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16. Abstract (Limit: 200 words)

Information derived from discussions during a visit to Japan is presented on two earthquakes which occurred in 1968 and which caused significant shaking of modern tall buildings: the Higashi-Matsuyama earthquake and the Takachi-Oki earthquake. The Higashi-Matsuyama earthquake had a Richter magnitude of 6.1. Its epicenter was about 50 km from downtown Tokyo, and the focus of the earthquake was at a depth of 70 km. The Tokachi-Oki earthquake had a magnitude of 7.8 and a focal depth of 20 km. The epicenter was off the northeast corner of Honshu. The largest city severely shaken by the earthquake was Hachinobe, about 170 km. from the epicenter. There was no damage to modern tall buildings in Tokyo during the Higashi-Matsuyama earthquake. In Hachinoke and its vicinity there are 16 multi-story buildings: ten having three stories, and two each having four, five, and six stories. Three of the three-story buildings were noted as considerably or heavily damaged. All remaining buildings were described as practically undamaged. The statistics presented are felt to be meaningful with regard to moderate or heavy damage but not necessarily correct with respect to light damage.

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DAMAGE STATISTICS FROM JAPANESE EARTHQUAKES

The writers visited Japan during the week of 23-29 April. In addition to holding discussions on various technical subjects (effect of soil conditions upon earthquake motions, microzoning practice, soil-structure interaction, probabilistic dynamic response, structural reliability), the writers attempted to gather statistics concerning damage to high-rise buildings during recent Japanese earthquakes. This result summarizes the few findings (see Tables 1 and 2). The matter will be pursued farther by correspondence.

There have been only two recent earthquakes which have caused significant shaking of modern tall buildings, both in 1968. The Higashi-Matsuyama earthquake had a Richter magnitude of 6.1; its epicenter was about 50 km from downtown Tokyo, and the focus of the earthquake was at a depth of 70 km. The Tokachi-Oki earthquake had a magnitude of 7.8 and a focal depth of 20 km. The epicenter was off the northeast corner of Honshu. The largest city severely shaken by the earthquake was Hachinobe, about 170 km from the epicenter.

The ensuing comments were derived from a group discussion at the Architectural Institute of Japan, following presentation of the writers' paper concerning optimum seismic protection.

Higashi-Matsuyama Earthquake

Dr. Izumi of the Building Research Institute stated flatly that there was no damage to modern tall buildings in Tokyo during this earthquake. When pressed as to what he meant by no damage, he insisted that there was literally no damage. The other engineers present at the meeting expressed agreement with this view. Hence, Table 1 records 100% of buildings as having zero damage. Based on the measured ground accelerations, the writers have assigned a modified Mercalli intensity 6^{+} to this experience.

Tokachi-Oki Earthquake

Yamahara (1970) lists 16 multi-story buildings in Hachinoke and vicinity: 10 having 3 stories, and 2 each having 4, 5 and 6 stories. Three of the 3-story buildings are listed as "considerably" or "heavily" damaged. All remaining buildings on the list were described as "practically undamaged."

During the discussion, an unidentified report (in Japanese) was scanned by Prof. Yoshimi of Tokyo Institute of Technology. He identified about 6 buildings having either 5 or 6 stories. Cracking of a few beams and/or columns was reported for one building. At another, it was reported that marble facing cracked. The remaining buildings were "practically undamaged." After listening to this discussion, the writers have judged the statistics in Table 2 to be reasonably representative.

Discussion

Like their American counterparts, Japanese earthquake engineers are attuned to significant structural damage and are not necessarily aware of minor damage of an architectural nature. Thus, while the statistics recorded in the attached tables probably are meaningful with regard to moderate or heavy damage, they are not necessarily correct with respect to light damage.

The experience in Japan may be compared with the experience during the 1971 San Fernando earthquake, by means of Table 3. Considering the difference in the design requirements, the experiences would appear to be similar.

Reference

Yamahara, H., 1969: "The Interrelation between Frequency Characteristics of Ground and Earthquake Damage to Structures," Soils and Foundations, Vol. 10, No. 1, pp. 57-74.

TABLE 1

Earthquake Damage Summary

Name of Earthquake (Location): HIGASHI-MATSUYAMA (TOKYO)
Date of Earthquake: JULY 1, 1968
Building Group Designation
Building Code or Age: Base shear coefficient 0.2
Height Zone: Various
Construction Type: Concrete and Steel

Number of Buildings

			Mercalli Intensity					
General	Detailed	Replacement Cost Ratio	4^-	5	6^+	7	8	9^+
No Damage	0	0			100%			
Light	1 2	.001 .005						
Moderate	3 4	.02 .05						
Heavy	5 6	.10 .30						
Requires Replacement	7 8	1.0 1.0						
TOTAL			at least 100					

The peak ground accelerations in Tokyo ranged from 0.02g to 0.1g. Buildings designed by the Japanese code are approximately 3 times stronger than buildings in California.

TABLE 2

Earthquake Damage Summary

Name of Earthquake (Location): TOKACHI-OKI (HACHINOBE)

Date of Earthquake: MAY 16, 1968

Building Group Designation

Building Code or Age: Base shear coefficient 0.18

Height Zone: 5-6 stories

Construction Type: RC

Number of Buildings

			Mercalli Intensity					
General	Detailed	Replacement / Cost Ratio	4^-	5	6	7	8-9	9^+
No Damage	0	0					20%	
Light	1	.001					40%	
	2	.005					20%	
Moderate	3	.02					20%	
	4	.05						
Heavy	5	.10						
	6	.30						
Requires Replacement	7	1.0						
	8	1.0						
TOTAL		4 to 6						

Intensity in Hachinobe was V on Japanese scale (8^+ on Modified Mercalli scale); peak accelerations were in vicinity of 0.2g. Damage statistics come from informal conversations with Japanese engineers. Buildings designed by the Japanese code are approximately 3 times stronger than buildings designed by the California Code.

TABLE 3

	Higashi-Matsuyama	Tokachi-Oki
Ratio peak ground acceleration to base shear coefficient	0.1 to 0.5	1.0 to 1.4
Corresponding region in Los Angeles	Long Beach, International Airport	Downtown Los Angeles
Damage in corresponding region in Los Angeles (to modern buildings)	None	Light

List of Internal Study Reports

1. R.V. Whitman, "Preliminary Work Plans and Schedules," August, 1971.

2. E.H. Vanmarcke and R.V. Whitman, "Background for Preliminary Expected Future Loss Computations," October, 1971.

3. P.J. Trudeau, "Identification of Typical Soil Profiles in the Boston Basin Area," November, 1971.

4. J.M. Biggs, "Comparison of Wind and Seismic Forces on Tall Buildings," December, 1971.

5. R.V. Whitman, "Contribution to State-of-the Art Report of the Earthquake Committee of the IABSE-ASCE Tall Buildings Committee—Economic and Social Aspects," March, 1972.

6. J.E. Brennan and R.J. McNamara, "Optimum Seismic Protection for New Building Construction in Eastern Metropolitan Areas," April, 1972.

7. C.A. Cornell and H.A. Merz, "Analysis of the Seismic Risk on Firm Ground for Sites in the Central Boston Metropolitan Area," January, 1972.

8. R.V. Whitman, J.W. Reed, P. Marshall, "1967 Caracas Venezuela Earthquake Tall Building Damage Review," May, 1972.