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POSTER SESSION 3

Computer-Aided Structural Engineering

Génie des structures assisté par ordinateur

Computergestützter konstruktiver Ingenieurbau

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

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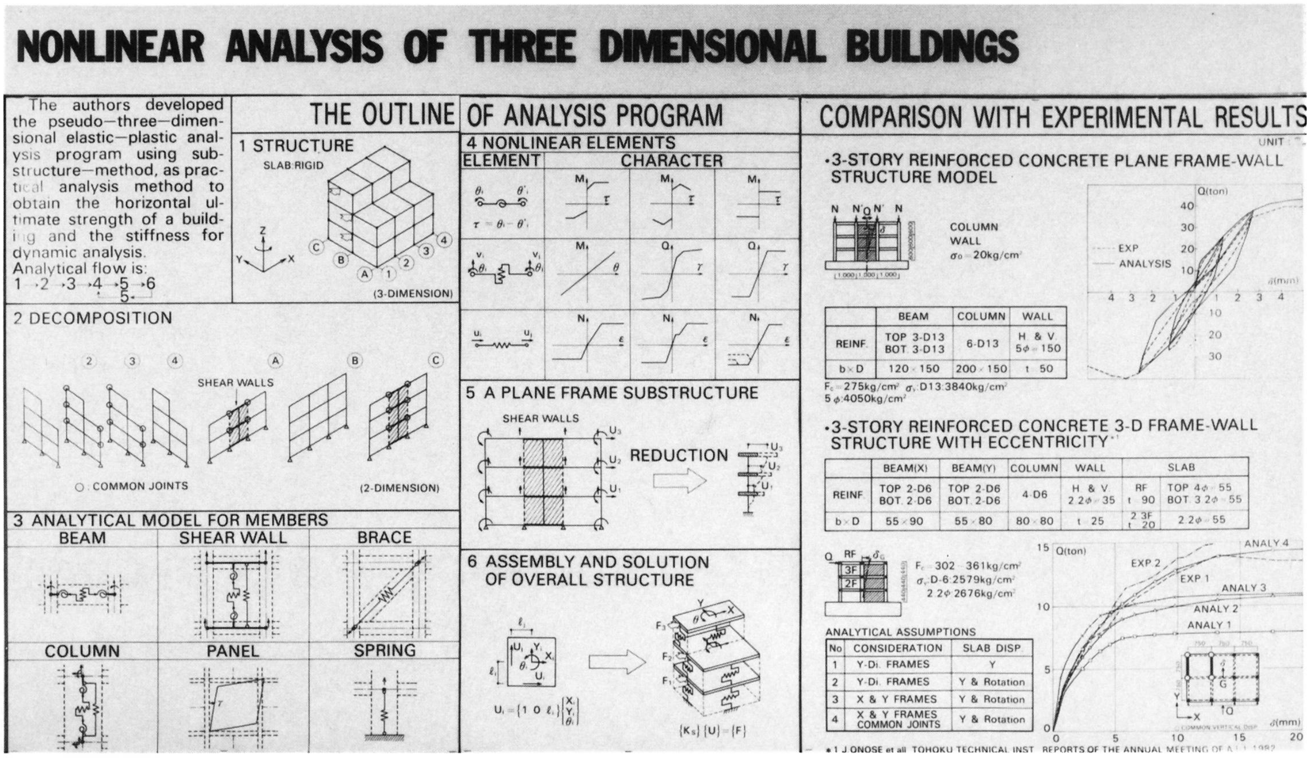
The authors developed the pseudo-three-dimensional elastic-plastic analysis program using substructure-method, as practical analysis method to obtain the horisontal ultimate strength of a building and the stiffness for dynamic analysis.

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
THE OUTLINE OF ANALYSIS PROGRAM
1 STRUCTURE
SLAB:RIGID
(3-DIMENSION)
2 DECOMPOSITION
SHEAR WALLS
○: COMMON JOINTS
(2-DIMENSION)
3 ANALYTICAL MODEL FOR MEMBERS
BEAM
SHEAR WALL
BRACE
COLUMN
PANEL
SPRING
4 NONLINEAR ELEMENTS
ELEMENT
CHARACTER
5 A PLANE FRAME SUBSTRUCTURE
SHEAR WALLS
REDUCTION
6 ASSEMBLY AND SOLUTION OF OVERALL STRUCTURE
{Ks} {U} = {F}
COMPARISON WITH EXPERIMENTAL RESULTS
•3-STORY REINFORCED CONCRETE PLANE FRAME-WALL STRUCTURE MODEL
COLUMN
WALL
σ0 = 20kg/cm²
EXP
ANALYSIS
Q(ton)
δ(mm)
BEAM
COLUMN
WALL
REINF.
TOP 3-D13
BOT. 3-D13
6-D13
H & V.
5φ @ 150
b×D
120×150
200×150
t 50
Fc = 275kg/cm² σy: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
Fc = 302 ~ 361kg/cm²
σy: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
Q(ton)
EXP.2
EXP.1
ANALY.4
ANALY.3
ANALY.2
ANALY.1
δ(mm)
*1 J.ONOSE et all TOHOKU TECHNICAL INST. REPORTS OF THE ANNUAL MEETING OF A.I.J. 1982

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COMPOUND STRIP ANALYSIS OF SLAB-GIRDER BRIDGES

COMPOUND STRIP - THE MECHANICS

The strain energy of the strip, including plate and attached beams and columns, is expressed in terms w(x,y) and minimized with respect to the displacements associated with the strip, Δ . This minimization gives a strip stiffness matrix for the compound strip which includes axial and flexural stiffnesses of the columns, flexural and torsional stiffness of the beams, and the stiffness of the plate. The strip stiffness matrices are combined in the conventional manner to form the global stiffness matrix. The half bandwidth of the stiffness matrix is small, which reduces the computation effort required to determine state variables which establish displacements and actions.

STRIP DISPLACEMENT FUNCTION

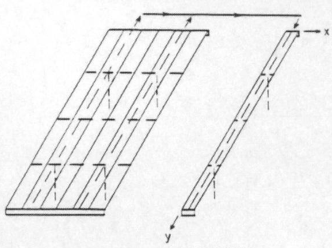
$$w(x,y) = \sum_{m=1}^{\infty} Y_m X_m = \sum_{m=1}^{\infty} Y_m [C] \{\Delta_m\}$$

$$Y_m = \sin\left(\frac{m \pi y}{\ell}\right)$$

C = a row vector containing third order Hermitian polynomials in x .

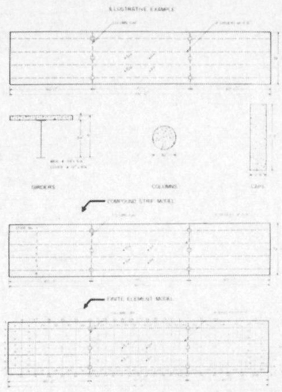
m = a column vector containing four displacements per mode m.

CSM IDEALIZATION

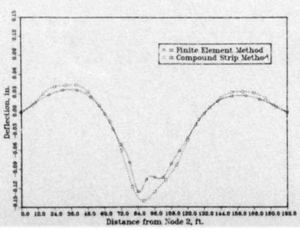


ANALYSIS SUMMARY

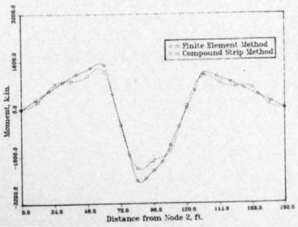
	FEM	CSM
Maximum Deflection, in.	0.126	0.128
Maximum Support Reaction, kip.	30.1	32.2
Maximum Girder Moment, kin.	-2430 1500	-2000 1270



Deflection Between Nodes 2 & 218



Girder Moment Between Nodes 2 & 218



Transverse Moment Between Nodes 91 & 99