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INFLUENCE OF THE DISCONTINUITY ALONG THE HEIGHT OF MULTISTORY FRAMES ON THEIR DYNAMIC AND SEISMIC RESPONSE

P a r t A:

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S u m m a r y

The addition of panels to some parts of the load carrying system, generates a discontinuity which, in the case of earthquake, influences the resulting forces of the members adjoining the locations of these discontinuities. The present study consists in the determination of the dynamical characteristics and the computation of the probable maximum seismic forces of the members of a typical midframe of 26-story symmetrical building. This frame is named as "basic frame". With the addition of panel elements to distinguished parts of the basic frame, 31 cases of frames, fromed thus, have been examined. The modal superposition method has been used for an envelop response spectrum of simulated seismic strong motions for the Athenian bed rock. In the determination of the stiffness matrix besides bending, also shearing deformations are included for the beams, while shearing and axial deformations are included for the columns. The results of the study are schematically presented as ratios of the member forces of the different frames to the "basic frame". This ratios for the studied cases, may reach the value of 240%.

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§1. Introduction.

During the construction of buildings it may happen to place in one or more parts of load carrying system,some additional panels which may be either out of reinforced or not concrete,or out of reinforced or not brickwall. It may also happen to take away some parts of a bigger panel. The abovesaid addition or substruction of stiffening elements generates a discontinuity to the load carrying system. This discontinuities,for several reasons,may not be considered into the design of the original structure either due to the calculation which becomes intricated,or because the panels have been added afterwards and are considered as being of "minor importance".

Many damages have been observed as in Fig.1 is shown,due to the addition of panels in the front. This picture shows a typical damage patern after the Tokachi-oki earthquake of 16 May 1968 in Japan,at modern seismic structures.

In the present paper the first only part of the study is given which consists in the addition to the "basic frame" of panels only. These panels occupy unique openings which are defined between two columns and are extended to two adjacent stories. The dimensions of the members of the "basic frame" are shown in Fig.2b.

Four kinds of frames have been distinguished,according to the location of panel elements. Thus,the "first frame" is a frame identical to the "basic" one,with a difference relying on the addition of panels in the first and second stories,see Fig.4. The "second frame" is a frame identical to the "basic" one to which panels have been added to the 7th and 8th stories,see Fig.5. The "third frame" is formed by the addition of panels to 16th and 17th stories of the "basic frame",see Fig.6. For the "fourth frame",panels have been added to the 23d and 24th stories of the "basic frame",see Fig.7. Each one of these kinds of frames comprises three types,according to the extent of the panels, see Fig. 4,5,6.

§2. The Theoretical Background.

A lumped mass model is used,the seismic response of which is given [1], [2]* after the solution of the system:

$$[m]\{\ddot{v}(t)\} + [c]\{\dot{v}(t)\} + [K]\{v(t)\} = -\ddot{y}_o(t)\{m\} \qquad (1)$$

By the application of a linear transformation to normal coordinates the solution of the system (1) is given by the sum:

$$v_i(t) = \sum_{r=1}^{n} \Delta_{ir}\psi_r\gamma_r(t) \qquad (2)$$

where:

$\psi_r = \sum_{i=1}^{n} \Delta_{ir}m_i$ is the participation factor of the r mode

Δ_{ir} the r normal mode and

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* Numbers in brackets correspond to the reference at the end of the paper.

$\gamma_r(t)$ time depended variable, solution of the equation:

$$\{\ddot{\gamma}(t)\} + \left[2\zeta\omega\right]\{\dot{\gamma}(t)\} + \left[\omega^2\right]\{\gamma(t)\} = -\ddot{y}_o(t) \qquad (3)$$

The probable maximum dynamic translations of the multistory structure is given [2] by the relation:

$$\max v_i(t) = \sqrt{\sum_{r=1}^{n}\left(\Delta_{ir}\psi_r \max\gamma_r(t)\right)^2} = \sqrt{\sum_{r=1}^{n}\left(\max v_{ir}(t)\right)^2} \qquad (4)$$

while for the probable maximum member forces yield the expresions:

$$\max Q_i(t) = \sqrt{\sum_{r=1}^{n}\left(\max Q_{ir}(t)\right)^2} \quad \text{and} \quad \max M_i(t) = \sqrt{\sum_{r=1}^{n}\left(\max M_{ir}(t)\right)^2} \qquad (5),(6)$$

where, according to the nomenclature at [2], $\max Q_{ir}$ and $\max M_{ir}$ are the maximum shear and moment of the r mode.

A probable envelope of Greek response spectra for adamping ratio ζ = 5% has been used as shown in Fig.8, corresponding to a base shear coefficient ε = 0.10, after table I of [2]. In the determination of the stiffness matrix [K] in the computer program, bending and shearing deformations have been included for beams, while bending, shearing and axial deformations have been included for columns, as is given in [3] and [4].

§3. The Results of the Study.

The first three eigenperiods of the basic frame are equal to: T_1=1.82sec, T_2=0.667sec, T_3=0.397sec, while the addition of the panels, as it has been done here, does not change these values remarkably, see Fig.9.

The knots of the normal modes has been observed that remove from the places where panels have been added, as is shown in Fig.9.

As far as the horizontal translations concern, the addition of panels reduces them in general, and this reduction is higher for the addition of panels in the down part of the frame.

For the columns, the most substantial irregularity appears at the inside ones, where their moments and shear forces may be up to 240% higher than that of the basic frame.

After 4 or 5 stories the disturbance due to the addition of panels damps out, and the member forces stay a little bit less than that of the basic frame.

References

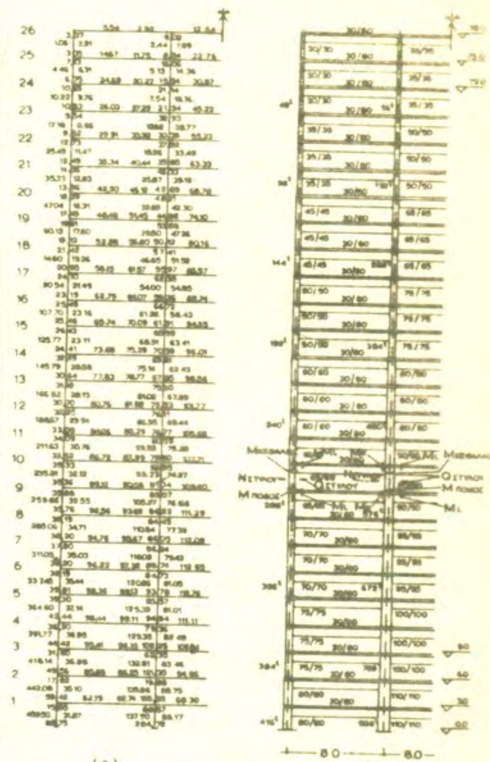
[1] Kokinopoulos E.F. in collaboration with Carydis P.G.: "Multidegree Plane Elastic Structures under the Action of Horizontal Seismic and other Dynamic Excitations", Scientific Public.of National Technical University, No 23, Athens,1972.

[2] Kokinopoulos F.E., Carydis P.G.: "Proposal for a Dynamic Aseismic Design of Multidegree Systems", Athens 1973.

[3] Beaufait F.W., Rowan Jr.W.H., Hoadley P.G., Hackett R.M.: "Computer Methods of Structural Analysis", Prentice-Hall Inc., 1970.

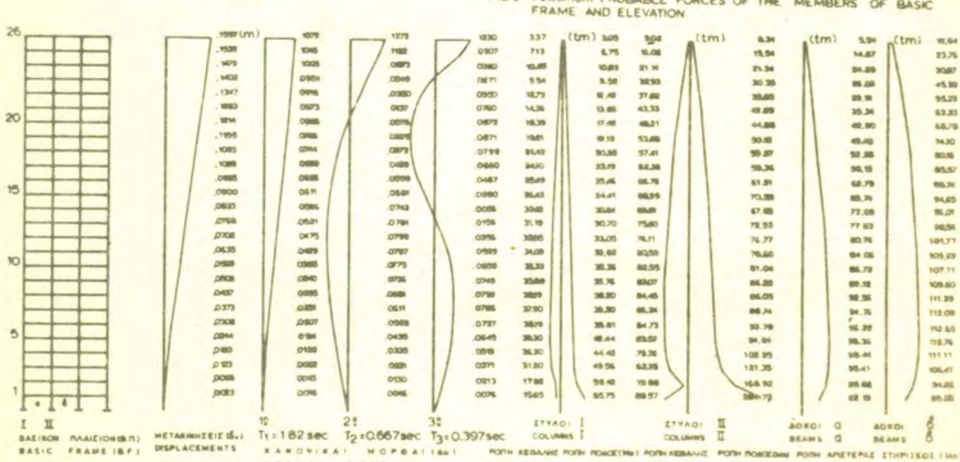
[4] Weaver Jr.W.: "Computer Programs for Structural Analysis", Van Nostrand, 1967.

Σχ. 1
Fig.1

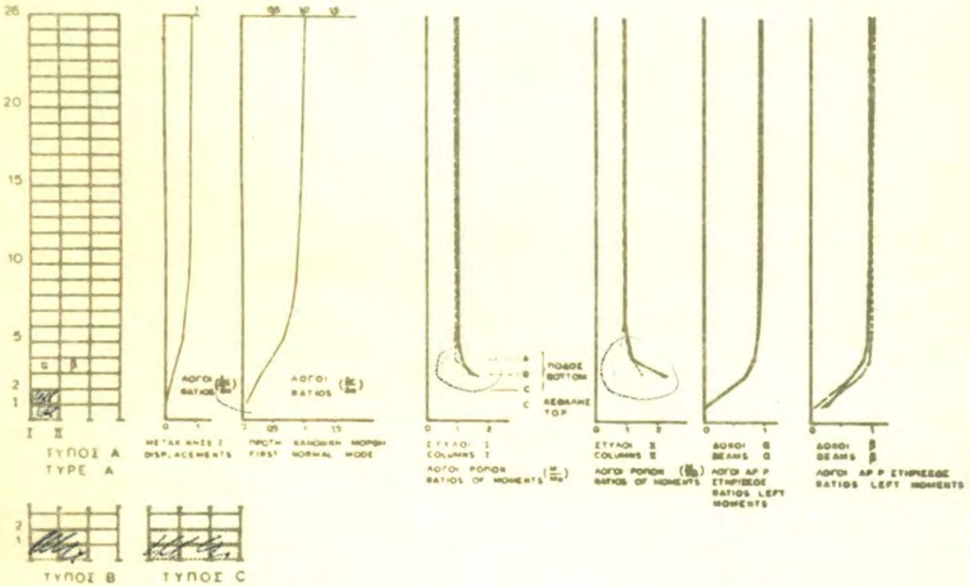


(a) (b)

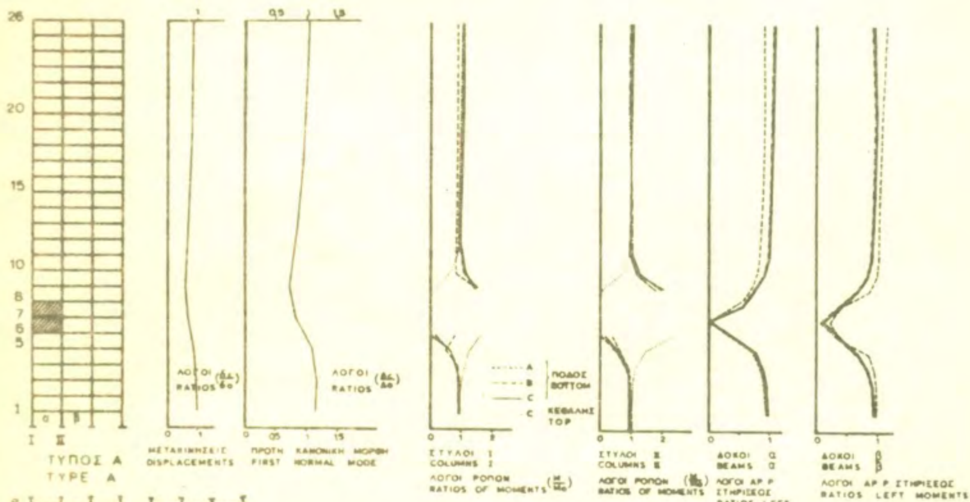
ΣΧ 2 ΜΕΓΙΣΤΗ ΠΙΘΑΝΗ ΕΝΤΑΣΙΣ ΚΑΙ ΤΟΜΗ ΒΑΣΙΚΟΥ ΠΛΑΙΣΙΟΥ
FIG 2 MAXIMUM PROBABLE FORCES OF THE MEMBERS OF BASIC FRAME AND ELEVATION



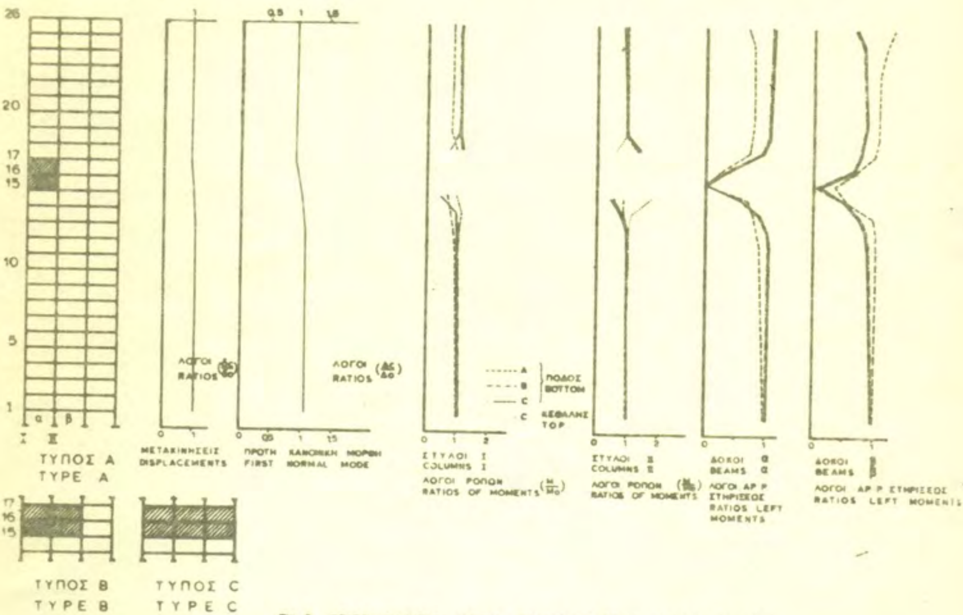
ΣΧ 3 ΒΑΣΙΚΟ ΠΛΑΙΣΙΟ ΚΑΝΟΝΙΚΑΙ ΜΟΡΦΑΙ, ΜΕΤΑΚΙΝΗΣΕΙΣ ΚΑΙ ΕΝΤΑΣΙΣ
FIG.3 BASIC FRAME NORMAL MODES, DISPLACEMENTS AND MEMBER FORCES



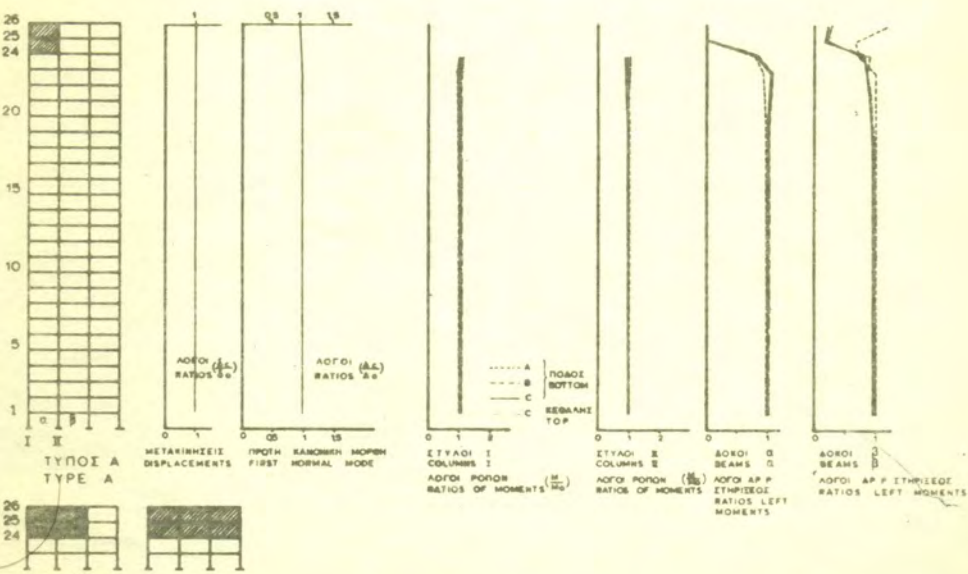
ΣΧ 4 ΠΡΩΤΟ ΠΛΑΙΣΙΟ ΛΟΓΟΙ ΕΝΤΑΣΕΩΣ ΠΡΟΣ ΒΑΣΙΚΟ ΠΛΑΙΣΙΟ.
FIG 4 FIRST FRAME RATIOS OF MEMBER FORCES TO THE BASIC FRAME.



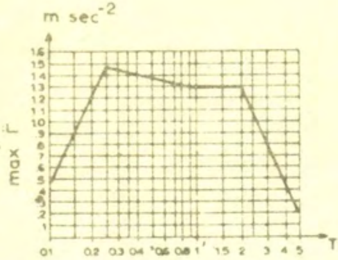
ΣΧ 5 ΔΕΥΤΕΡΟ ΠΛΑΙΣΙΟ ΛΟΓΟΙ ΕΝΤΑΣΕΩΣ ΠΡΟΣ ΒΑΣΙΚΟ ΠΛΑΙΣΙΟ
FIG 5 SECOND FRAME RATIOS OF MEMBER FORCES TO THE BASIC FRAME



ΣΧ 6 ΤΡΙΤΟ ΠΛΑΙΣΙΟ ΛΟΓΟΙ ΕΝΤΑΣΕΩΣ ΠΡΟΣ ΒΑΣΙΚΟ ΠΛΑΙΣΙΟ.
FIG.6 THIRD FRAME RATIOS OF MEMBER FORCES TO THE BASIC FRAME



ΣΧ 7 ΤΕΤΑΡΤΟ ΠΛΑΙΣΙΟ ΛΟΓΟΙ ΕΝΤΑΣΕΩΣ ΠΡΟΣ ΒΑΣΙΚΟ ΠΛΑΙΣΙΟ
FIG.7 FOURTH FRAME RATIOS OF MEMBER FORCES TO THE BASIC FRAME



ΣΧ 8 ΦΑΣΜΑ ΟΛΙΚΩΝ ΕΠΙΤΑΧΥΝΣΕΩΝ.
FIG 8 THE ABSOLUTE ACCELERATION RESPONSE SPECTRUM

ΣΧ 9 ΛΟΓΟΣ ΙΔΙΟΠΕΡΙΟΔΩΝ λ = T_0/T ΚΑΙ ΘΕΣΙΣ ΤΩΝ ΚΟΜΒΩΝ ΤΩΝ ΚΑΝΟΝΙΚΩΝ ΜΟΡΦΩΝ
FIG 9 RATIO OF EIGENPERIODS $\lambda = T_0/T$ AND LOCATION OF THE KNOTS OF NORMAL MODES