Interaction between panel buildings and the soil

Autor(en): **Kaliszky, S.**

Objekttyp: **Article**

Zeitschrift: **IABSE congress report = Rapport du congrès AIPC = IVBH Kongressbericht**

Band (Jahr): **11 (1980)**

PDF erstellt am: **26.05.2024**

Persistenter Link: https://doi.org/10.5169/seals-11415

XI

Interaction between Panel Buildings and the Soil

Influence réciproque de bâtiments en panneaux préfabriqués et du sol

Wechselwirkung zwischen vorfabrizierten Grosstafelgebäuden und Boden

S. KALISZKY
Professor, Dr.
Technical University
Budapest, Hungary

SUMMARY
Simple discrete models are presented which are suitable for the unified analysis of systems composed of prefabricated large panel buildings and the soil. Another method takes the simultaneous development of the structure and the dead load during construction into consideration.

RESUME
L'auteur présente de simples modèles discrets aptes au calcul intégré de bâtiments en grands panneaux préfabriqués et du sol. Une autre méthode considère l'évolution de la structure et de son poids propre pendant la construction.

ZUSAMMENFASSUNG
Es werden einfache, diskrete Modelle aufgeführt, die für die gekoppelte Berechnung von aus vorgefertigten Grosstafelelementen ausgebildeten Gebäuden und dem Baugrundverhalten geeignet sind. Eine andere Methode zieht das gleichzeitige Entstehen des Tragwerkes und der Baugrundbelastung während der Erstellung des Gebäudes in Betracht.

1. INTRODUCTION

Recently, at the Technical University of Budapest theoretical research has been carried out in connection with the investigation of the interaction between the prefabricated large panel buildings and the soil [1,2]. In this work among others simple discrete models have been developed which are suitable for the unified analysis of the panel structure and the subgrade.

2. THE MODEL OF THE PANEL STRUCTURE

In the analysis of the structure each prefabricated large panel is considered a single rigid element /Fig.1./ These elements are interconnected at the corners and along the edges by elastic springs acting in tension or compression and in shear, respectively. The springs simulate the elastic behaviour of the panels and the joints. Their coefficients for panels with various dimensions and openings should be determined by separate analysis /e.g. by finite element method/ beforehand and are stored in the computer [2].

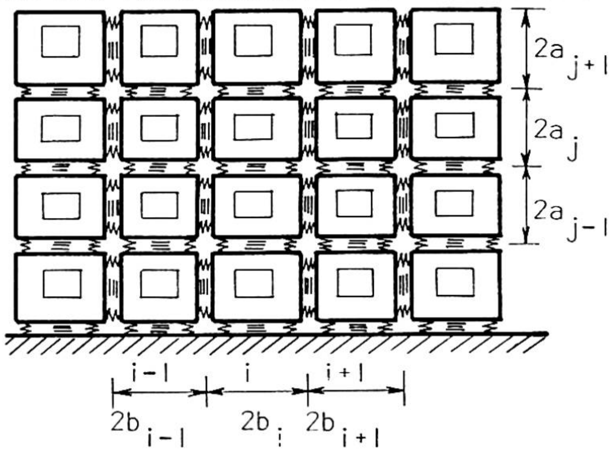

Fig.1. The model of the structure

When analysing a wall of a building /plane problem/ the equilibrium, compatibility and constitutive equations of the panel ij are expressed in the form

$$\begin{bmatrix} \underline{\underline{O}} & \underline{\underline{G}}^{*}_{ij} \\ \underline{\underline{G}}_{ij} & \underline{\underline{F}}_{ij} \end{bmatrix} \begin{bmatrix} \underline{u}_{ij} \\ \underline{s}_{ij} \end{bmatrix} + \underline{q}_{ij} = \underline{O} \qquad /1/$$

or eliminating $\underline{s}_{ij}$

$$\underline{\underline{K}}_{ij}\, \underline{u}_{ij} = \underline{q}_{ij} \,. \qquad /2/$$

Here $\underline{\underline{G}}^{*}_{ij}$, $\underline{\underline{F}}_{ij}$ and $\underline{\underline{K}}_{ij} = \underline{\underline{G}}^{*}_{ij}\, \underline{\underline{F}}^{-1}_{ij}\, \underline{\underline{G}}_{ij}$ denote the equilibrium, flexibility and stiffness matrices and $\underline{q}_{ij}$, $\underline{s}_{ij}$ and $\underline{u}_{ij}$ are the vectors of the external loads, the spring forces and the displacements of the element in question. The stiffness matrix $\underline{\underline{K}}$ of the whole wall can be derived from the matrices of the individual panels [2] and then from equation

$$\underline{\underline{K}}\, \underline{u} = \underline{q} \qquad /3/$$

the displacements $\underline{u}$ of the elements and the spring forces can be determined. These latter form the basis of dimensioning of the joints.

3. THE MODEL OF THE ELASTIC SUBGRADE /SOIL/

The model of the subgrade consists of prismatical elements which transmit normal and shear stresses on their horizontal and vertical contact surfaces, respectively /Fig.2/a/ [3,4]. A proportion /2α/ of the force acting on the top of an element is transmitted by shear to the two neighbouring elements, while the reminding part /1-2α/ of the force loads the supporting element. Thus, the

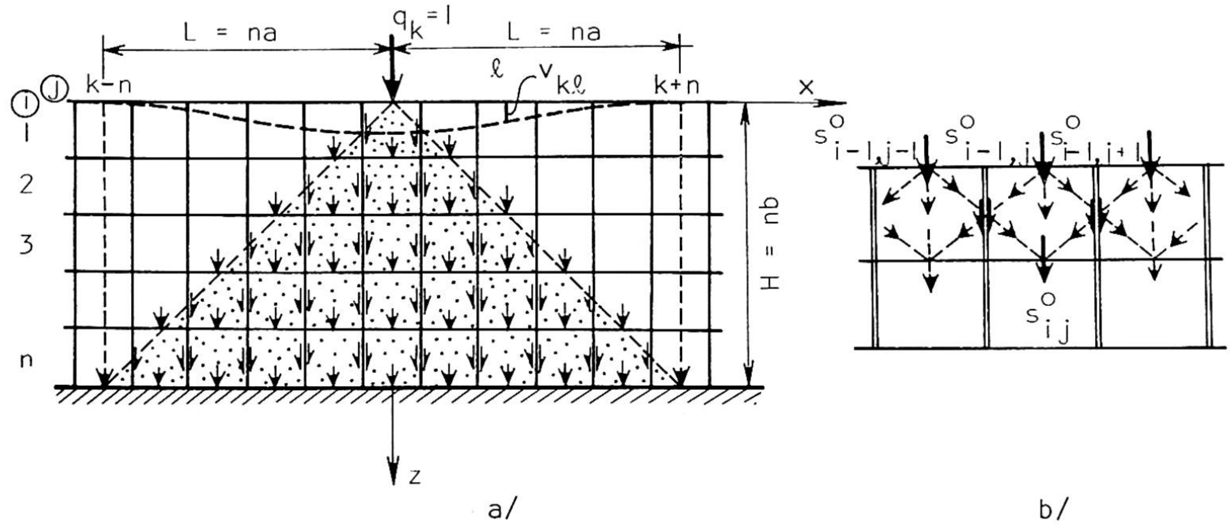

Fig.2. The model of the subgrade

pressure distribution of the whole subgrade caused by a unit force acting on the boundary is defined by the recurrent formula /Fig.2/b/:

$$s^o_{1j} = \delta, \qquad \delta = \begin{cases} 1, & \text{if } j = k \\ 0, & \text{if } j \neq k \end{cases} \qquad /4/$$

$$s^o_{ij} = (1 - 2\alpha)\, s^o_{i-1,j} + \alpha\left(s^o_{i-1,j-1} + s^o_{i-1,j+1}\right)$$

From these the vertical displacements of the horizontal boundary of the subgrade can be obtained:

$$v_{k\ell} = \frac{1}{k} \sum_{i=1}^{n} s^o_{i\ell} \,. \qquad /5/$$

These influence coefficients determine the elements of the flexibility matrix $\underline{\underline{F}}_s$ and the stiffness matrix $\underline{\underline{K}}_s = \underline{\underline{F}}_s^{-1}$ of the elastic subgrade. The parameters k and α of the model can be calculated from the material constants of the soil [4].

4. ANALYSIS OF THE SOIL-STRUCTURE INTERACTION

The combination of the stiffness matrices of the structure and the subgrade makes possible the unified analysis of the whole system which gives the internal forces in the joints of the panels and the settlements and stresses of the soil.

According to the experience of the numerical examples the computation time is relatively short and the accuracy of the results checked by the finite element method [7] is statisfactory for practical use.

The models have been extended to the investigation of spacial structures and to the limit analysis of systems composed of panel structures and the soil [5,6]. In this latter method the plastic deformations of the structure are concentrated in the joints and the plastic behaviour of the subgrade is characterized by the linearized Tresca yield condition. The analysis leads to linear programming and makes possible the ivestigation of the extremal limit states of panel buildings caused e.g. by gas explosion, cavitation of the soil and earthquake. The research on stochastical approach of problems described is in progress [8].

Previously, an other method has been developed which besides the interaction of the panel structure and the soil takes the effect of the simultaneous development of the structure and the dead load during construction into consideration [1]. Because of this latter phenomenon only the lower part of the building plays a dominant role in the interaction with the foundation and the soil /Fig.3/a/.

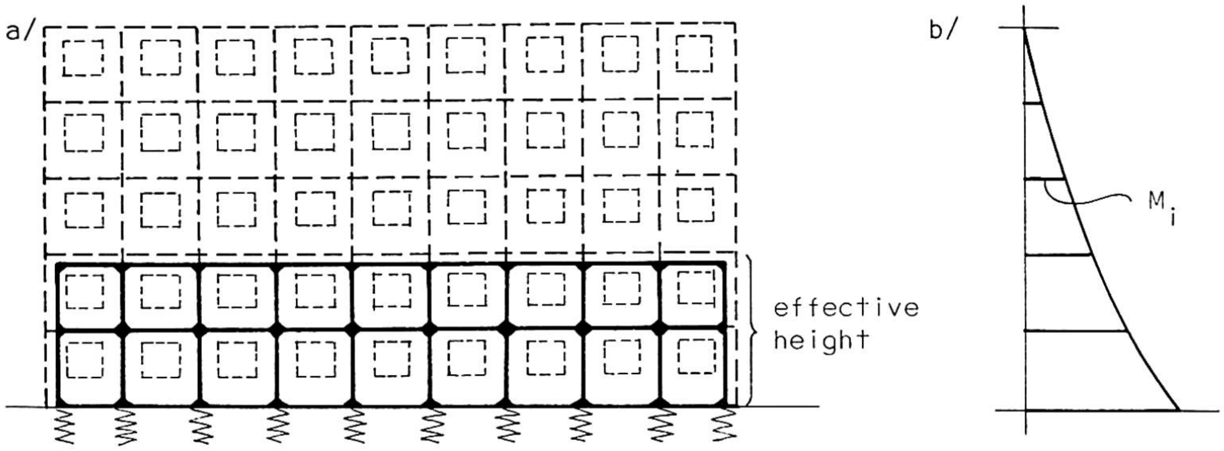

Fig.3. a/ Frame model, b/ bending moment distribution of the lintels

The height of the effective part depends on rigidity conditions and is given in diagrams. The analysis is based on the frame model for the structure and on the Ohde-method for the subgrade. At last, in each vertical section the sum of the beams obtained by these models should be devided among the lintels of the original building. According to the numerical experiences this distribution can be approximated by a second order parabola /Fig.3/b/.

The method described is suitable for the rapid estimation of the effect of soil-structure interaction on panel buildings.

REFERENCES

1. KALISZKY,S., GYÖRGYI,J., LOVAS,A.: The internal forces of panel buildings due to vertical displacements. Magyar Épitőipar 1977.8.
2. KALISZKY,S., WOLF,K.: Analysis of panel buildings by the use of rigid panel model. Periodica Polytechnica.Civil Eng. 1979. Vol.23. /3/
3. KALISZKY,S., GALASKÓ,GY.: Numerical applications of the pyramid model of subgrade. Periodica Polytechnica. Civil Eng. Vol. 20. /3-4/ 1976.
4. KALISZKY,S.: Simple, discrete models of elastic subgrade. Acta Technica Acad. Sci.Hung. Tom.86. /3-4/ 1978.
5. KALISZKY,S.: Statically admissible stress fields of plane plastic problems. Bul.Acad.Polonaise Sci. 1979.
6. KALISZKY,S.: The analysis of panel structures by the use of discrete models. Épités- Épitészettudomány /in press/
7. BOJTÁR,I.: Analysis of spatial plate structures. Periodica Polytechnica. Civil Eng. 1979. Vol. 23.3.
8. VÁSÁRHELYINÉ,SZABÓ,A.: Stochastic analysis of panel buildings in case of random lack of the joints. Épités- Épitészettudomány 1980. /in press/
9. MEHLHORN,G.: Analysis of plain structures with forces in their middle plane composed of precast concrete panels. IASS Bulletin No.58. Vol.XVI.2.