OBSERVATION OF EARTHQUAKE RESPONSE OF REINFORCED CONCRETE WEAK-MODEL STRUCTURES

by

Tsuneo OKADA(I) and Ryoichi TAMURA(II)

SUMMARY

Since August 1983, an earthquake response observation by R/C weak model structures has been carried out at the Chiba Experimental Field Station, Institute of Industrial Science, University of Tokyo. Twenty five sets of acceleration and displacement records were obtained by January 1985. This paper describes the characteristics of the weak model structures, and some results observed in several weak earthquakes.

OUTLINE OF WEAK MODEL STRUCTURES

The structures are five-story building models which are about 1/4 of actural structure. One is a weak column structure, and the other is a weak beam structure. The size of the structures is shown in Fig 1, and column and beam sections are shown in Fig 2. Shown in Fig.3 and Fig.4 are the yield hinge mechanisms and story shear v.s. story displacement obtained by a static nonlinear frame analysis. The story shear coefficient for each story at the yield hinge mechanisms are shown Table 1. The base-shear coefficient at the yield hinge mechanisms is 0.15 for weak column structure and 0.17 for weak beam structure. The maximum story displacements calculated by nonlinear frame analysis to Hachinohe 1968(NS) record, of which the peak acceleration were adjusted to 100 gals and 200 gals, are also shown Fig.4. The design fundamental natural periods were 0.4 sec. for both structures.

I)Professor, Institute of Industrial Science, University of Tokyo.
II)Graduate Student, University of Tokyo.

INSTRUMENTATION AND DATA ACQUISITION SYSTEM

Three-component accelemeters and displacement meters to measure the relative displacements between stories are installed at each floor as shown in Fig.5. Strain gages are also attached on reinforcing bars. All instruments start simultaneously when the accelemeter at 40 meters below the ground surface catches 1.0 gal. All data are recorded in digital recorders and processed by a minicomputer. For a visual record, two moter driving cameras and a camera for VTR are installed for each structure.

OBSERVED EARTHQUAKE RESPONSE

During eighteen months from August in 1983 to January in 1985, twenty five sets of earthquake records have been obtained. Table 2 shows the earthquake records of which intensities were greater than II in JMA scale. The maximum recorded acceleration was 32 gals at the first floor and 166 gals at the top.

The first, and second natural period obtained from Fourier spectra of the recorded acceleration data are shown in Table 3. The record of December 6, in 1983 is the record of free vibration test, and the others are the records of real earthquakes.

The natural periods calculated by the measured concrete Young's modulus (3x10xx5 kg/cm^2) are shown in Table 4. For the weak beam structure, three different values of the effective slab width to increase beam stiffness are considered. Type A is conformed with AIJ codes. For Type B, a whole slab width is considered as effective. The width of Type C is adjusted so that the calculated natural period coincides with the observed one. The observed natural periods of the weak column structure have become longer than the initial values, which suggests that the crackes have occurred.

As an example of the records of earthquake response to the intensity III in JMA scale earthquake of January 1, in 1984 is reported here. The records of X-axis direction of the weak column structure, and Y-axis direction of the weak beam structure are shown. Table 5 shows the the maximum recorded acceleration at each floor and relative displacement between the stories of each structure. The calculated response to the recorded accelerations at first floor are also shown there.

In the case of the weak column structure, the calculated values are larger than the observed values and the opposite for the weak beam structure. Figs.6 and 7 show the recorded accelerations and Fourier spectra at the first and top floor.

CONCLUDENG REMARKS

Earthquake records have been stored up steadily, and the project is progessing smoothly. However, there are some discrepancies between observed values and calculated one, and further invesigation is intended.

REFERENCES

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[4] T.OKADA et al. "Observation of Earthquake Response of Reinforced Concrete Weak Model Building Structures (Part I)", Seisan-Kenkyu (Journal of IIS), Institute of Industrial Science, University of Tokyo, Vol 35, No.9, Sep. 1983.

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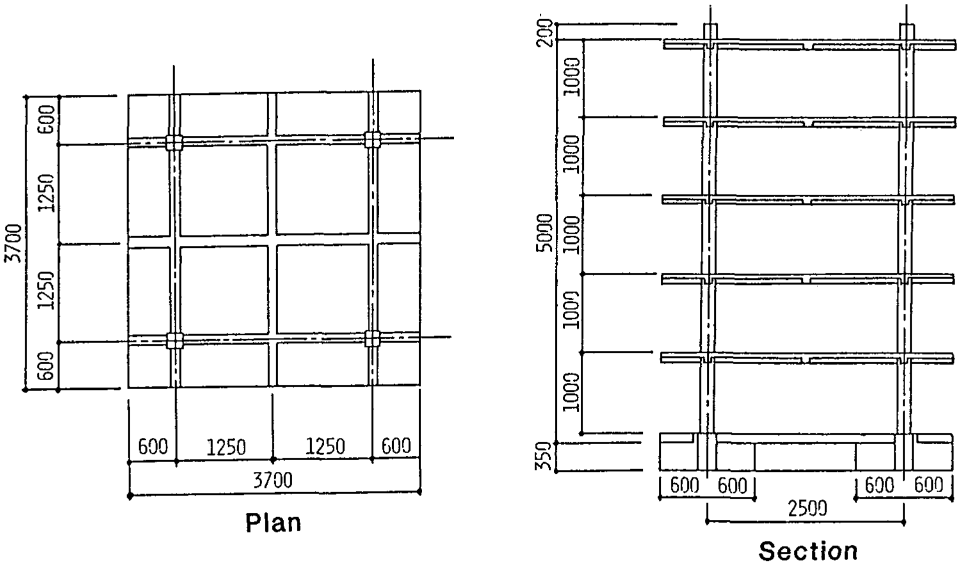


Fig.1 Plan and Section of Weak Model Structures

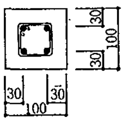
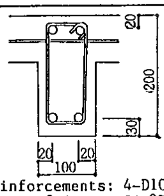
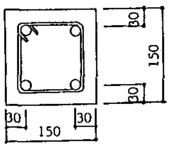
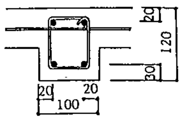
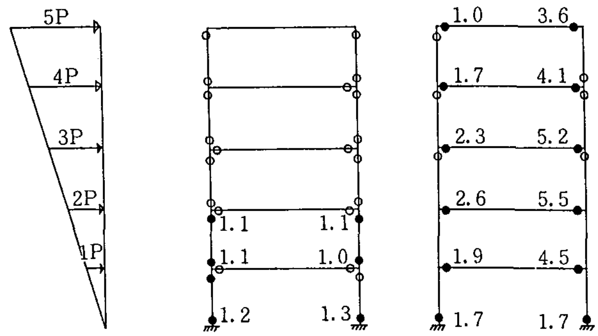
	Column Section	Beam Section
Weak Column Structure	 Reinforcements: 4-D6(SD30) Hoop: 2φ @30(SR24)	 Reinforcements: 4-D10(SD30) Stirrup: 2φ @30(SR24)
Weak Beam Structure	 Reinforcements: 4-D10(SD30) Hoop: 2φ @30(SR24)	 Reinforcements: 4-D6(SD30) Stirrup: 2φ @30(SR24)

Fig.2 Column and Section of Weak Model Stractures



Horizontal Force Weak Column Structure Weak Beam Structure

● : Yield Hinge O : Flexural Crack Numerals : Maximum Member Ductility

Fig.3 Location of Yield Hinges at the Yield Hinge Mechanisms

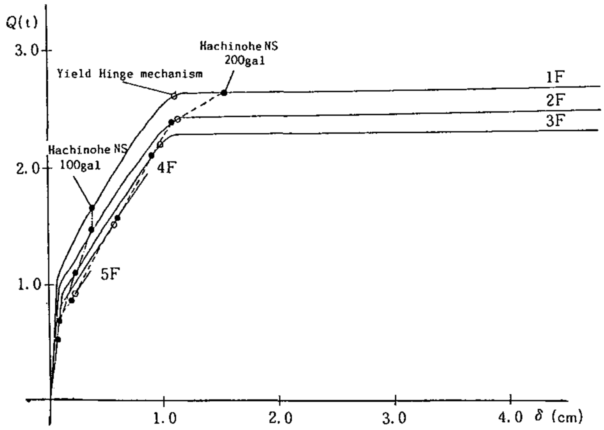


Fig.4-A Story Shear vs. Story Displacement of Weak Column Structure

Table 1-A

Story Shear Coefficient of Weak Column Structure

5F	0.25
4F	0.24
3F	0.20
2F	0.17
1F	0.15

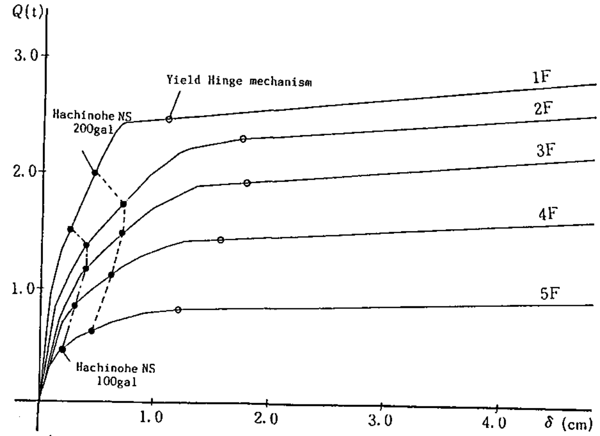


Fig.4-B Story Shear vs. Story Displacement for Weak Beam Structure

Table 1-B

Story Shear Coefficient of Weak Beam Structure

5F	0.30
4F	0.24
3F	0.21
2F	0.19
1F	0.17

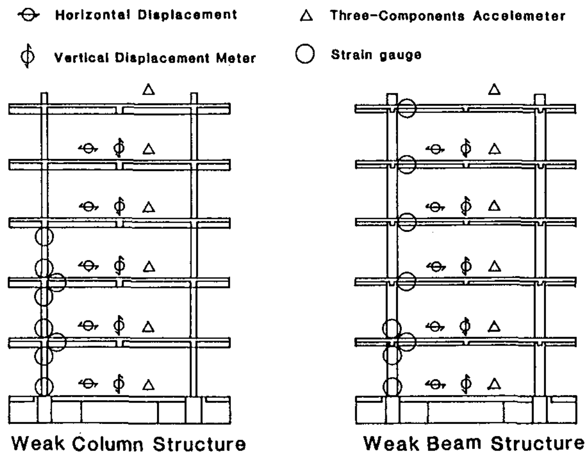


Fig.5 Location of Instruments

Table 2 **Observed Earthquakes**

(Intensity II in JMA Scale or More)

NO	Date	Time	Epicenter	Depth (km)	Epicentural Distance (km)	Magumitude JMA Intensity	Outline of record			
							Type	Direction	Maximum Acceleration 1st Floor	 Top Floor
3	'83. 9. 2	12: 6	36°40' N 141° 1' E	49	142	5.2 II	RC1	X	(8.0)	21.06
								Y	(7.2)	16.18
							RC2	X	4.31	22.49
								Y	4.31	22.49
4	'83. 10.28	10:50	36°13' N 139°59' E	60	67	5.2 III	RC1	X	(12.2)	59.81
								Y	(13.9)	38.76
							RC2	X	11.96	79.43
								Y	13.40	62.69
5	'83. 12.30	11:30	35°13' N 140°43' E	50	55	5.4 III	RC1	X	(11.5)	——
								Y	(15.6)	——
							RC2	X	——	——
								Y	——	——
7	'84. 1. 1	18: 4	33°37' N 136°50' E	388	374	7.3 III	RC1	X	32.45	119.39
								Y	28.00	117.73
							RC2	X	27.35	122.27
								Y	24.42	166.05
8	'84. 1.17	20:14	36°27' N 141°15' E	43	138	5.6 III	RC1	X	15.25	54.81
								Y	16.49	68.90
							RC2	X	14.93	50.09
								Y	13.91	41.57
10	'84. 2.14	1:53	35°35' N 139°5 E	70	93	5.0 II	RC1	X	8.26	29.14
								Y	10.53	31.79
							RC2	X	7.93	34.79
								Y	8.81	30.79
12	'84. 3. 6	11:19	29°28' N 139° 8' E	460	692	7.9 IV	RC1	X	24.00	112.43
								Y	26.17	84.65
							RC2	X	24.75	99.89
								Y	24.42	103.22
14	'84. 4,24	13:13	30°53' N 138°49' E	400		6.7 II	RC1	X	6.51	38.37
								Y	8.58	32.63
							RC2	X	5.80	42.49
								Y	7.79	41.27
17	'84. 5,30	7:58	35°36' N 140°09' E	80		4.4 II	RC1	X	4.14	10.06
								Y	4.99	9.77
							RC2	X	4.37	23.58
								Y	4.93	20.02
19	'84. 9,14	8:49	35°47' N 137°31' E	0		6.8 II	RC1	X	4.61	11.83
								Y	4.16	13.10
							RC2	X	3.83	16.68
								Y	4.35	20.49
20	'84. 9,15	7:15	35°46' N 137°27' E	0		6.2 II	RC1	X	3.19	10.96
								Y	2.21	16.64
							RC2	X	2.53	10.97
								Y	2.38	10.84
24	'84. 12, 7	10:50	35°35' N 140°10' E	74		4.0 II	RC1	X	6.53	——
								Y	3.88	12.21
							RC2	X	6.26	26.54
								Y	4.32	16.13
25	'84. 12,17	23:49	35°38' N 140°03' E	75		4.9 III	RC1	X	29.45	91.55
								Y	28.86	86.99
							RC2	X	18.52	105.60
								Y	20.95	91.32

Notion : RC1 = Weak Column Stracture

RC2 = Weak Beam Stracture

( ) = The Acceieration at GL-1m

Blank = In Preparation

Table 3 **Observed Natural Period**

Weak Column Stracture

(SEC)

	'83. 9. 2	'83.10.28	'83.12. 6	'84. 1. 1
First Natural Period	0.35~0.36	0.37 ~0.39	0.44 ~0.45	0.43 ~0.44
Second Natural Period	0.12	0.12 ~0.13	0.15	0.15 ~0.16

Weak Beam Stracture

(SEC)

	'83. 9. 2	'83.10.28	'83.12. 6	'84. 1. 1
First Natural Period	0.28 ~0.29	0.29	0.30	0.29~0.30
Second Natural Period	0.09	0.09	0.09	0.09

Table 4 **Calculated Natural Period**

Weak Column Stracture

	TYPE A B = 59 cm
First Natural Period	0.34
Second Natural Period	0.11

Weak Beam Stracture

	TYPE A B = 59 cm	TYPE B B = 185 cm	TYPE C B = 117 cm
First Natural Period	0.34	0.25	0.28
Second Natural Period	0.10	0.077	0.083

Table 5-A

Maximum of Response of the Weak Column Structure (Earthquake of Jan.1,1984)

Acceleration (GAL)

	Observation	Calculation
R	117.7	129.0
5	87.9	114.0
4	87.3	89.8
3	77.3	84.2
2	56.6	54.7
1	28.0	28.0

Story Displacement (MM)

	Observation	Calculation
5	0.55	0.32
4	1.25	0.59
3	1.15	0.84
2	0.89	0.90
1	0.77	0.97

Table 5-B

Maximum of Response of the Weak Beam Stracuture (Earthquake of Jan.1,1984)

Acceleration (GAL)

	Observation	Calculation
R	122.3	83.7
5	108.3	72.7
4	89.1	59.8
3	58.6	40.1
2	33.2	26.4
1	27.4	27.4

Story Displacement (MM)

	Observation	Caluculation
5	0.30	0.18
4	0.58	0.31
3	0.75	0.43
2	0.80	0.45
1	0.51	0.27

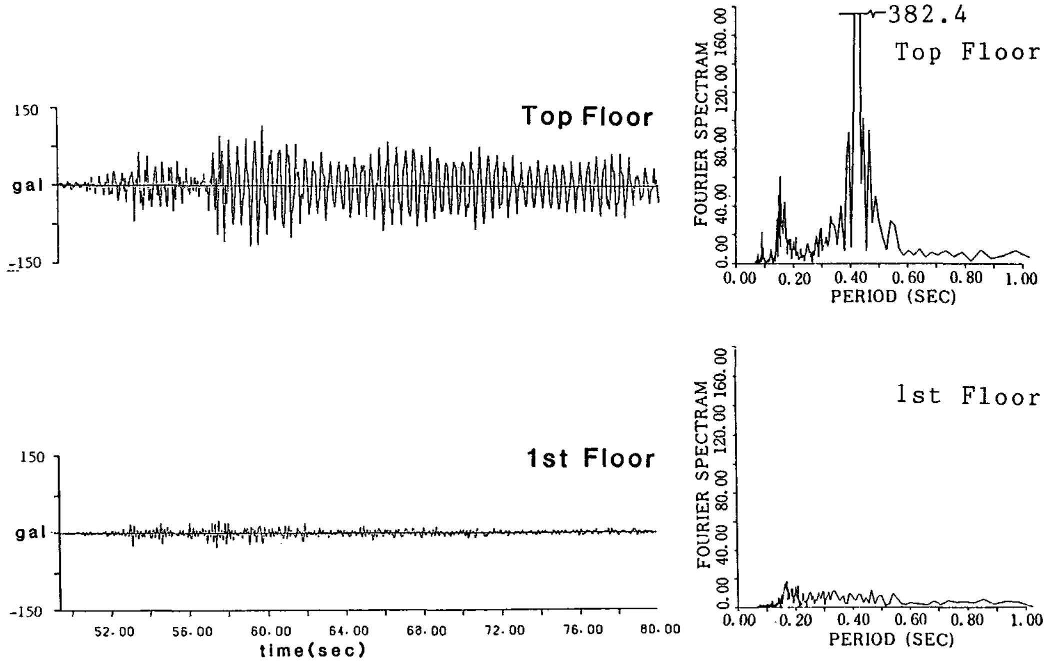


Fig.6 Recoded Time Histories and Fourier Spectra of the Weak column Structure (Earthquake of Jan.1,1984)

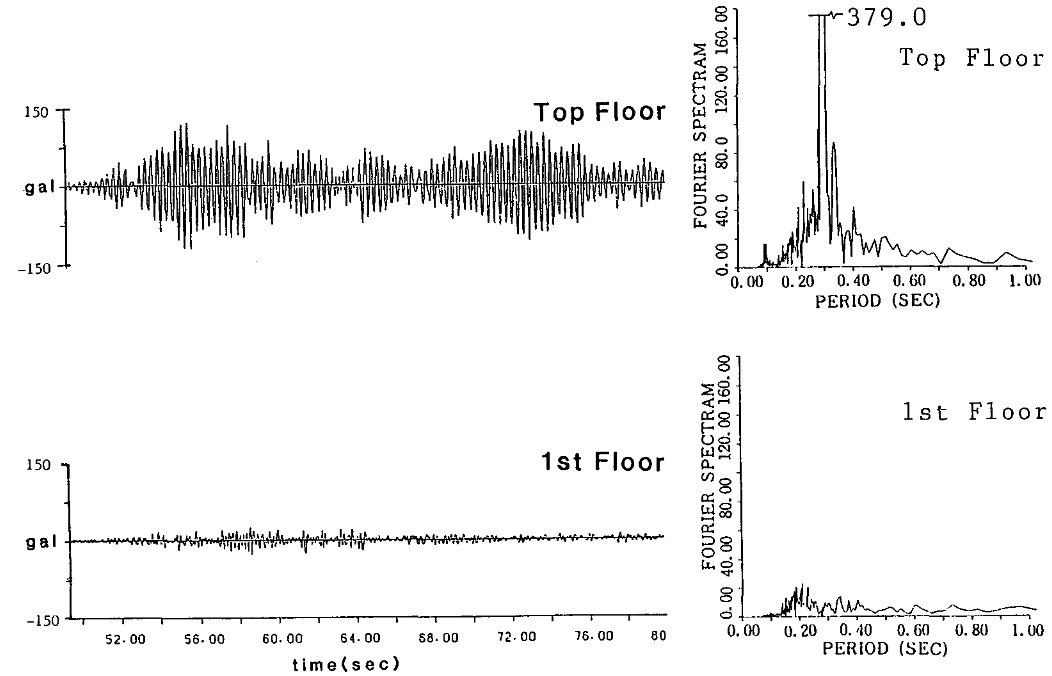


Fig.7 Recoded Time Histories and Fourier Spectra of the Weak Beam Stracture (Earthquake of Jan.1,1984)