

REFERENCES

1. Meek, J., *Matrix Structural Analysis*. Tokyo: McGraw-Hill Kogakusha, 1971.
2. Sarria, A., *Ingeniería Sísmica*. Bogotá: Ediciones UNIANDES, 1990.
3. Clough, R., Penzien, J., *Dynamics of Structures*. Tokyo: McGraw-Hill Kogakusha, 1975.
4. Wiegel, R.(ed.), *Earthquake Engineering*. Englewood Cliffs, 1970.
5. Asociación Colombiana de Ingeniería Sísmica, "Código Colombiano de Construcciones Sismoresistentes, Comentarios, Manuales y Especificaciones." Bogotá, 1991.
6. Rosenblueth, E. (ed.), *Design of Earthquake Resistant Structures*. New York, 1981.
7. Lomnitz, C., Rosenblueth, E. (eds), *Seismic Risk and Engineering Decisions*. Amsterdam, 1976.
8. Akiyama, H., *Earthquake-Resistant Limit-State Design for Buildings*. Tokyo, 1985.
9. Park, R., Paulay, T., *Reinforced Concrete Structures*. John Wiley & Sons, New York, 1975.
10. Arnold, C., Reitherman, R. *Building Configuration and Seismic Design*. John Wiley & Sons, New York, 1982.
11. Newmark, N. M., Rosenblueth, E., *Fundamentals of Earthquake Engineering*. Prentice Hall, Englewood Cliffs, N.J., 1971.
12. Applied Technology Council, *Tentative Provisions for Development of Seismic Regulations for Buildings* (Report ATC 3-06). Palo Alto, California, 1978.
13. Bazán, E., Meli, R., *Manual de Diseño Sísmico de Edificios*. México: Editorial Limusa,
14. CERESIS, "Evaluación de los Efectos Económicos de los Terremotos." Proyecto SISRA, Lima, 1984.
15. Iglesias, J., "Evaluación de la Capacidad Sísmica de Edificios en la Ciudad de México." México: Secretaría de Obras, 1986.

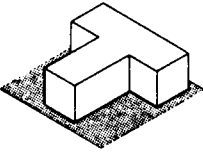
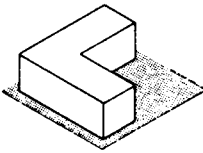
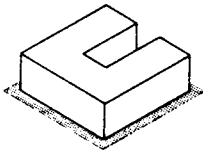
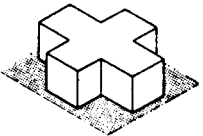
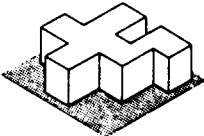
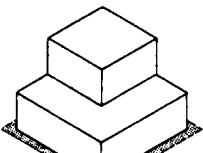
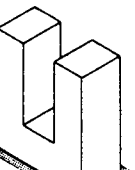
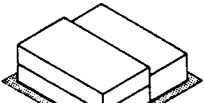
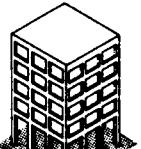
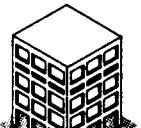
16. Applied Technology Council, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook* (Report ATC-21). Redwood City, California, 1988. (FEMA Report 154, July 1988).
17. Hirosawa, M., "Evaluation of Seismic Safety and Guidelines on Seismic Retrofitting Design of Existing Reinforced Concrete Buildings" (VI Seminar for Structural Engineers on Seismology and Engineering for Earthquakes, Tokyo, 1976), 1988.
18. Organización Panamericana de la Salud, *Análisis de Riesgo en el Diseño de Hospitales en Zonas Sísmicas* (Edición de varios artículos). Washington, D.C., 1989.
19. Applied Technology Council, *Evaluating the Seismic Resistance of Existing Buildings* (Report ATC-14). Redwood City, California, 1987.
20. Applied Technology Council, *A Handbook for Seismic Evaluation of Existing Buildings* (Preliminary Report ATC-22). Redwood City, California, 1989.
21. Applied Technology Council, *Seismic Evaluation of Existing Buildings: Supporting documentation* (Report ATC 22-1). Redwood City, California, 1989.
22. Asociación Colombiana de Ingeniería Sísmica, "Adición, Modificación y Remodelación del Sistema Estructural de Edificaciones Existentes antes de la Vigencia del Decreto 1400/84" (Norma AIS-150-86). Bogotá, 1986.
23. Dowrick, D.J., *Diseño de Estructuras Resistentes a Sismos para Ingenieros y Arquitectos*. México: Editorial Limusa, 1984.
24. Iglesias, J. et al., *Reparación de Estructuras de Concreto y Mampostería*. México: Universidad Autónoma Metropolitana, 1988.

ANNEX 1:
CONFIGURATION CONSIDERATIONS

- ▶ ***IRREGULARITIES IN STRUCTURES***
- ▶ ***LOCATION OF SHEAR WALLS***

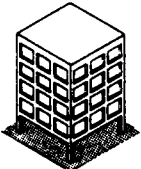
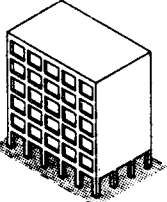
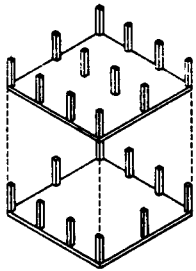
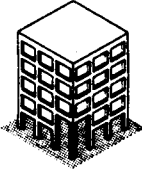
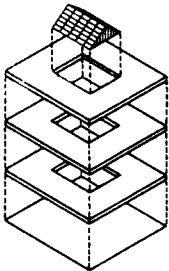
IRREGULARITIES IN STRUCTURES

A. BUILDINGS WITH IRREGULAR CONFIGURATION

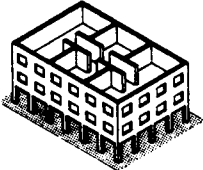
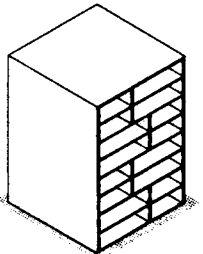
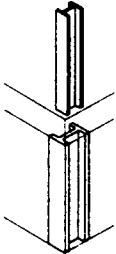
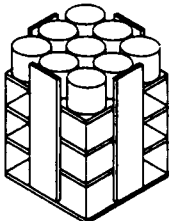
				
T-shaped plan	L-shaped plan	U-shaped plan	Cruciform plan	Other complex shapes
				
Setbacks	Multiple towers	Split levels	Unusually high story	Unusually low story

Outwardly uniform appearance but nonuniform mass distribution, or converse

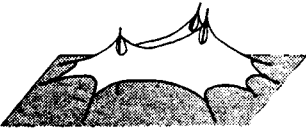

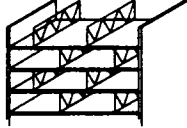
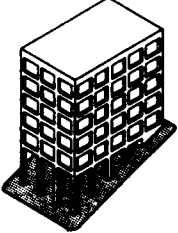
B. BUILDINGS WITH ABRUPT CHANGES IN LATERAL RESISTANCE

				
"Soft" lower levels	Large openings in shear walls	Interruption of columns	Interruption of beams	Openings in diaphragms

C. BUILDINGS WITH ABRUPT CHANGES IN LATERAL STIFFNESS

			
Shear walls in some stories, moment-resisting frames in others	Interruption of vertical-resisting elements	Abrupt changes in size of members	Drastic changes in mass/stiffness ratio

D. UNUSUAL OR NOVEL STRUCTURAL FEATURES

			
Cable-supported structures	Shells	Staggered trusses	Buildings on hillsides

Graphic interpretation of "irregularities in structures or in systems of frameworks," from *SEAO Recommended Lateral Force Requirements and Commentary*. (Taken from *Configuration and Seismic Design of Buildings*, Christopher Arnold and Robert Reitherman, John Wiley and Sons, New York, 1982, p. 8. Reprinted with permission.)

LOCATION OF SHEAR WALLS

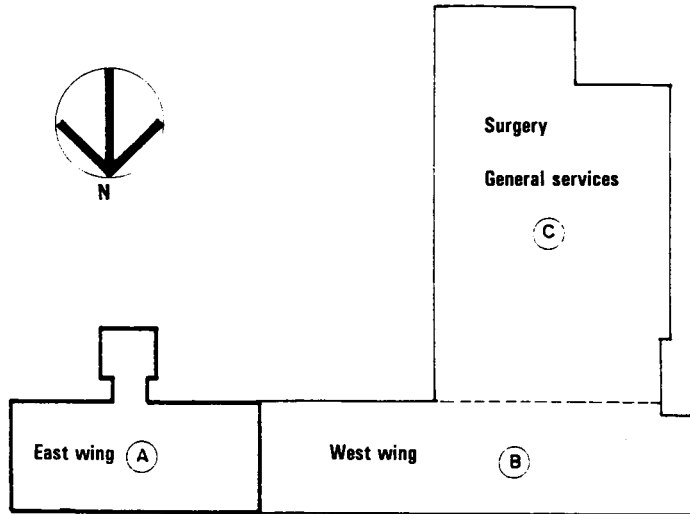
SCHEMATIC CONFIGURATION	RESISTIVE ELEMENTS FOR ← EARTHQUAKE FORCES	RESISTIVE ELEMENTS FOR ↑ EARTHQUAKE FORCES	RESISTIVE ELEMENTS FOR TORSION ↻
			 MAJOR PROBLEM: NO TORSIONAL RESISTANCE
			 LITTLE TORSIONAL RESISTANCE (SMALL LEVEL ARM)
			 TWO-AXIS ANALYSIS IS NOT SUFFICIENT: FOR FORCES ALONG THIS DIAGONAL AXIS ↗, THERE ARE NO RESISTANT ELEMENTS
	 PRODUCES TORSION	 PRODUCES TORSION	

Location of shear walls. Schematic plans can be seen as sets of resistant elements with various orientations (to resist translation) and with variable distances to the center of rigidity (to resist rotation or torsion). (Taken from *Configuration and Seismic Design of Buildings*, Christopher Arnold and Robert Reitherman, John Wiley and Sons, New York, 1982, p. 42. Reproduced with permission.)

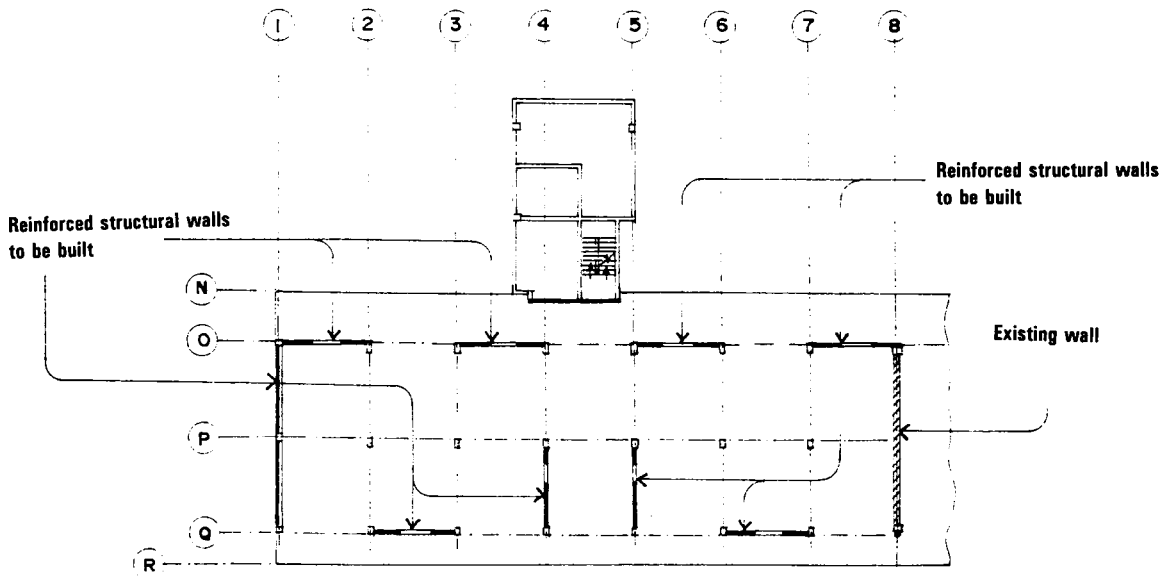
ANNEX 2:
EXAMPLES OF REHABILITATION

- ▶ *HOSPITAL NACIONAL DE NIÑOS*
- ▶ *HOSPITAL MEXICO*
- ▶ *HOSPITAL MONSEÑOR SANABRIA*

HOSPITAL NACIONAL DE NIÑOS

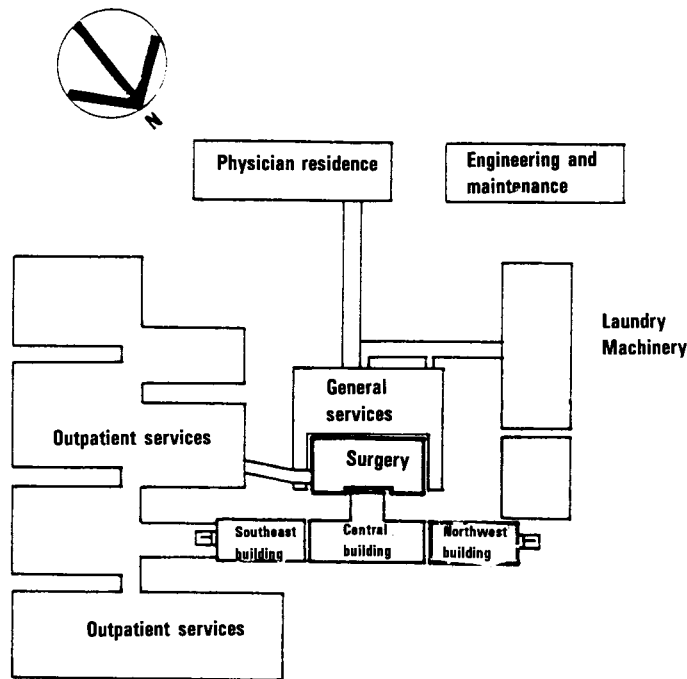


GENERAL LAYOUT--HOSPITAL NACIONAL DE NINOS







ARCHITECTURAL PLANE FOR RETROFITTED EAST WING
(HOSPITAL NACIONAL DE NINOS) (Scale 1:400)

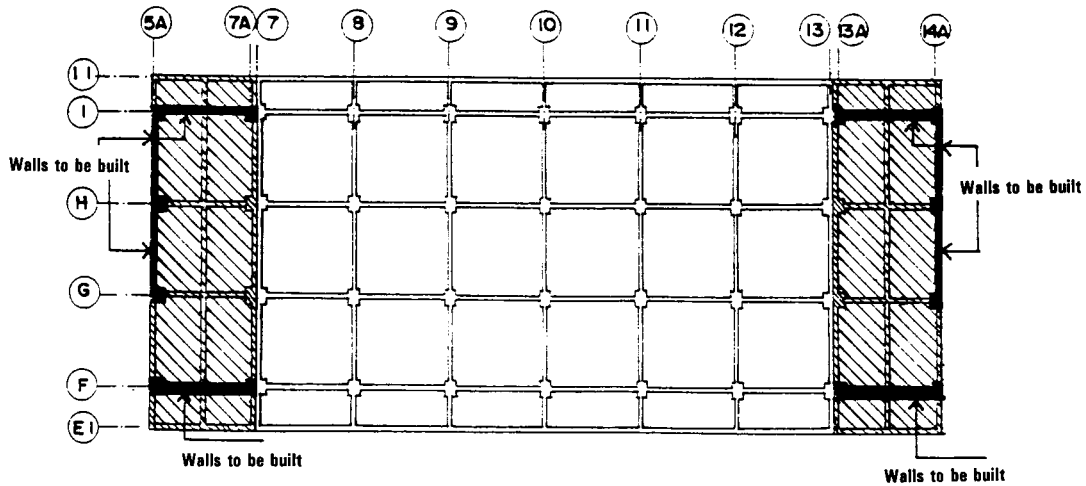
HOSPITAL MEXICO



**DISTRIBUTION OF PRINCIPAL BUILDINGS
(HOSPITAL MEXICO)**

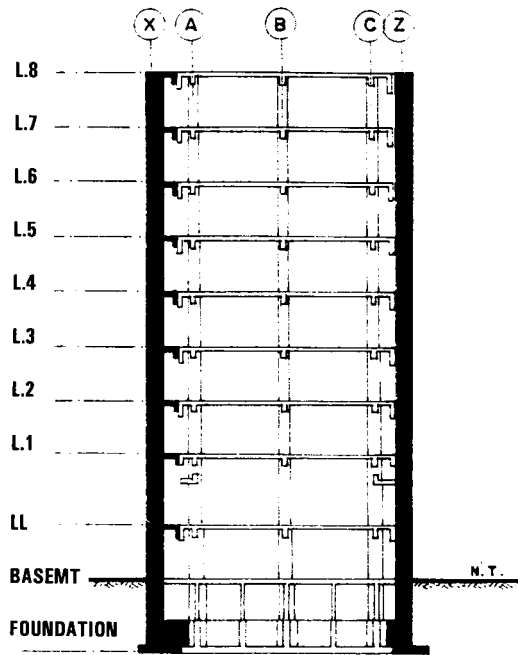
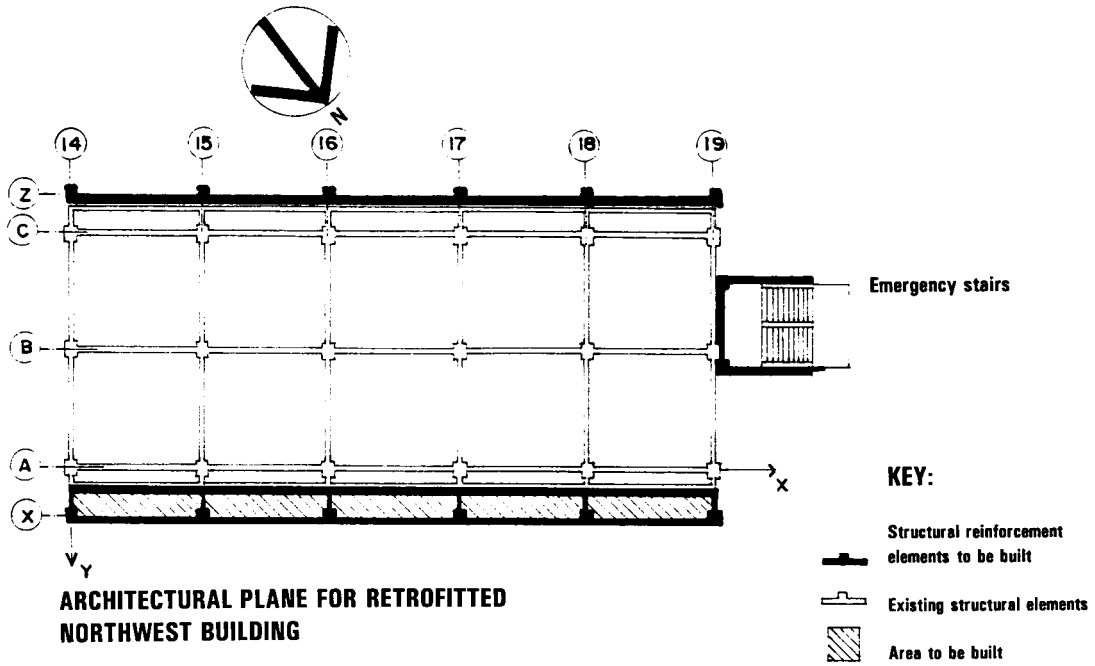
KEY:

-  Reinforced structural walls to be built
-  Structural elements to be built
-  Existing structural elements
-  Area to be built

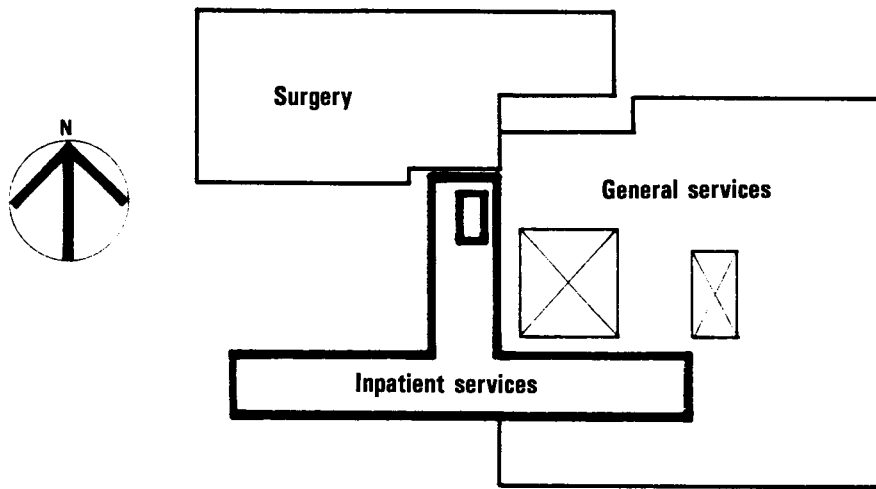


STRUCTURAL PLANE FOR SURGERY BUILDING

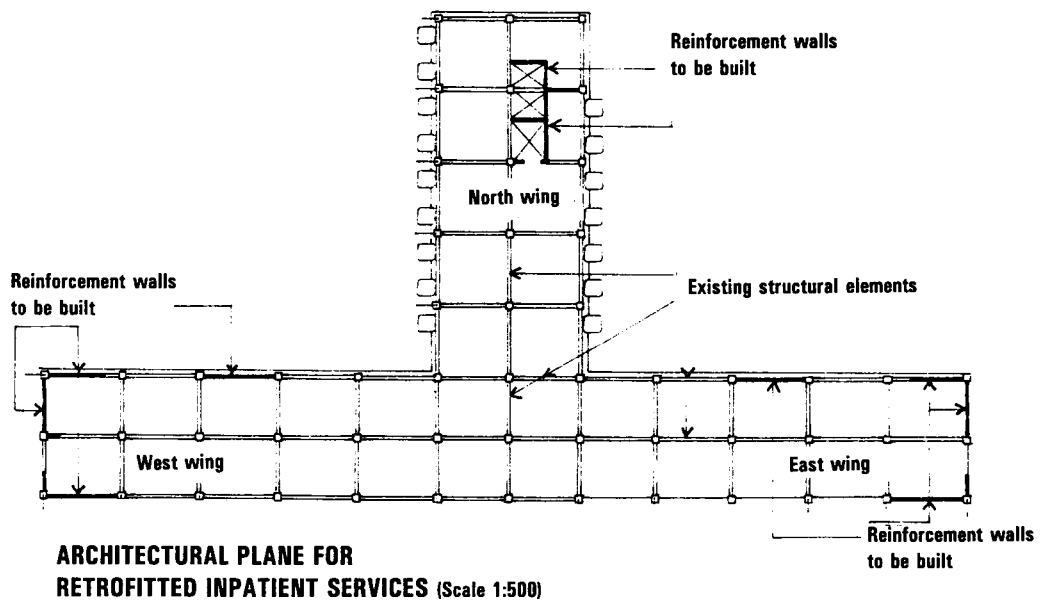
HOSPITAL MEXICO (CONTINUED)



HOSPITAL MONSEÑOR SANABRIA



GENERAL LAYOUT OF HOSPITAL MONSEÑOR SANABRIA



ARCHITECTURAL PLANE FOR
RETROFITTED INPATIENT SERVICES (Scale 1:500)

ANNEX 3:

RECOMMENDED BIBLIOGRAPHY

Below is a selected list of useful publications that amplify on the concepts explained in the various chapters.

CONCEPTUAL ASPECTS

- ▶ Bolt, B.A., *Terremotos* (Serie Reverté Ciencia y Sociedad). Barcelona: 1981.
- ▶ Cardona, O.D., "Evaluación de la Amenaza, la Vulnerabilidad y el Riesgo", Regional Workshop for Training in Disaster Administration, ONAD/PNUD/OPS/OEA, Bogotá, May 1991; *II Simposio Latinoamericano de Riesgo Geológico Urbano*, Vol.1, EAFIT, Pereira, July 1992.
- ▶ Cardona, O.D., "Términos de Uso Común en Manejo de Riesgos", AGID Report no. 13, EAFIT, *I Seminario Andino de Geología Ambiental*, Medellín, April 1990.
- ▶ Earthquake Engineering Research Institute (EERI), *Reducing Earthquake Hazards: Lessons Learned from Earthquakes* (Publication No. 86-02). Oakland, California: EERI, 1986.
- ▶ EERI Committee on Seismic Risk, "Glossary of Terms for Probabilistic Seismic-Risk and Hazard Analysis", *EERI Earthquake Spectra*, 1(1):33-40, 1984.
- ▶ EERI, *Reducing Earthquake Hazards: Lessons Learned from the 1985 Mexico Earthquake* (Publication No. 89-02). Oakland, California: EERI, 1989.
- ▶ EERI Committee on Seismic Risk, "The Basics of Seismic Risk Analysis," *EERI Earthquake Spectra*, 5 (4):675-801, 1990.
- ▶ Pan American Health Organization, *Disaster Mitigation Guidelines for Hospitals and Other Health Care Facilities in the Caribbean* (Emergency Preparedness Program). Washington, D.C., 1992.

EVALUATION OF STRUCTURAL VULNERABILITY

- ▶ Aktan A.E., I-Kang Ho, "Seismic Vulnerability Evaluation of Existing Buildings," *EERI Earthquake Spectra*, 6(3): 439-472, 1990.
- ▶ Applied Technology Council, *Evaluating the Seismic Resistance of Existing Buildings* (ATC-14). Redwood City, California: Applied Technology Council, 1987.
- ▶ Applied Technology Council, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook* (ATC 21). Redwood City, California: Applied Technology Council, April 1988. (FEMA Report 154, July 1988).
- ▶ Applied Technology Council, *Evaluating the Seismic Resistance of Existing Buildings* (Preliminary Report: ATC-22). Redwood City, California: Applied Technology Council, 1989. (FEMA Report 178, June 1989).
- ▶ Applied Technology Council, *Seismic Evaluation of Existing Buildings: Supporting Documentation* (ATC-22-1). Redwood City, California: Applied Technology Council, 1989.
- ▶ Arnold C., Durkin M., *Hospitals and the San Fernando Earthquake*. California: Building Systems Development Inc., 1983.
- ▶ Asociación Colombiana de Ingeniería Sísmica (AIS COMITE-400), *Análisis de Vulnerabilidad Sísmica del Hospital Universitario del Valle*. Bogotá, July 1992.
- ▶ Blejwas T., Bresler B., *Damageability in Existing Buildings* (Report no. UCB/EERC-78/12). Earthquake Engineering Research Center, University of California, August 1979.
- ▶ Cardona O.D., "Metodología para la Evaluación de la Vulnerabilidad Sísmica de Edificaciones y Centros Urbanos", *VII Seminario Latinoamericano de Ingeniería Sismo-Resistente - IX Jornadas Estructurales*, SCI/AIS/MOPT, Bogotá, October 1991.
- ▶ Cardona O.D., Hurtado J.E., "Análisis de Vulnerabilidad Sísmica de Estructuras de Concreto Reforzado", *Reunión del Concreto*, ASOCRETO, Cartagena, 1992.
- ▶ Ghosh, S.K. (editor), *Earthquake Resistant Concrete Structures Inelastic Response and Design* (SP-127), ACI, 1991.
- ▶ Hirose M., *Evaluation of Seismic Safety and Guidelines on Seismic Retrofitting Design of Existing Reinforced Concrete Buildings*. Tsukuba, Japan: International Institute of Seismology and Earthquake Engineering, 1988.
- ▶ Iglesias, J., *Evaluación de Edificios de Concreto en la Ciudad de México*. México, D.F.: Departamento de Materiales, Universidad Autónoma Metropolitana, 1988.

- ▶ National Center for Earthquake Engineering Research (NCEER), *IDARC: Inelastic Damage Analysis of Reinforced Concrete Frame Shear-Wall Structures* (Technical report no. NCEER-87-0008). Buffalo, New York: State University of New York, 1987.
- ▶ Nigel Priestley, M.J., Michele Calvi, G., "Towards a Capacity-Design Assessment Procedure for Reinforced Concrete Frames," *EERI Earthquake Spectra* 7(3): 413-437, 1991.
- ▶ Ohkubo M., *Current Japanese System for Evaluation of Seismic Capacity of Existing Reinforced Concrete Buildings Structures*. Tsukuba, Japan: International Institute of Seismology and Earthquake Engineering, December 1991.
- ▶ Rivera de Uzcátegui, I., *Evaluación Primaria de Edificios Bajos ante Solicitaciones Sísmicas, Aplicación al Hospital Universitario de Mérida*. Mérida, Venezuela: Universidad de los Andes, 1989.
- ▶ Tassios T.P., *Evaluation of the Relative Seismic Risk of Existing Buildings by Means of Simplified Vulnerability Techniques*. (Popayán Project Report presented in Athens, Greece, December 1989.)

REPAIR AND RETROFITTING OF BUILDINGS

- ▶ ACI, *Seismic Design for Existing Structures*, Seminar Course Manual SCM-14(86), Detroit 1986.
- ▶ Cruz, M.F., *Comportamiento de Hospitales en Costa Rica Durante los Sismos de 1990*. San José, Costa Rica: Organización Panamericana de la Salud, 1991.
- ▶ Englekirk R.E., Sabol T.A., "Strengthening Buildings to Life Safety Criterion," *EERI Earthquake Spectra*, 7(1): 81-87, 1991.
- ▶ Federal Emergency Management Agency, *Techniques for Seismically Rehabilitating Existing Buildings--Preliminary* (Report No. 172). Emitsburg, Maryland: National Earthquake Hazards Reduction Program, March 1989.
- ▶ Hirose M., *Evaluation of Seismic Safety and Guidelines on Seismic Retrofitting Design of Existing Reinforced Concrete Buildings*. Tsukuba, Japan: International Institute of Seismology and Earthquake Engineering, August 1988.
- ▶ Iglesias J. et al., "Reparación de Estructuras de Concreto y Mampostería", *Asociación Colombiana de Ingeniería Sísmica, AIS, Boletín No. 42*, Bogotá, November 1991.
- ▶ National Center for Earthquake Engineering Research (NCEER), *Manual of Repair Methods for Civil Engineering Structures Damaged by Earthquakes*. State University of New York at Buffalo, 1990.
- ▶ Ohkubo M., *Current Japanese System on Seismic Capacity and Retrofit Techniques for Existing Reinforced Concrete Buildings and Post-Earthquake Damage Inspection and Restoration Techniques* (Kyushu Institute of Design, Fukuoka, Japan) Report No. SSRP-91/02, University of California at San Diego, May 1991.

- ▶ Perbix T.W., Burke P., "Toward a Philosophy for Seismic Retrofit: The Seattle Experience," *EERI Earthquake Spectra*, 5(3): 557-569, 1990.
- ▶ Platt C.M., Shepherd R., "Some Cost Considerations of the Seismic Strengthening of Pre-Code Buildings" *EERI Earthquake Spectra*, 1(4): 695-720, 1985.
- ▶ Rodriguez M., Park R., "Repair and Strengthening of Reinforced Concrete Buildings for Seismic Resistance," *EERI Earthquake Spectra*, 7(3): 439-459, 1991.
- ▶ Sugano S., *Seismic Strengthening of Existing Reinforced Concrete Buildings in Japan*. Tsukuba, Japan: International Institute of Seismology and Earthquake Engineering, December 1991.
- ▶ U.S. Department of Defense, *Seismic Design Guidelines for Upgrading Existing Buildings*. Technical Manual, Army TM 5-809-10-2, Navy NAVPAC P-355.2, Air Force AFM 88-3, Chapter 13, Section B, September 1988.

REDUCTION OF NON-STRUCTURAL VULNERABILITY

- ▶ Earthquake Engineering Research Institute (EERI), *Non-Structural Issues of Seismic Design and Construction* (Publication No. 84-04). Oakland, California: 1984.
- ▶ Federal Emergency Management Agency, *Non-Structural Earthquake Hazard Mitigation for Hospitals and Other Care Facilities* (FEMA Report IG 370), Emitsburg, Maryland, 1989.
- ▶ Federal Emergency Management Agency, *Reducing the Risk of Non-Structural Earthquake Damage: A Practical Guide* (FEMA Report No. 74), Emitsburg, Maryland, 1985.
- ▶ Federal Emergency Management Agency, *Seismic Considerations—Health Care Facilities* (FEMA Report No. 150), Emitsburg, Maryland, 1990.
- ▶ McGavin, G.L., *Earthquake Protection of Essential Building Equipment Design Engineering Installation*. New York: John Wiley & Sons, 1981.

