EARTHQUAKE RESPONSE OF RC PILOTIS BUILDING SUBJECTED TO OFF MIYAGI PREFECTURE EARTHQUAKE 1978 IN JAPAN

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SUMMARY

A three story, one bay x one bay RC(reinforced concrete) pilotis building that actually suffered a disastrous damage from Off Miyagi Prefecture Earthquake 1978 is chosen as a structural model for numerical calculations. Total 26 ground accelerograms including the Off Miyagi Prefecture Earthquake recorded at Tohoku Univ. 120 Km away from the epicenter were used for response calculations.

Although deformation ability of first story is estimated not more than $40x10^{-3}$rad, response deformation may probably exceed $50x10^{-3}$rad. Consequently, more amount of deformation ability should be provided for first story columns to avoid entire collapse.

INTRODUCTION

When the amount of bearing walls provided for first story is smaller than that for upper story, columns of first story would suffer severely and collapse entirely, that may induce fatal damage for the whole structure. If the building is one bay as well as pilotis type, such a way of failure may take place more easily.

In this paper, a rough estimate of maximum response deformation of first story due to strong ground motion will be obtained in reflection to the properties of Skeleton Curve.

MODEL FOR RESPONSE CALCULATION

Structure Considered. The structure considered in this paper is illustrated in Fig.1. Because first story columns of "A" frame were damaged most severely by the Earthquake shaking in N-S direction, response analysis was made in regard to the structure which consists of "A"-and "B" frames. There are RC walls in second and third story of both "A" and "B" frames. However, not a wall is provided for first story. Therefore, the structure in N-S direction can be thought as a pilotis structure.

The lumped mass system as shown in Fig.2 is adopted. In this model, only first story has nonlinear hysteresis that is illustrated in Fig.3. But upper stories are assumed to remain linear elastic. Viscous damping of 5% of critical is included

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at upper stories. Fig.4 shows first mode shape of this model.

Skeleton Curve. Specific points P_c, P_{y1} and P_{y2} in Fig.3 are determined according to the results of static analysis, outline of that was described in Ref.1. Base shear coefficient C_B of point P_{y2} results in 0.21. Both beginning point P_f and ending point P_u of negative slope are given by refering to the experimental test results. Envelope curves in Fig.5 are examples of such test results(Ref.2).

To examine the effect of skeleton curve, four different skeleton curves are prepared as shown in Fig.6. These are designated as "Ductile","Medium","Brittle" and "Strengthen", respectively. The actual skeleton curve could be estimated to lie between Medium and Brittle models, on comparing experimental data with the properties provided for first story columns listed in Table-1. And still, poor web reinforcement ratio of 0.09% suggests that the deformation ability of these columns is less than 40×10^{-3}rad.

RESPONSE COMPUTATION

Each accelerogram listed in Table-2 is multiplied by a factor to obtain maximum value of 300 gal, since the maximum ground motion is presumed to have been 300 gal at the site.

Maximum response deformations of first story are plotted on each skeleton curve in Fig.6, where numbers accompanied with the plots are the ones alloted to accelerograms individually as shown in the first column of Table-2.

Fig.6 shows that seven accelerograms bring about maximum deformations greater than 40×10^{-3}rad in case of Brittle model. And even in case of Medium model, three accelerograms including the Off Miyagi Prefecture Earthquake (No. 25) bring about those greater than 70×10^{-3}rad. This may indicate a high possibility of entire collapse of the structure considered.

There can be seen no fewer than three plots that are greater than 60×10^{-3}rad on Strengthen model in Fig.6. Thus, aseismic properties of a structure can not be improved only by raising strength from C_B=0.21 to C_B=0.3. While, the plots on Ductile model seem to indicate that if the bearing strength of C_B=0.21 is maintained up to deformation of $40 \sim 50 \times 10^{-3}$rad, response deformation can be reduced to nearly 50×10^{-3}rad, and the possibility of collapse may decrease remarkably.

CONCLUSION

Response calculations are only a few examples, we may conclude that the maximum deformation will be greater than 50×10^{-3}rad. And it is more effective for improving the aseismic properties to increase deformation ability rather than to raise bearing strength.

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REFERENCES

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(2) Building Research Institute, "A List of Experimental Results on Deformation Ability of Reinforced Concrete Columns under Large Deflection (No.3)," Kenchiku Kenkyu Shiryo, No.21, Feb., 1978.

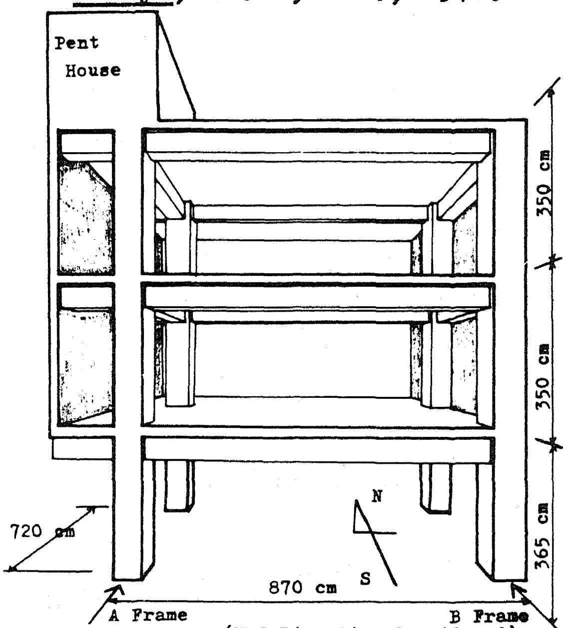


Fig. 1. RC Three Story Pilotis Structure.

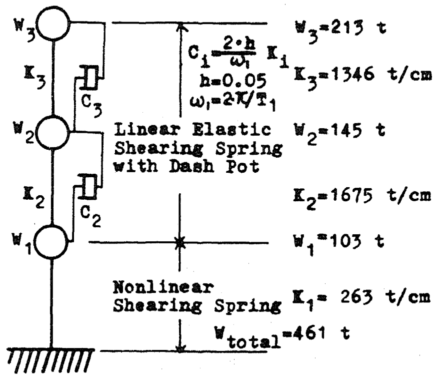


Fig. 2. Lumped Mass System.

Table-1. First Story Column.

Shear Span Ratio=2.23	
Design Concrete Strength	F_c=180 Kg/cm^2
Compression Stress due to Gravity	σ_0=13~40 Kg/cm^2 σ_0/F_c=0.07~0.22
yield Stress of Steel Bar	σ_y=2400 Kg/cm^2
Reinforcement Ratio	p_t=0.35~0.58 %
Web Reinforcement Ratio	p_w=0.09 %

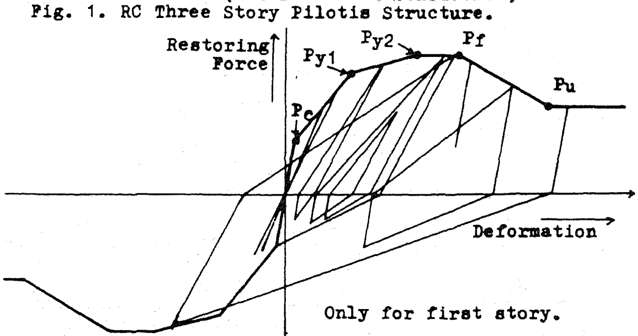


Fig. 3. Model of Restoring Force Characteristics.

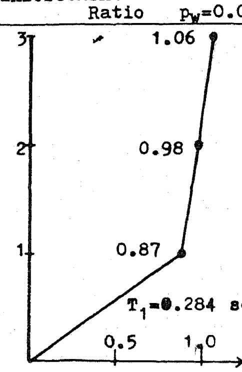


Fig. 4. First Mode Shape..

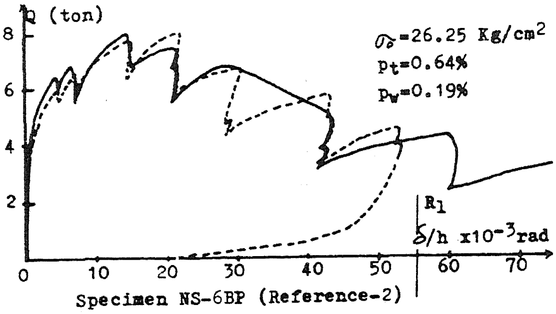
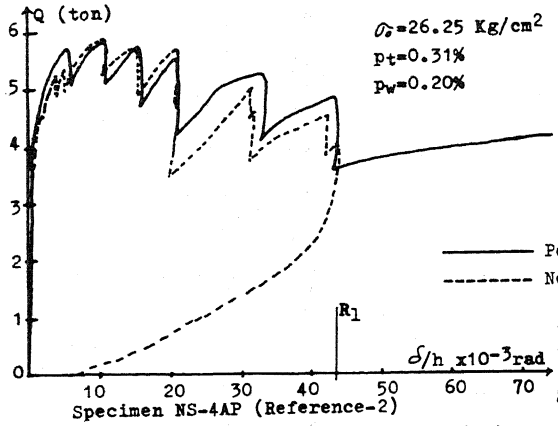


Table-2 EARTHQUAKE LIST

NO.	NAME	DATE	COMP	MAXIMUM gal	DURAT sec
1	AKITA 502	1964JUN.16	NS	90.0	38.0
2	"	"	EW	80.0	38.3
3	IBARAGI 606	1964FEB. 5	NS	40.0	41.0
4	"	"	EW	35.0	39.1
5	NAGOYA 306	1963MAR.27	NS	10.0	17.3
6	"	"	EW	10.0	16.6
7	OHSAKA 206	1963MAR.27	NS	30.0	43.5
8	"	"	EW	25.0	43.4
9	SENDAI 501	1962APL.30	EW	45.0	23.3
10	TOKYO 101	1956FEB.14	NS	74.0	11.4
11	KANAGAWA608	1965JAN.27	NS	20.0	28.6
12	"	"	EW	25.0	28.2
13	HACHINOHE	1968MAY 16	NS	224.9	40.0
14	"	"	EW	182.9	40.0
15	OITA	1975APL.21	NS	45.2	15.0
16	"	"	EW	70.6	15.0
17	EL-CENTRO	1940MAY 18	NS	319.5	29.3
18	"	"	EW	222.5	29.7
19	TAFT	1952JUL.21	NS	174.4	30.0
20	"	"	EW	154.8	29.9
21	OLYMPIA	1949APL.13	NS	184.2	30.3
22	"	"	EW	318.5	29.9
23	ROMANIA	1977MAR. 4	NS	194.9	40.1
24	"	"	EW	163.1	40.1
25	TOHOKU UNIV.	1978JUN.12	NS	258.0	40.9
26	"	"	EW	202.7	40.9



R1 ;Critical Deflection defined in Ref. 2, A limit of deformation ability.

——— Positive Region.
-------- Negative Region.

Section BxD =25x25 cm
Concrete Strength F_c =137 Kg/cm^2
Shear Span Ratio M/QD =2.0
Axial Stress σ_0 = N/B·D =26.25 Kg/cm^2

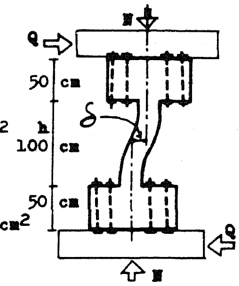


Fig. 5. Envelope Curves of RC Columns in Large Deflection. (Ref. 2)

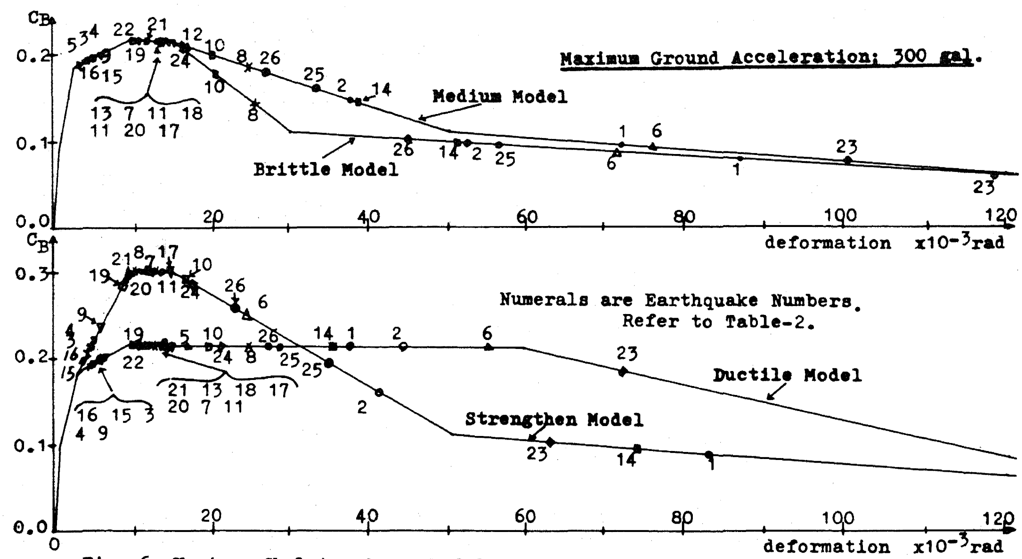


Fig. 6. Various Skeleton Curve Models and Maximum Response Deformation.