1 На стержень действует локальная резонансная поверхностная нагрузка, равномерно распределенная до сечения $x = b \leq 1$. Ее можно представить в аналитическом виде с помощью функции Хевисайда $H_0(x)$.

2 На стержень действует резонансная погонная поперечная сила Q_0 = const, приложенная в сечении на расстоянии a от начала координат.

3 На трехслойный стержень в сечении $x = a$ действуют резонансный поперечный момент интенсивности M_0 = const.

Проведен численный анализ полученных решений. Исследованы условия появления ложного резонанса.

LATERAL LOAD SHARING BY WALLS AND DEFORMABILITY OF THE WOOD-FRAMED BUILDING

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1. Introduction

Selected results of experimental test of the wood-framed with sheathing building structure in natural scale under lateral loading have been discussed in the paper. Behavior under applied loading of completely constructed the wood-framed residential building without finishes inside and outside has been investigated and then compared to the analytical model. The loading applied to the structure was lower than that predicted for the ultimate limit states in order to further construction and execution of finishes in the building foreseen for residents occupation.

During the tests wall displacements were measured due to evaluation of values and characteristics of total building deformations.

The further steps of analysis evaluate the stiffness of individual structural element and method of distribution of the applied external loading on the wall diaphragms. The stiffness of the wall obtained in result of experimental test were taken in analysis of redistribution of applied lateral external loading to the wall diaphragms. The tests were conducted on similar panel construction to those used in building structure, and the continuous - rigid beam analogy as the static scheme of the floor diaphragm supported on deformable walls were used in analysis. Numerical model of the floor diaphragm in three dimensional scheme of structure supported on deformable vertical diaphragms was alternatively used in analysis.

2. Description of the tested building structures

Wood-framed sheathed large panel single story with a living attic area constructed on reinforced concrete floor structure over basement was selected for tests. The height of the first store was 2,74m. Folded (pitched) roof structure was constructed as the rafter timber structure with indirect support on wooden beams.

Wall diaphragms were constructed using polish spruce (Picea) wood with studs of 45x135 mm cross-sections spaced axially at 600mm, with both sides structural sheathing thickness of 12.5 mm chip boards inside and 12.5 mm thickness of wood-derivatives board exterior applied.

The first floor slab was constructed using solid wood joists with the cross-section of 60x180mm spaced on 450mm and 2x60x180mm spaced on 400mm for span of floor 300 cm and 390cm. Chip-boards thickness of 19 mm were used in construction of the floor joists sheathing. Roof rafters with the cross-section of 45x180mm and axial spacing of 625mm, and the top structural sheathing with chip-boards thickness of 12.5 mm were used in roofing structure.

3. Methodology and test procedure and selected results

Horizontal loading in the sectional distributed form was applied on the height of the first floor level. The following phases of loadings and their values were applied to the wood-framed building structures.

Stabilizing - Phase I loading and displacements was conducted under $P_s = 4{,}0kN$ lateral load.

Phase II applied horizontal loading was similar to that arising during the exploitation (wind) load level, $P_e = 24{,}0kN$ and than final value of allowable because of the constructed building elements interconnecting links safety $P_u = 40{,}0kN$.

The wall top edge displacements at the level of the bottom floor slab were measured in two directions; perpendicular and parallel to the line of applied loading. Readings were realized after applying of each 4.0 kN loading increment.

Displacements of the individual walls in the function of varying stages of applied to the whole building structure loading were recorded, and corresponding displacements of the top wall edges in the function of the loading distributed on each wall (in the function of the wall stiffness) were plotted.

4. Displacements and wall stiffness

The displacements of the top walls edges related to the standard requirements in respect of serviceability limit state not exceeding allowable values for the exploitation stages of loadings being resulted from the designed wind pressure on the building. The allowable displacements at the exploitation loading stage is limited to the value of $y_{lim} = 0{,}002h_s$ and in case of particular wall height of $h_s = 2{,}74$m cannot exceed $y_{lim} = 5{,}48$mm.

The analysis of particular wall panel stiffness and distribution of applied external loading was conducted taking into account and accepting the experimentally obtained author characteristics $P = f(\delta)$ for different geometry and structure of the tested series of wall diaphragms.

Analysis of distribution of externally applied loading to particular building walls were conducted considering the continuous rigid beam analogy for the selected static schemes representing arrangement of supporting walls in longitudinal and transverse direction of building. The transversal direction was loaded with torsion moment as a result of external loading and its eccentricity relating to the wall plane gravity center. Numerical model of the floor horizontal diaphragm supported on deformable walls was also adopted in analysis.

The wall stiffness

$K = \frac{P}{\delta}$ was computed for the stage of exploitation loading not exceeding wind design loading where

P – the lateral loading to the wall, δ - displacement of the top edge of wall. Computed deformations of the substitute continuous rigid beam reflecting floor slab supported on flexible walls were compared to the results obtained from experimental test of whole building under comparable loading levels, and than compared to the results of displacements from numerical model. The maximum displacement has not exceed 2 mm.

5. Summary

The following conclusions can be formulated in result of conducted experimental tests and pre analysis applying the simplest continuous rigid beam model of the floor diaphragm:

- Horizontal displacements of the top wall edges obtained from experimental tests of the whole building structure incomparably lower to those considered as the allowable for the wood-framed building structures,
- Displacements and deformations of the whole building structure experimentally obtained in result of tests do not confirm commonly applied assumption on infinite stiffness of the floor diaphragms in its plane; the obtained results are testifying the flexibility and deformability of the horizontal diaphragms in their planes,
- The static analysis of the floor diaphragm considered as the continuous rigid beam of large stiffness supported on flexible walls gave the resulted horizontal displacements 1.2 to 3.1 times higher than those obtained in results of experimental tests for equivalent loading levels,
- Much lower horizontal displacements at the floor level in real building structure obtained from experimental tests are resulted from the common interconnection of the perpendicular walls and spatial (3D) behavior of the floor diaphragms.
- Partial displacements were accumulated in the flexible links connecting floor slab with the walls and along the walls vertical interconnecting links,
- The analysis of the wood-framed sheathed buildings in the three-dimensional schemes (3D modeling) precisely specifies whole building displacements, load sharing to the particular wall and final analysis of interconnecting link stressing and final prediction of the behavior of whole building structure different geometry under different loading before its construction.