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Structural elements of multifloor frames

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1. Space supporting systems

In compliance with the vertical structural elements composition we divide systems into skeletals, bearing-walls, and combined ones. In principle, we divide structural elements into two groups: the first said are bar elements and the second form flat ones. Walls are the flat plane structural elements loaded primarily in the middle-plane level that can be shaped like web girders and shear walls. The web girders exploit a load-bearing web of the higher floor to release the lower floor layout. Shear walls represent the basic components of the three-dimensional stiffening of a building, these walls transfer the horizontal even vertical loads to foundation construction.

2. Stiffening elements under horizontal loading

As a rule, stiffening elements are made up of shear walls and communication cores, transferring not only the horizontal loadings but they represent even the vertical loading carry-over. [2] It is possible to determine the vertical loading magnitude from the issues analysis of floor plates or approximately from load areas of the adjacent floor structures. The horizontal loadings of the elements tackled are stipulated by both the building position and its structural design. Horizontal loading usually acting on buildings, apart from other things, are represented by eg

- extraordinary horizontal loading
- geotechnics load
- seismicity loading

2.1 Earth pressure loading

This pressure can range whatever values between the active and passive pressure subject to the magnitude and strain direction, and displacement of both, the construction or its part. For very small (virtually negligible) strains of the structure, a soil acts for the most part in an elastic state, for bigger deformations, the structure under earth pressure gain importance the plastic (irreversible) deformation constituents gradually earth pressure ranges the increased active pressure values, and when squeezing into the soil more, plastic deformation constituents gradually gain importance and the earth pressure ranges magnitudes of the reduced passive pressure.

2.2 Earth pressure at a standstill

This pressure is expressed by a magnitude of the initial pressure at a standstill before building works are commenced which will be then influenced by technological processes when building up the supporting structure. The pressure at a standstill represents region of the predominant elastic deformation without almost significant strains. The limit values of the earth pressure at a standstill are "active earth pressure" (the least value) and "passive earth pressure" (the highest value).

$$\sigma_0 = \sigma_z \,.\, K_0 ,$$

where

$$K_0 = (1 - \sin \varphi')\sqrt{OCR},$$

φ'	effective coefficient of soil internal friction, for cohesive soils it is possible instead φ' introduce $\text{tg}\, \varphi_c = \text{tg}\, \varphi + c/\sigma_z$,
φ	soil internal friction angle,
c	soil cohesion,
σ_z	vertical pressure at depth z,
OCR	coefficient of overcondolidation.

2.3 Extraordinary loading

Eg the gas explosion loading is in question, or the vehicle impacts (such as at the garages, car parks) or the high-lift trucks (in the halls and storage structures).

2.4 Gas explosion loading

The design pressure is contemplated as larger from among quantities

$$p_{Ed} = 3.0 + p_v \text{ [kN/m}^2\text{]} \quad \text{and} \quad p_{Ed} = 3.0 + 0.5 \,.\, p_v + 0.04 / (A_v/V)\, 2 \text{ [kN/m}^2\text{]},$$

where p_v is an evenly distributed statical pressure in kN/m2 when the infilling elements are damaged.

For glass walls is considered p_v = 3kN/m^2,

A_v area of exhaust elements in m^2,

V space volume in m^3.

The relations hold good for $V \leq 1000$ m^3 and A_v/V ranges from 0.05 to 0.15 m^{-1}.

2.5 Seismic effects

In a simplified fashion, this loading can be transferred to the horizontal forces loading applied in floor plate planes. In is necessary to consider the seismic loads if those are larger than the 1.5 multiple of wind loading. When performing a reduced calculation of equivalent horizontal forces, we determine the first natural frequency of the building.

2.6 Dynamic structural characteristics:

Magnitude	X direction	Y direction
Stiffness constant to calculate natural frequency	$K_x = 3EI_x/h_i^3$	$K_y = 3EI_y/h_i^3$
Natural frequency	$\omega_x = \sqrt{K_x/M}$	$\omega_y = \sqrt{K_y/M}$
Vibration period	$T_{1x} = 2\pi/\omega_x$	$T_{1y} = 2\pi/\omega_y$
Design value of spectrum acceleration corresponding to vibration period	$S_{dx} = S_d(T_{1x})$	$S_{dy} = S_d(T_{1y})$
Total equivalent horizontal force	$F_{bx} = S_{dx} \cdot M \cdot \lambda_x$	$F_{bx} = S_{dx} \cdot M \cdot \lambda_x$

In the event of reduced method of equivalent horizontal forces determination, the biggest value of the spectrum acceleration is usually considered (B – C region).

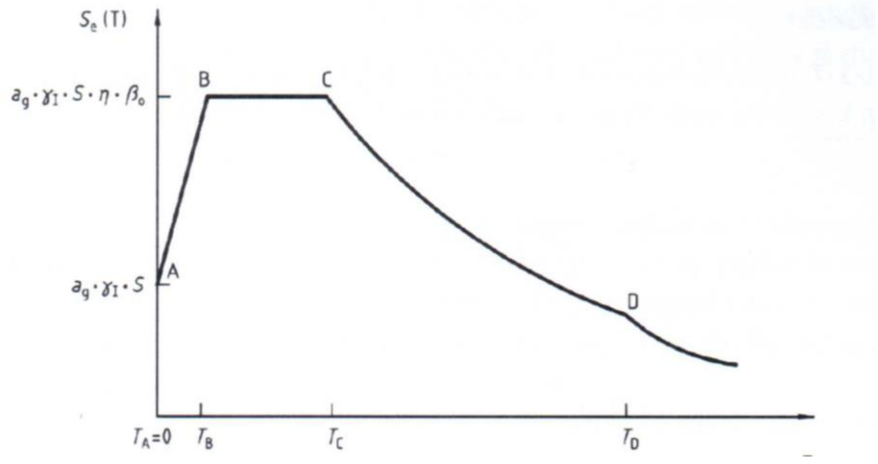

Fig. 1. Spectrum acceleration belonging to the construction work location, [1]

3. Design documentation

Within the bounds of program documentation of a multifloor structure there is chiefly important to determine the loading on its walls and columns. Concurrently, load-bearing reinforced concrete elements are dimensioned above all with respect to the horizontal reinforcement, and further the load-carrying capacity for masonry, steel connections, and timber plates is checked.

Eg, according to [3], program problems can embrace: wind loading determination; design walls and columns; global loading division of both floor slabs and bed-plate foundations; control of both actions and loading stages; imperfect loadings determination (earthquake loading, response forces, buckling resistance coefficients); determination of the extreme loads for walls and columns; vertical loadings summarisation; verification dependent on material; presentation of results.

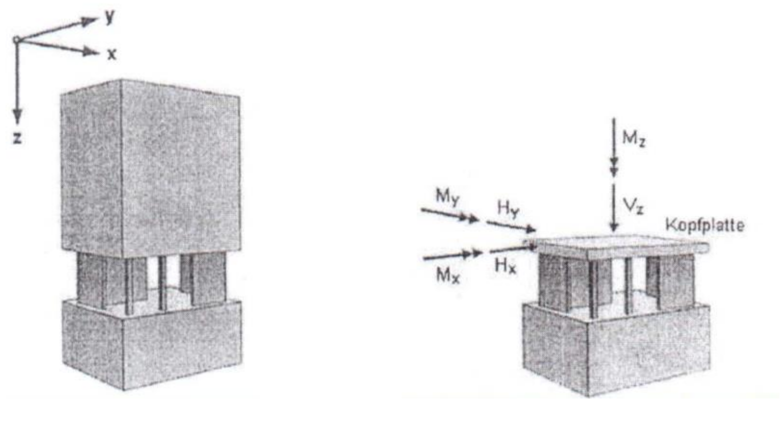

Fig. 2. Top building being load himself, [3]

Problem algorithm is illustrated in Fig. 2. A top part of the building originates loading in the form of both the dead load and imposed one. It is subjected to further loadings (eg snow) and primarily also to horizontal wind loads and aptly as loading or imperfect one.

Loadings can be summarized and transferred to a floor slab in the top edge height of the monitored storey. Now, it is necessary to prove that the walls and columns can jointly catch these loadings when applying safety defined concepts. In order to a necessity is to divide loadings into individual load – bearing elements. This division is performed in a ratio of walls to columns taking into account the facts in this way, that supporting elements react by diverse response forces to a displacement (rotation) of the plates. It is assumed that the walls are subject in the wall direction only. Possible wall loadings scheme is fully described by the quantities qa_i, qe_i and H_i. This approach will be a success all the time, at least, if three walls are defined which do not lie on line, its basic lines do not intersect in the same point and some of whom one wall has not located parallel to the other one.

4. Conclusions

In the paper presented, important problems of both the design and assessment of multi-storey structures are laid down, particularly horizontal stiffness guarantee, coupling and analysis of shape factors of structural elements, what is connected with requirements for their layout and systematization of horizontal loadings. In next part, the guidelines for operating sequence in the points concerning, apart from other things, eg material properties and dimensioning reinforced concrete and columns.

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