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Autor: Aizawa, S. / Nagashima, T. / Higashibata, Y.

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Elastic-Plastic Analysis of Three Dimensional Buildings, with Substructure Method

S. AIZAWA, T. NAGASHIMA, Y. HIGASHIBATA,
J. IMAMIYA, Y. HAYAMIZU, I. YAMAGUCHI
Takenaka Komuten Co. Ltd.
Tokyo, Japan

The authors developed the pseudo-three-dimensional elastic-plastic analysis program using substructure-method, as practical analysis method to obtain the horisontal ultimate strength of a building and the stiffness for dynamic analysis.

Frames interconnected by floor diaphrams which are rigid in their own plane are considered as substructures in the basic formulation. And the three-dimensional effect of a building was adopted as the following taking the practicability into account.

1) The geometrical horizontal position of each plane frame in the floor is considered, the plane frame-matrix is converted into the global coordinate system, the stiffness matrix of the whole building is drawn up and the horizontal rotation-stiffness considering the eccentricity of the rigidity against the center of gravity is drawn up.

2) The plane frame-matrix is condensed leaving the vertical degree of freedom of the joint designated as external degree of freedom, when drawing up the total stiffness matrix, the constrained effect of straight crossed frame is considered by making coincide as common vertical degree of freedom of mutual frames.

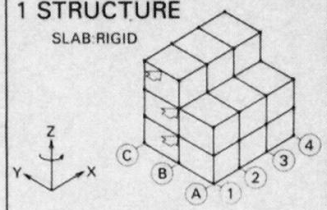
The elastic-plastic judgments are carried out at the member level, and the elastic-plastic elements of each member are as follows. The bending and shearing element has rigid-plastic rotational springs in both ends, and the central part consists of beam models of bending = elasticity and shearing = elastic plasticity. The rotational spring part is condensed when the element matrix is piled up to the plane frame-matrix. Each restoring force model of bending and shearing adopts in principle the tri-linear type, the bending buckling can be considered, the M-N correlation is considered in the column model, and axial elements adopts the bi-linear model considering buckling. As hysterical characteristics of each element, normal, degrading and slip models are provided. In order to confirm the adaptability of this program, the analysis of static force experimental model of (1) RC plane frame (3 layers, 3 spans, H x L = 1.8 x 3 m), (2) RC three-dimensional frame(3 layers, 3 x 2 spans, H x L x W = 1.32 x 2.25 x 1.5 m) including the anti-seismic wall. The experimental result and the analytic result of every models corresponded well, and especially in the model of (2) the effect of the pseudo-three-dimensional analysis was well expressed.

NONLINEAR ANALYSIS OF THREE DIMENSIONAL BUILDINGS

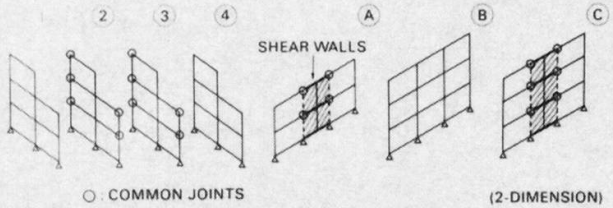
The authors developed the pseudo—three—dimensional elastic—plastic analysis program using substructure—method, as practical analysis method to obtain the horizontal ultimate strength of a building and the stiffness for dynamic analysis.
Analytical flow is:
1 →2 →3 →4 →5 →6
5←

THE OUTLINE OF ANALYSIS PROGRAM

1 STRUCTURE

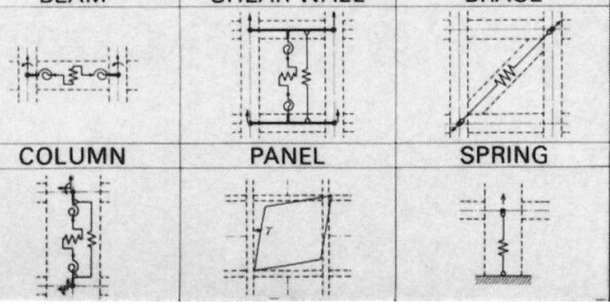


2 DECOMPOSITION



3 ANALYTICAL MODEL FOR MEMBERS

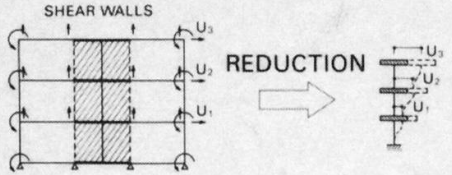
BEAM	SHEAR WALL	BRACE
COLUMN	PANEL	SPRING



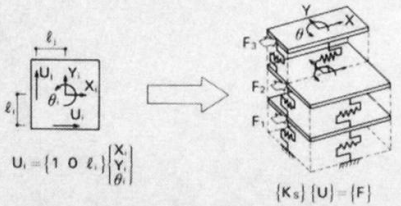
4 NONLINEAR ELEMENTS

ELEMENT	CHARACTER		
θ_i θ'_i $\tau = \theta_i - \theta'_i$	M_i τ	M_i τ	M_i τ
V_i θ_i	M_i θ	Q_i γ	Q_i γ
U_i U_j	N_i ε	N_i ε	N_i ε

5 A PLANE FRAME SUBSTRUCTURE



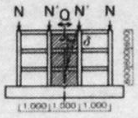
6 ASSEMBLY AND SOLUTION OF OVERALL STRUCTURE



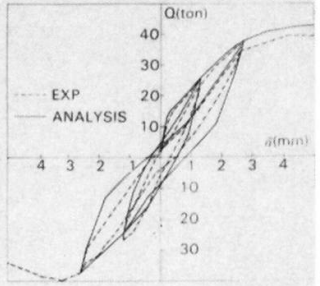
COMPARISON WITH EXPERIMENTAL RESULTS

UNIT :

•3-STORY REINFORCED CONCRETE PLANE FRAME-WALL STRUCTURE MODEL



COLUMN
WALL
σ_0 = 20kg/cm²

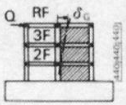


	BEAM	COLUMN	WALL
REINF.	TOP 3-D13 BOT. 3-D13	6-D13	H. & V. 5φ@150
b×D	120×150	200×150	t 50

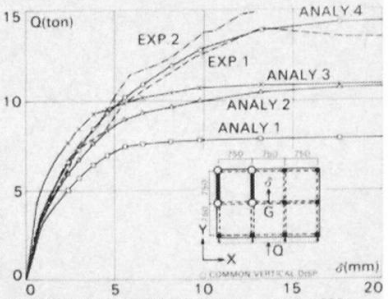
F_c = 275kg/cm² σ_y D13:3840kg/cm²
5φ:4050kg/cm²

•3-STORY REINFORCED CONCRETE 3-D FRAME-WALL STRUCTURE WITH ECCENTRICITY*1

	BEAM(X)	BEAM(Y)	COLUMN	WALL	SLAB	
REINF.	TOP 2-D6 BOT. 2-D6	TOP 2-D6 BOT. 2-D6	4-D6	H. & V. 2.2φ@35	RF t 90	TOP 4φ@55 BOT. 3.2φ@55
b×D	55×90	55×80	80×80	t 25	2.3F t 20	2.2φ@55



F_c = 302 ~ 361kg/cm²
σ_y D-6:2579kg/cm²
2.2φ:2676kg/cm²



ANALYTICAL ASSUMPTIONS

No	CONSIDERATION	SLAB DISP.
1	Y-Di. FRAMES	Y
2	Y-Di. FRAMES	Y & Rotation
3	X & Y FRAMES	Y & Rotation
4	X & Y FRAMES COMMON JOINTS	Y & Rotation

*1 J. ONOSE et all. TOHOKU TECHNICAL INST. REPORTS OF THE ANNUAL MEETING OF A.I.J. 1982