
POTENTIAL FAILURE***

***RELATIVE  
VULNERABILITY  
[1 (Best) to 10 (Worst)]***

Horizontal and vertical transition in stiffness and cause failure of individual members.

**8 - 9**



Theaters and  
Assembly Halls

# ANALYSIS OF VULNERABILITY

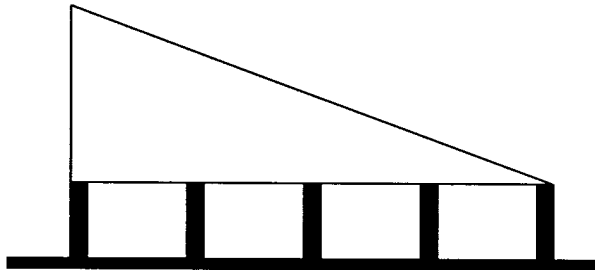
**BUILDING  
ELEVATION**

**LOCATIONS OF  
POTENTIAL FAILURE**

**RELATIVE  
VULNERABILITY**  
*[1 (Best) to 10 (Worst)]*

Horizontal and vertical transition in mass and stiffness may cause failure columns.

**9 - 10**



Sports Stadiums

# ANALYSIS OF VULNERABILITY

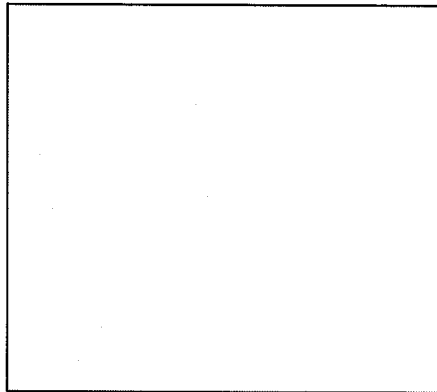
**FLOOR PLAN**

**POTENTIAL PROBLEMS**

**RELATIVE VULNERABILITY**  
**[1 (Best) to 10 (Worst)]**

None, if symmetrical layout maintained.

**1**



Box

# ANALYSIS OF VULNERABILITY

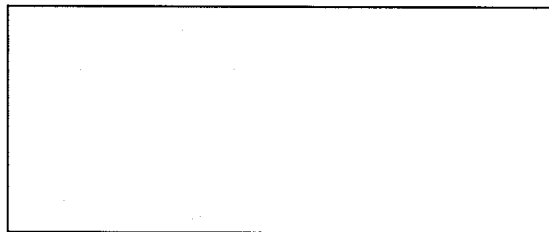
**FLOOR PLAN**

**POTENTIAL PROBLEMS**

**RELATIVE VULNERABILITY**  
**[1 (Best) to 10 (Worst)]**

**2 - 4**

Differences in length and width will cause differences in strength, differential movement, and possible overturning.

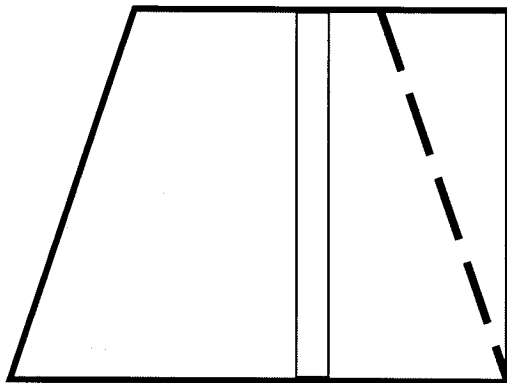


Rectangle

# ANALYSIS OF VULNERABILITY

**FLOOR PLAN**

**POTENTIAL PROBLEMS**



Street Corner

**RELATIVE VULNERABILITY**  
**[1 (Best) to 10 (Worst)]**

**2 - 4**

Asymmetry will cause torsion and enhance damage at corners.



# ANALYSIS OF VULNERABILITY

*FLOOR PLAN*

*POTENTIAL  
PROBLEMS*

*RELATIVE  
VULNERABILITY  
[1 (Best) to 10 (Worst)]*

**5 - 10**

Asymmetry will  
enhance damage at  
corner regions.

“U” - Shape

# ANALYSIS OF VULNERABILITY

*FLOOR PLAN*

*POTENTIAL PROBLEMS*

*RELATIVE VULNERABILITY*  
*[1 (Best) to 10 (Worst)]*

**4**

Open space in center reduces resistance and enhance damage at corner regions.

Courtyard in Corner

# ANALYSIS OF VULNERABILITY

**FLOOR PLAN**

**POTENTIAL  
PROBLEMS**

**RELATIVE  
VULNERABILITY**  
**[1 (Best) to 10 (Worst)]**

**8**

Asymmetry will cause torsion and enhance damage at intersection and corners.

“L” - Shape

# ANALYSIS OF VULNERABILITY

*FLOOR PLAN*

*POTENTIAL  
PROBLEMS*

*RELATIVE  
VULNERABILITY  
[1 (Best) to 10 (Worst)]*

**5 - 7**

Directional variation in stiffness will enhance damage at intersecting corner.

“H” - Shape

# ANALYSIS OF VULNERABILITY

*FLOOR PLAN*

*POTENTIAL  
PROBLEMS*

*RELATIVE  
VULNERABILITY  
[1 (Best) to 10 (Worst)]*

**8 - 10**

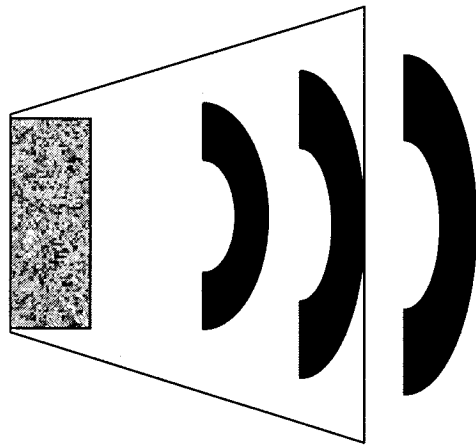
Asymmetry and directional variation in stiffness will enhance torsion and damage at intersecting.

Complex Floor Plan

# ANALYSIS OF VULNERABILITY

**FLOOR PLAN**

**POTENTIAL PROBLEMS**



Theaters

**RELATIVE  
VULNERABILITY**  
*[1 (Best) to 10 (Worst)]*

**4 - 5**

Asymmetry will cause torsion and enhance damage along curved boundary.

# ANALYSIS OF VULNERABILITY

***FLOOR PLAN***

***POTENTIAL  
PROBLEMS***

***RELATIVE  
VULNERABILITY  
[1 (Best) to 10 (Worst)]***

**5- 9**

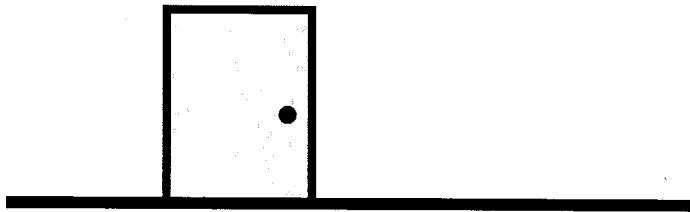
Asymmetry and irregularities will cause torsion and enhance damage along boundaries and at corners.

Curved Plan

# ANALYSIS OF VULNERABILITY

***INTERNAL  
PROPERTIES***

***POTENTIAL  
PROBLEMS***



Opening in  
Shear Wall

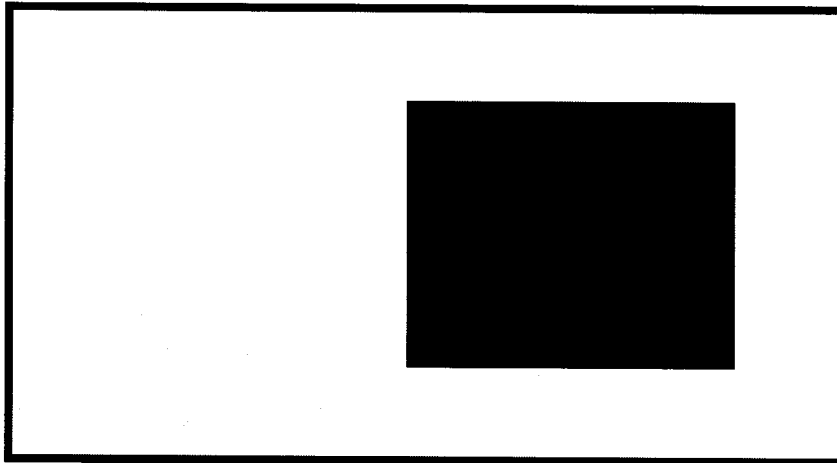
Asymmetry and discontinuities in strength will cause torsion and concentrate stress around the opening.



# ANALYSIS OF VULNERABILITY

***INTERNAL  
PROPERTIES***

***POTENTIAL  
PROBLEMS***



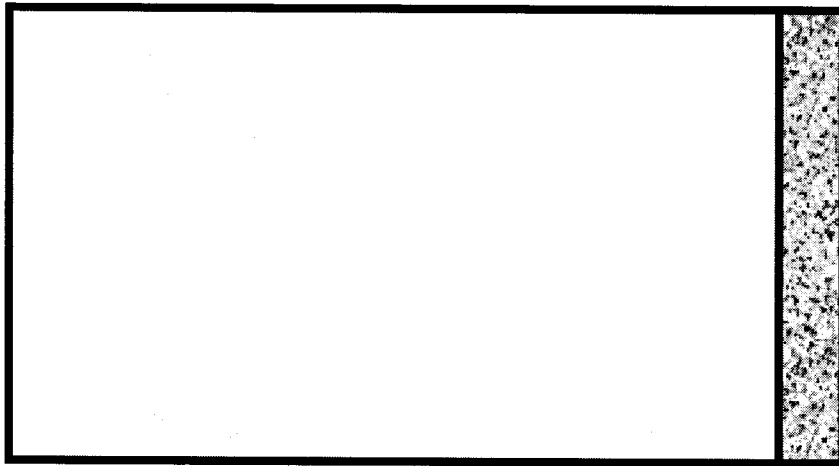
Opening in  
Shear Wall

Asymmetry and variable  
stiffness will cause torsion  
and cracking/failure at  
staircase and elevator well.

# ANALYSIS OF VULNERABILITY

***INTERNAL  
PROPERTIES***

***POTENTIAL  
PROBLEMS***



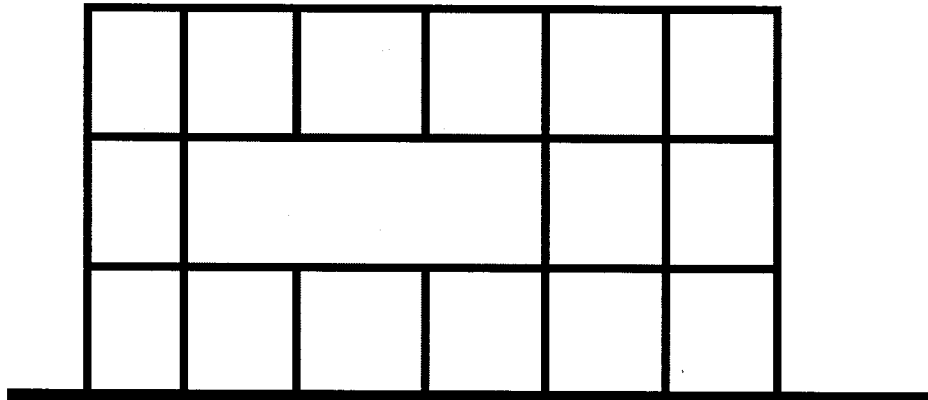
Shear Wall or  
Retaining Wall

Variable stiffness will  
enhance cracking and failure  
on weaker side of structure.

# ANALYSIS OF VULNERABILITY

***INTERNAL  
PROPERTIES***

***POTENTIAL  
PROBLEMS***



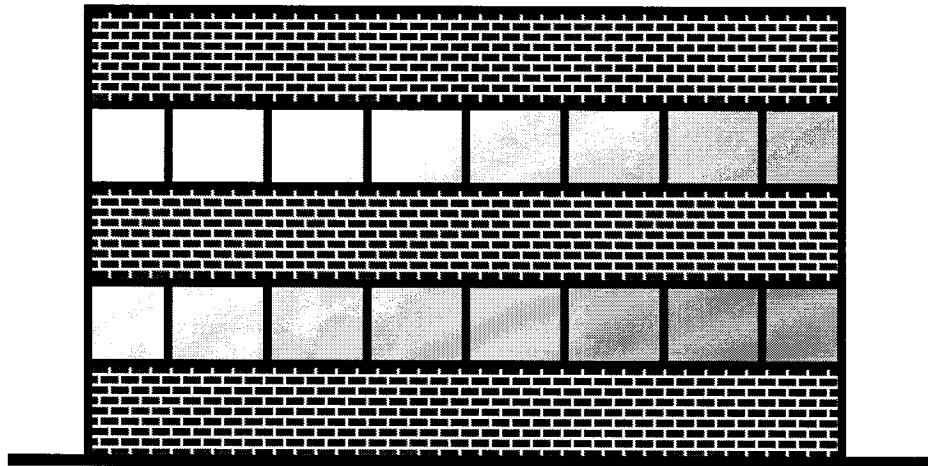
Different or  
Irregular Spans

Asymmetry and irregularities  
will cause torsion and  
enhance failure at all points  
of irregularity.

# ANALYSIS OF VULNERABILITY

**INTERNAL  
PROPERTIES**

**POTENTIAL  
PROBLEMS**



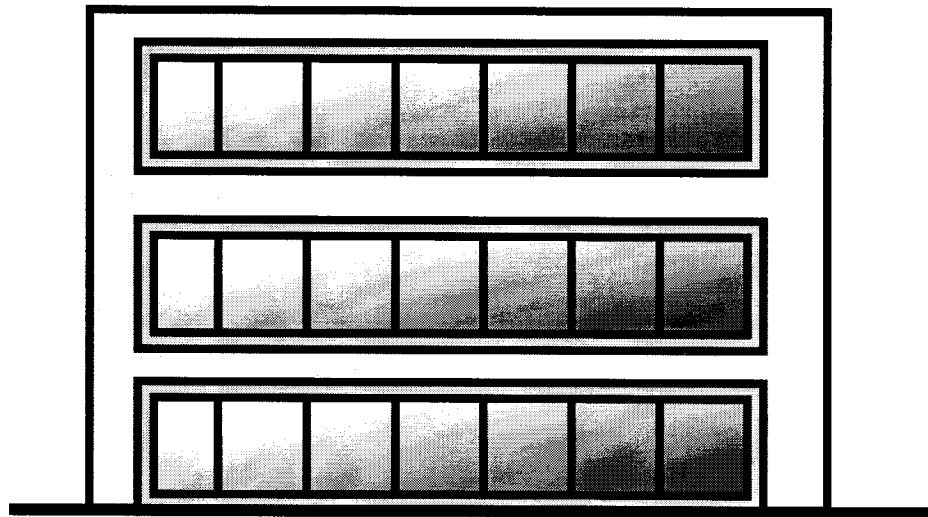
Window Bands  
Interrupting In-Fill Walls

Vertical transitions in seismic resistance will enhance failure at the “*short columns*”.

# ANALYSIS OF VULNERABILITY

***INTERNAL  
PROPERTIES***

***POTENTIAL  
PROBLEMS***



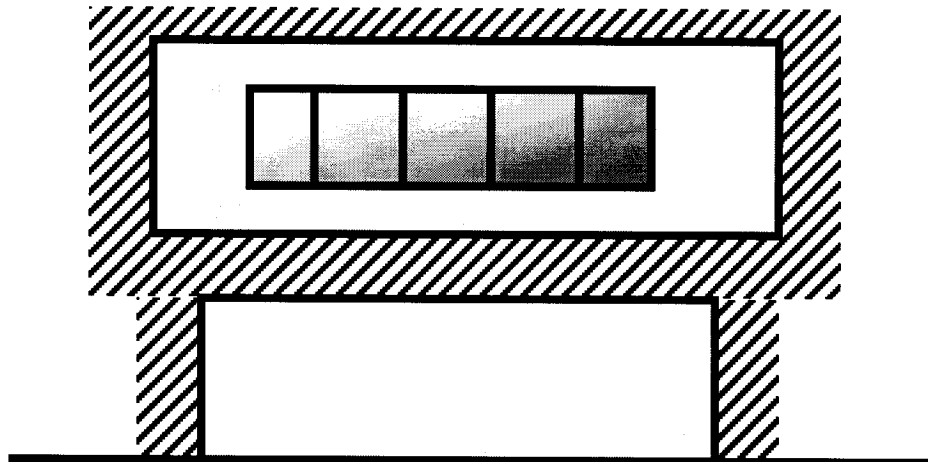
Three Story Frame

Vertical transitions in stiffness will enhance failure at the transition points.

# ANALYSIS OF VULNERABILITY

***INTERNAL  
PROPERTIES***

***POTENTIAL  
PROBLEMS***



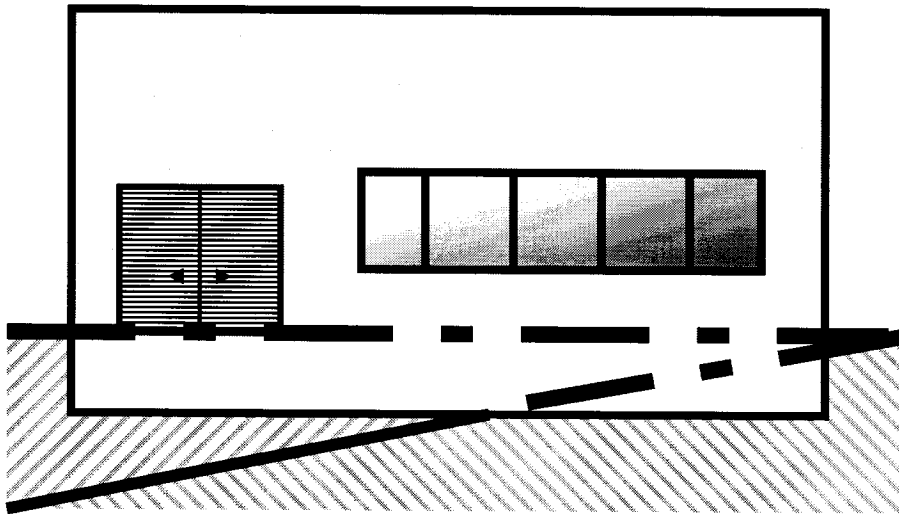
Offset Columns

Vertical transitions in mass will enhance cantilever action, overturning moment, and failure at transition points.

# ANALYSIS OF VULNERABILITY

***INTERNAL  
PROPERTIES***

***POTENTIAL  
PROBLEMS***



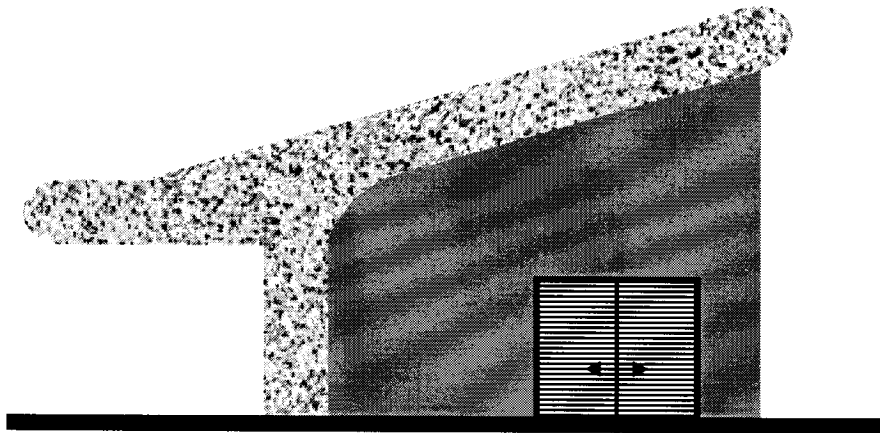
Horizontal transition in depth of foundation will cause rocking and failure at edges.

Irregular Foundation

# ANALYSIS OF VULNERABILITY

***INTERNAL  
PROPERTIES***

***POTENTIAL  
PROBLEMS***



Canopy

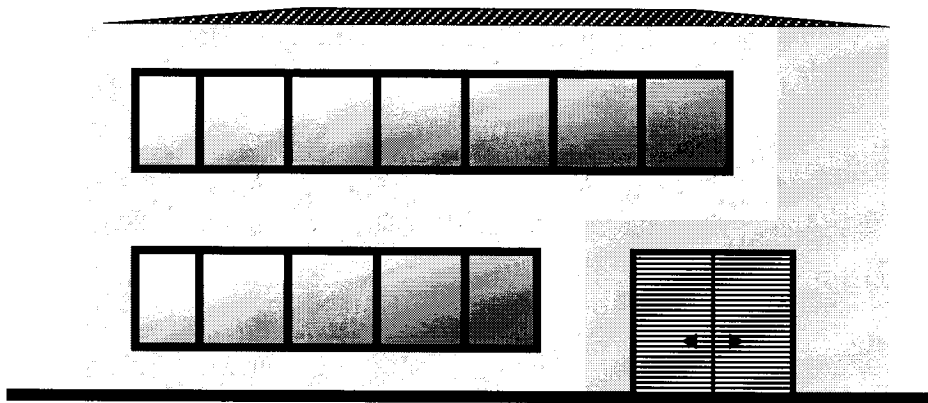
Horizontal and vertical transition in mass and stiffness and asymmetry will cause torsion, overturning, and failure at interaction.



# ANALYSIS OF VULNERABILITY

***INTERNAL  
PROPERTIES***

***POTENTIAL  
PROBLEMS***



Industrial or Commercial  
Facility

Discontinuities in mass, stiffness, and damping will enhance at all transition points.

# ANALYSIS OF VULNERABILITY

***INTERNAL  
PROPERTIES***

***POTENTIAL  
PROBLEMS***



**DUPONT**

Water Tower

Top-heavy structure vulnerable to distant earthquakes and resonance of thick soft soils because of vertical transition in mass. Rocking, overturning, and foundation failure enhanced.

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