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1972 MANAGUA EARTHQUAKE DAMAGE TO TALL BUILDINGS

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Damage to buildings of five or more stories during the 1972 Managua earthquake is evaluated. Information on building performance is organized and presented by means of the damage probability matrix. The damage states are described. The probabilities reflect the relationship between ground shaking intensity and the amount of building damage. All buildings over five stories high suffered some damage, ranging from light nonstructural damage and concrete cracking to total collapse. Most of these buildings had reinforced concrete frames as lateral force resisting systems. These did not seem to perform as well as the reinforced concrete shear wall buildings. In general, an average value of damage state six seems appropriate to these buildings. This data, however, seems contrary to the belief that these buildings were of significant seismic design.

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INTRODUCTION

This report concerns itself with Tall Building Damage during the 1972 Managua Earthquake and deals with damage to buildings of five or more stories, only.

The purpose of this report is to organize and present information on building performance by means of the damage probability matrix (1). (The damage states referred to in this report are described in Appendix A.). These probabilities reflect the relationship between ground shaking intensity and the amount of building damage.

All data was collected from reports (2,3,4) on the Managua Earthquake.

THE 1972 MANAGUA EARTHQUAKE

On December 27, 1972 at about 12:29 a.m. local time, the main shock of the earthquake occured with an epicenter within, or very close to, the city. The Richter magnitude of the shock was 6.25. Accelerograph readings 4 kilometers to the west of the downtown area recorded peak accelerations between .33g and .39g. The duration of shaking of the peak accelerations above above .20g was 5 seconds, and it is thought that the peak acceleration in the center of the city may have approached .50g. The Modified Mercalli Intensity is thought to have been 8^+ (5)* Damage surveys show approximately 5 - 10,000 dead, 20,000 injured and 220-250,000 left homeless. Public and private property damage is estimated at $851 million.

Much of the older residential and commercial construction in Managua was of the type called "Taquezal", a timber framed adobe construction. These buildings were inherently weak, although heavy enough to generate large lateral forces. Throughout Managua these buildings collapsed, and these collapses constitute the main part of life loss in Managua. Also, all buildings over 5 stories high suffered some damage, ranging from light nonstructural damage and concrete cracking to total collapse.

*Other interpretations would suggest on MMI between 9 and 10.

DATA BASE

Table 1 lists about half of the buildings of 5 or more stories in the heavily shaken area. Most of the buildings had reinforced concrete frames as lateral force resisting systems. These did not seem to perform as well as the reinforced concrete shear wall buildings.

There was no universal code in Managua at the time of the earthquake, however, it is thought that various buildings were designed in accordance with the zone 3 requirements of the UBC. Just how many and which buildings were designed in this way is relatively uncertain. With regards to this code issue, Table 2 separates a group of buildings from the main building list (Table 1). These buildings, all designed since 1960, are believed to have had seismic design (6). According to Jose Teran, with regards to these buildings, "... The new requirements, the new architects, and the new magnitudes, demanded the more complex studies of soil testing, seismic design more or less to U. S. building codes, and ..." (6). The damage states of these buildings determined from available damage descriptions as well as the damage state correlated to actual replacement costs of these buildings are given in Table 2. In general, an average value of damage state six seems appropriate to these buildings. This, however, seems somewhat contrary to the belief that these buildings were of significant seismic design. Table 3 compares buildings of seismic design with other tall buildings in Managua. The only significant difference is that of the total collapse percentage* I think it is reasonable to say that the question of code requirements in Managua remains unsolved.

Special attention should be given to the difficult classification of the Banco De America. Due to the building stiffness provided by the shear walls, non structural damage was very light, approximately equivalent to damage state two. However, there appears to be enough visable cracking and structural damage to merit a damage state of four. The high

*This may really be the main difference in buildings without and with earthquake design: less likelihood of collapse but not less likelihood of damage during a major earthquake.

TABLE 1

LIST OF BUILDING FIVE OR MORE STORIES IN MANAGUA, 1972

	NAME	STORIES	YEAR BUILT	DAMAGE STATE	TYPE
1.	Banco America	17	1964	4	CSW
2.	Banco Central	15	1964	5	C. Frame
3.	Edificio Carlos	6	1965	4	C. Frame
4.	Lang Building	6	1956	6	C. Frame Reticular Flat Plate
5.	Banco De Viviendo	5	1962	6	C. Frame
6.	Social Security Bldg.	11	1960	5	C. Frame
7.	Balmoral Hotel	8	1969	6	C. Frame
8.	Immobilaria	7		4	CSW
9.	IBM	7		4	S. Frame
10.	Seguro La Protectera	6	1969	7	C. Frame
11.	Supreme Court	5	1967	6	C. Frame & CSW
12.	Pan-Am Insurance	6		4	C. Frame & CSW
13.	Inter Continental Hotel	8	1968	6	C. Frame
14.	Guerrero Pineda	5	1952	8	C. Frame
15.	Gran Hotel	5		8	C. Frame
16.	Red Cross Bldg.	5		8	C. Frame
17.	Banco National	5		4	CSW
18.	ENALUF	5	1968	4	C. Frame & CSW
19.	Telcor	7	1966	6	C. Frame

TABLE 3

DAMAGE MATRIX COMPARISON BETWEEN BUILDINGS OF SEISMIC DESIGN (TABLE 2) AND OTHER BUILDINGS OVER FIVE STORIES

DAMAGE CATAGORY		MERCALLI INTENSITY 8^{+}			
General	Detailed	Buildings of Seismic Design		Other Buildings	
No damage	0	0	(o)	0	(o)
Light	1	0	(o)	0	(o)
	2		(o)		(o)
Moderate	3	.22	(o)	.50	(o)
	4		(2)		(5)
Heavy	5	.67	(2)	.20	(o)
	6		(4)		(2)
Requires Replacement	7	.11	(1)	.30	(o)
	8		(o)		(3)
TOTAL		1.00	(9)	1.00	(10)
Mean Damage Ratio - %		32		38	

TABLE 5

PROBABILITY MATRIX VALUES FOR MMI 8+

DAMAGE CATAGORY	C. FRAME 5-8	C. FRAME 11-17	CSW 5-8	CSW 11-17	CSW & C. FRAME 5-8	CSW & C. FRAME 11-17	OTHER 5-8	OTHER 11-17
NO DAMAGE	0	0	0	0	0	0	0	0
LIGHT DAMAGE	0	0	0	0	0	0	0	0
MODERATE DAMAGE	1/10	0	2/2	1/1	2/2	0	1/2	0
HEAVY DAMAGE	5/10	2/2	0	0	0	0	1/2	0
REQUIRES REPLACEMENT	4/10	0	0	0	0	0	0	0

APPENDIX A

"EARTHQUAKE DAMAGES STATES"

	Damage State	Damage Ratio*	
		Central Value	Range
0	No Damage	0	0 - 0.05
1	Minor non-structural damage--a few walls and partitions cracked, incidental mechanical and electrical damage	0. 1	0.05 - 0.3
2	Localized non-structural damage--more extensive crackling (but still not widespread); possibily damage to elevators and/or other mechnical/electrical components	0.5	0.3 - 1.25
3	Widespread non-structural damage--possibly a few beams and columns cracked, although not noticable	2	1.25 - 3.5
4	Minor structural damage--obvious cracking or yielding in a few structural members: substantial non-structural damage with widespread cracking	5	3.5 - 7.5
5	Substantial structural damage requiring repair or replacement of some structural members; associated extensive non-structural damage	10	7.5 - 20
6	Major structural damage requiring repair or replacement of many structural members; associated non-structural damage requiring repairs to major portion of interior; building vacated during repairs	30	20 - 65
7	Building condemned	100	65 - 100
8	Collapse	100	100

*Ratio of cost of repair to replacement cost.