STUDY on the Structural Principle of the Flexural Deformation Response Control System and its Practical Use

S05: JAEE Special Session
S05-02:
Spectacular Projects of Passively-Controlled Buildings

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1. INTRODUCTION

The newly developed “Super RC Frame” structure system, outlined in Figure 1, can provide column-free, beam-less residential spaces, and allows enough architectural flexibility in plan layout. This paper describes the principle of this unique control technique for a flexural structure, and demonstrates an application example in practical use.

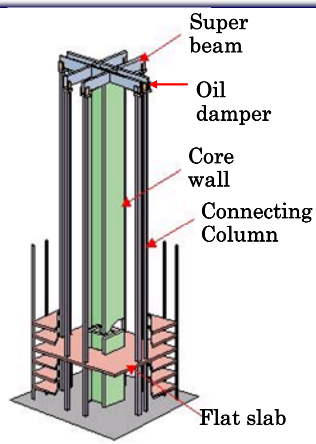
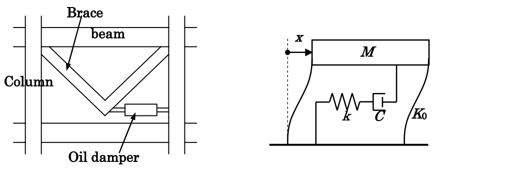


Fig.1 Concept of the flexural deformation response control system

2. BASIC CHARACTERISTICS OF FLEXURAL DEFORMATION RESPONSE CONTROL SYSTEM

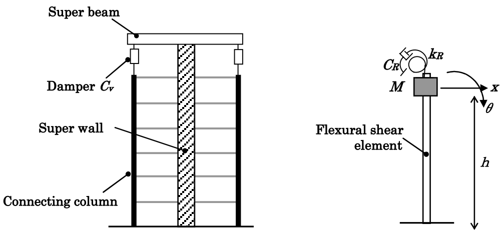
Fundamental dynamic characteristics of a conventional response controlled structure equipped with a damper at each story are expressed by the three elements Maxwell model as shown in Figure 2. In this structural system, it is well known that there is an optimum value for damper’s parameter, and the maximum control effect is determined by the stiffness condition.

Next, consider the structure installed with the damper to control the rotational deformation shown in Figure 3. The mathematical model of the structure where damper is settled vertically between a super beam and a connecting column is shown by Maxwell model which can only resist against rotational freedom. A damping coefficient C_R of the rotational dash-pot depends on a damping coefficient C_v of the damper settled vertically and a radius of gyration. It is same for rotational spring k_R.



(a) Placing of damper (b) Three element Maxwell vibration model

Fig.2 Structural model of response control damper system settled in inter-story



(a) Placing model of damper (b) Flexural shear model

Fig.3 Flexural deformation response control

Separating the only structural lateral stiffness K_0 and additional △k, the lateral complex stiffness K^* with oil damper is expressed below.

$$K^* = K_0 + \Delta k = \left(r - \frac{u^2}{s} \right) + \Delta k$$

, here r, u and s depend on a structural system (section property).

Developing and translating this additional stiffness △k, △k is expressed below.

$$\Delta k = \frac{u^2}{s} - \frac{u^2}{s + \dfrac{k_R C_R pi}{k_R + C_R pi}} = \frac{\dfrac{u^2}{s(s+k_R)} k_R \dfrac{u^2}{s^2} C_R pi}{\dfrac{u^2}{s(s+k_R)} k_R + \dfrac{u^2}{s^2} C_R pi}$$

Where $\frac{u^2}{s(s+k_R)} k_R = \tilde{k}$ $\quad \frac{u^2}{s^2} C_R = \tilde{C}$ △k could be expressed $\Delta k = \dfrac{\tilde{k}\tilde{C}pi}{\tilde{k} + \tilde{C}pi}$.

So, this equation corresponds to the Maxwell model.

Therefore a flexural deformation response control structure corresponds strictly to a three elements Maxwell model and all the results obtained from the study based on the ordinary response controlled structure installed with the damper at inter-story can be applicable.

3. PPRACTICAL USE OF THE FLEXURAL DEFORMATION RESPONSE CONTROL SYSTEM

By applying these above mentioned knowledge to the practical building, being proper and useful is verified. An example of such application is showed below.

Building Outline:	
- Location:	Kanda Chiyoda-ku, Tokyo
- Designed by:	Kajima Corporation, Architectural and Engineering Design Group
- Type of occupancy:	Apartment houses, stores
- Site area:	3,045,43 ㎡
- Building area:	1,065,28 ㎡
- Gross floor area:	39,518,61 ㎡
- No. of stories:	40 stories, 1 basement levels
- Building height:	136,7m
- Construction period:	June 2002－August 2004
Structural Outline	
- Type:	Reinforced Concrete
- System:	Super RC Frame
- Foundation:	Concrete drilled piers with belled bottom

Fig.4 Building Perspective

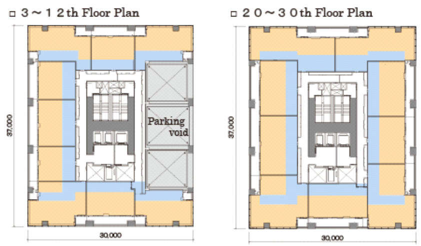


Fig. 5 Typical Floor Plan

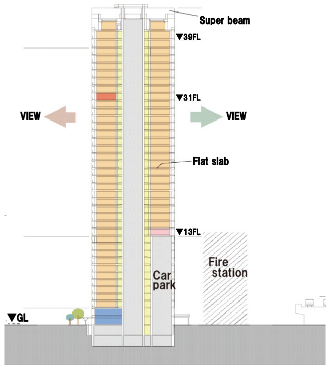


Fig.6 Building Section

Fig.7 Inner Space under Construction