Analysis of the vertical tensions on masonry structures with different combinations of load

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Abstract: The work shows the stress of the masonry structures with different combinations of load.
Keywords: Masonry, permanent and variable loads, forces, eccentricity, eurocodes

1 Introduction

Masonry structures of buildings over the past 30 years, was significantly transformed. The structures from the compact and small-sized masonry elements and ordinary mortar gradually moving on to more sophisticated products of larger dimensions. To use the bricks today is important factor still a static load rating. The total bearing capacity of masonry is not just strenght theirs masonry elements, but their combination with mortar and other technical parameters such as size of load, eccentricity of forces and rigidity. The standards (Eurocodes) reported the conditions, procedures and limitations for the design of structures, but the actual numerical solution we must make.

2 Experiment - analysis vertical tension

Finding the size and changes of the vertical stress in different locations in masonry structure of the building in terms of different load combinations is the subject of our work and that contribution. The work examines the size of the resultant force from the vertical load on individual floors or selected reference buildings. Determines the amount of eccentricity forces in the cross section and the size of the resulting tensions in different parts of cross section of the masonry structure. To determine the size of the individual values was compiled simple program involving various possible combinations of load. A program can change the thickness of masonry structures, materials and conceptions of horizontal structures and the size of the variable load on the floor.

Calculations were performed to compare the sizes of forces for the individual load combinations for ultimate limit states and serviceability limit states. Equations were used for characteristic load combination and design combinations. For the three equations for a combination of permanent and variable loads that can be use according to the standard EN 1990 - Eurocode. These are the calculations of variants of the design load values for ultimate limit state (ULS) of brickwork in compression. For minimum operating load values and the values for the long-term effects. It is a combination of quasi-permanent It is a calculation for serviceability limit state (SLS). For the loads combination by original old Czechoslovak standards CSN 730035 1986 is used to compare with Eurocodes. Load acting on the masonry is defined in the following combinations in the table no.1. Parctional load factors (coefficients) have value for the permanent load of 1.35 (($\gamma_{g,1}$) and 1.5 for variable load ($\gamma_{q,i}$). Factor $\psi_{0,\iota}$ is used to reduce other variable loads coefficients $\psi_{1,\iota}$ and $\psi_{2,\iota}$ for reducing variable load operating design situation.

These procedures (load combinations) always comes to comparing for one variable seven values of forces and eccentricities and four tension values (for the concentric pressure, the eccentrical and extreme pressure section)

	Combination of actions	equation	coefficient ψ
1	characteristic values	$E_d = \Sigma (G_{k,j} + Q_{k,1} + \psi_{0,\iota} * Q_{k,,\iota})$	$\psi_{0,\iota} = 0,7$
2	design values for ULS		
2a	equation 6.10 of EN 1990	$E_d = \Sigma (\gamma_{g,j} * G_{k,j} + \gamma_{q,1} * Q_{k,1} + {}_{q,i} * \psi_{0,\iota} * Q_{k,,\iota})$	$\psi_{0,\iota} = 0,7$
2b	equation 6.10a of EN 1990	$= \Sigma (\gamma_{g,j} * G_{k,j} + \gamma_{q,1} * \psi_{0,1} * Q_{k,1} + {}_{q,i} * \psi_{0,\iota} * Q_{k,,\iota})$	$\psi_{0,\iota} = 0,7$
2c	equation 6.10b of EN 1990	$= \Sigma (\xi * \gamma_{g,j} * G_{k,j} + \gamma_{q,1} * Q_{k,1} + {}_{q,i} * \psi_{0,\iota} * Q_{k,,\iota})$	$\psi_{0,\iota} = 0,7$, $\xi = 0,85$
3	values for SLS		
3a	quasipermanent	$E_d = \Sigma (G_{k,j} + \psi_{2,\iota} * Q_{k,1} + \psi_{2,\iota} * Q_{k,,\iota})$	$\psi_{2,\iota} = 0,3$
3b	frequent	$E_d = \Sigma (G_{k,j} + \psi_{1,1} * Q_{k,1} + \psi_{2,\iota} * Q_{k,,\iota})$	$\psi_{1,1} = 0,5$, $\psi_{2,\iota} = 0,3$
4	design for ULS according to CSN 730035	$E_d = \Sigma (\gamma_{g,j} * G_{k,j} + \gamma_{q,1} * Q_{k,1} + {}_{q,i} * \psi_{,\iota} * Q_{k,,\iota})$	

Fig 1– Combinations of actions for ULS and SLS

As a reference sample is considered a six-storey building with two wings. This building is a commonly-built brick building with the usual maximum allowable height of buildings. Calculations can e performed for lower and other objects.

.	**Combination**	**Vertical** Force (kN)	**eccentr.** of force (mm)	**porovnání hodnot** ku a	ku b	**Compressive tension** centric (kPa)	average (kPa)	minimum (kPa)	Maximum (kPa)
	2st floor								
1	characteristic	208,73	27,15	1,00	0,73	556,62	**557,46**	314,80	798,44
2a	design eq. 6.10	284,92	27,40	1,36	1,00	759,78	**771,05**	426,65	1092,90
2b	design eq. 610a	275,53	26,63	1,32	0,97	734,76	**745,34**	421,65	1047,86
2c	desigm eq.6.10b	248,14	27,95	1,19	0,87	661,70	**671,71**	365,83	957,56
3a	quasipermanent	194,14	25,43	0,93	0,68	517,70	**524,82**	307,02	728,38
3bf	frequent	198,31	25,95	0,95	0,70	528,82	**536,24**	309,24	748,40
4	old standard ČSN	225,26	28,61	1,08	0,79	600,70	**610,01**	325,74	875,66
	1st floor								
1	characteristic	227,47	24,92	1,00	0,73	606,58	**607,50**	364,77	848,40
2a	design eq. 6.10	310,21	25,17	1,36	1,00	827,23	**838,48**	494,10	1160,35
2b	design eq. 610a	300,83	24,39	1,32	0,97	802,21	**812,78**	489,10	1115,32
2c	desigm eq.6.10b	273,43	25,36	1,20	0,88	729,15	**739,14**	433,28	1025,01
3a	quasipermanent	212,87	23,20	0,94	0,69	567,66	**574,77**	356,98	789,46
3b	frequent	217,04	23,71	0,95	0,70	578,78	**586,20**	578,75	798,36
4	old standard ČSN	246,06	26,19	1,08	0,79	656,15	**665,45**	656,15	656,15

Fig. 2 - Vertical tension for a wall thickness of 375mm on six-storey building, the lowest two floors

Structural scheme and forces

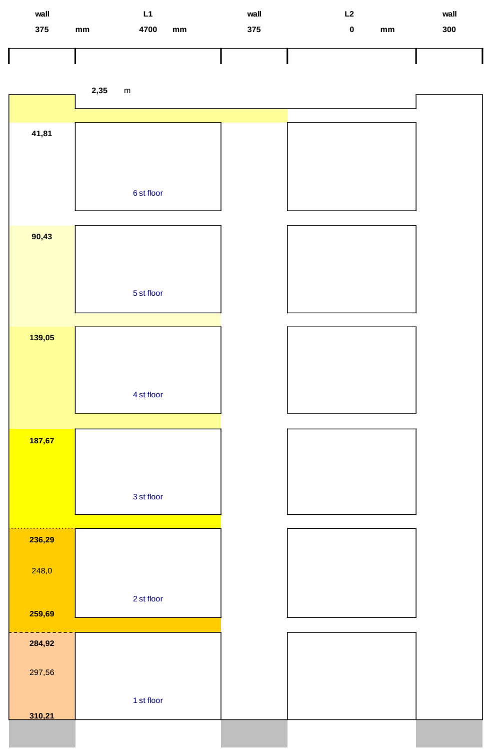
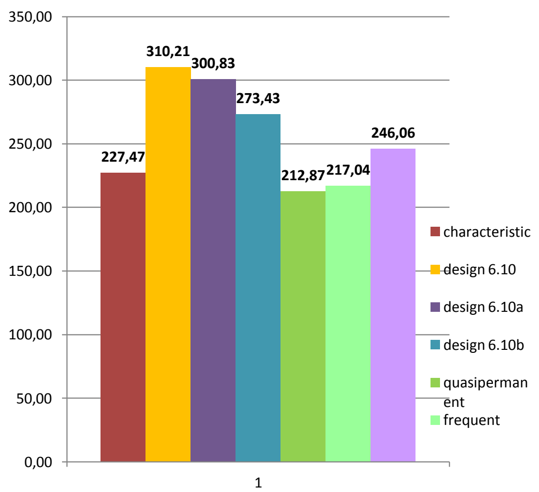


Fig.3 – structural scheme and forces in masonry – six storey building,wall 375 mm

Forces and tension in the masonry

six-storey building, wall 375 mm, panel ceilings

Vertical forces (kN)



Vertical tension (kPa)

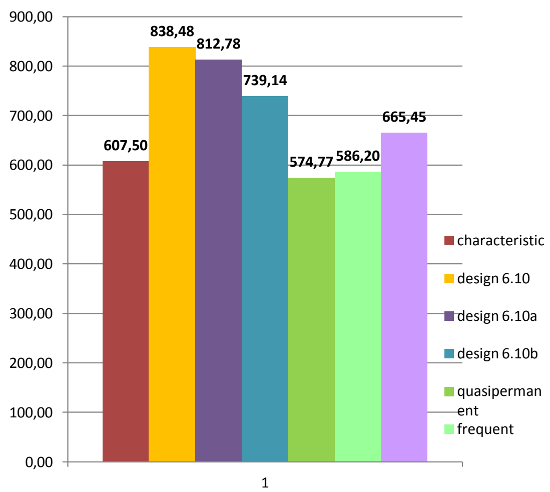


Fig. 4 - Vertical forces and tension (MPa) for a wall thickness of 375 mm on six-storey building made. The walls are of vertically perforated bricks, ceilings are monted or are from panels

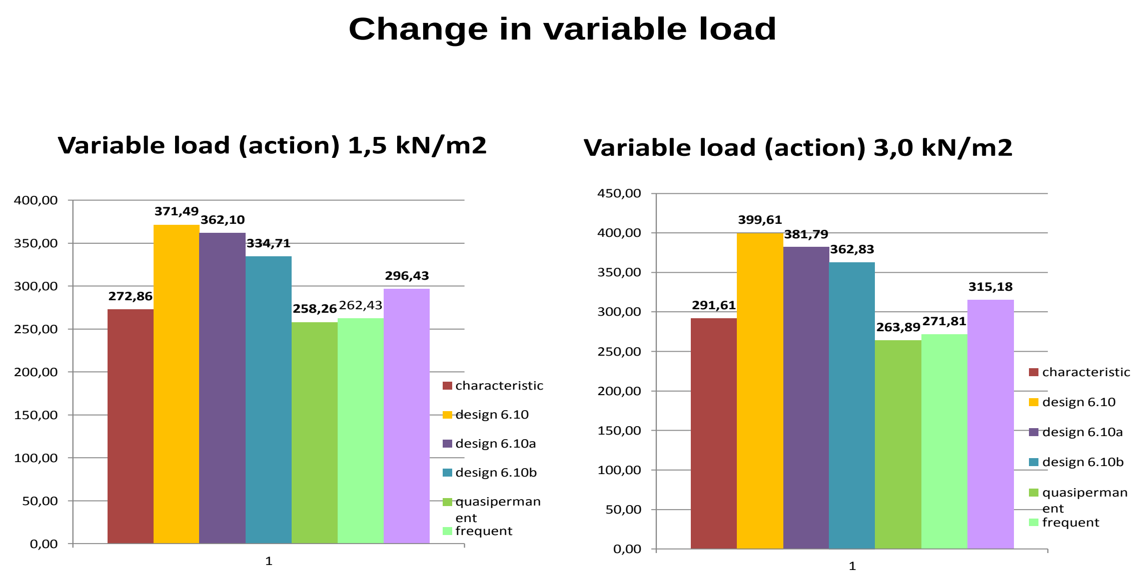


Fig. 5 - Sample results when you change the variable load (forces in kN) - six-storey

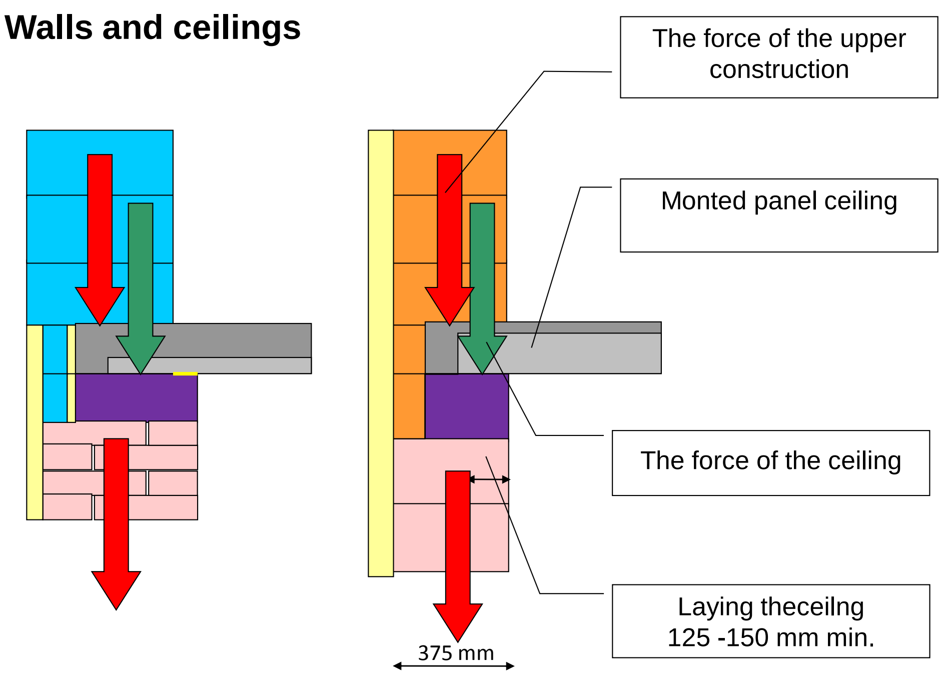


Fig. 6 - Example vertical forces on the wall thickness of 375 mm

The result is a practical verification of the size of the forces in the cross-sections of masonry buildings, including the eccentricity of forces and inferred vertical stress. Results can be calculated for different material variants and variants masonry ceiling structure. Calculations were examined in concrete ceilings of hollow panels and weighing from 2.5 kN / m2 in solid monolithic slab cross sections of 200 mm (5 kN / m2). Variable load on the floor has been considered in category A for flats (1.5 kN / m2), offices - category B (2.5 kN / m2) and areas with tables category C (3.0 kN / m2) according to the standard CSN EN 1991-1-1. Calculated values of forces and tensions give the normative variants of load combinations according to EN 1990. There are obvious differences in the results in a typical example, the limit and operational loads

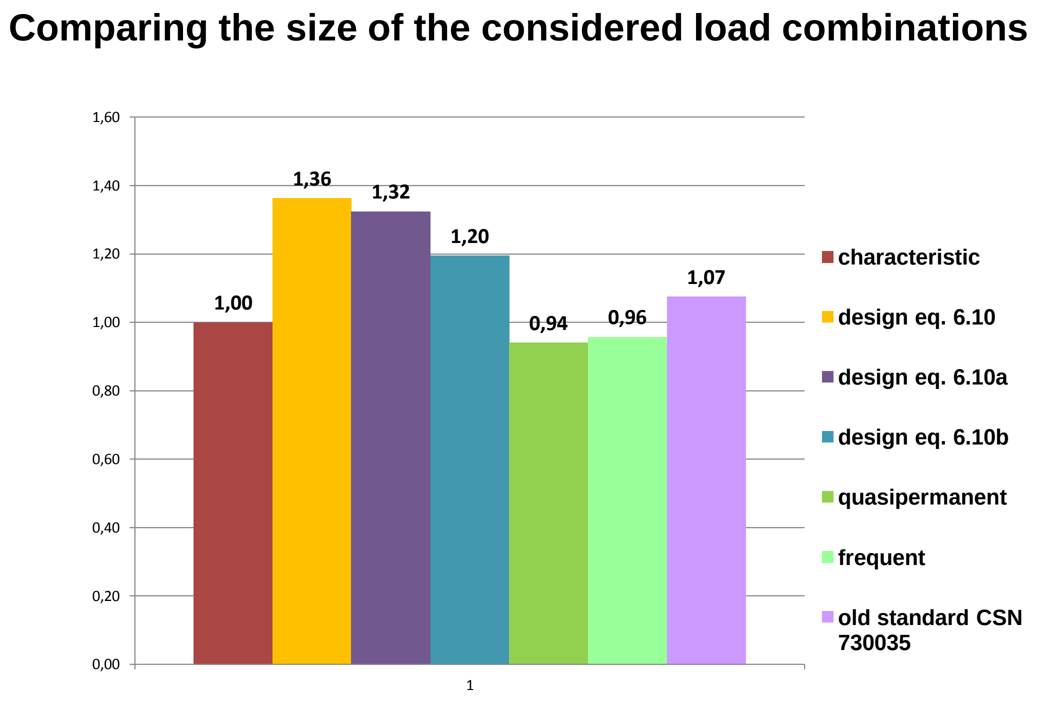


Fig. 7 - Comparing the size of the combinations – six-storey building, wall 450 mm

3 Summary

Comparison of the effects of the load combination was made for a six-storey building with a wingspan of 5 meters ceilings. It is a usual building - reference building

Limit state - carrying capacity

Results are from the calculations in differences 3-5% in the assessment of the values according to the combination equation 6.10a or 6.10 specified in CSN EN 1990. Second procedure gives the commonly used conservative results. Process according to 6.10 b is by 10 -12% lower. Procedures according to equations 6.10 is to 27 % higher than the initial proposal by Czech standards. Yet it has been implemented under this standard, many buildings for decades without problems Differences make values of load factors. Process according to equation 6.10a with a reduction of permanent loads is correct and legislative solutions.

Changes to variable loads on the floors evoke the vertical forces increase by about 7.5%.

Limit state - usability

It is also necessary to verify the effects of the load for the quasi-permanent and frequent load combination. These combinations are two variants for the minimum operating load. There should not be exceeded eccentricity of the vertical force equal to a sixth of the cross-section to avoid tense of mortars and eventual opening of the bed joints by tension.

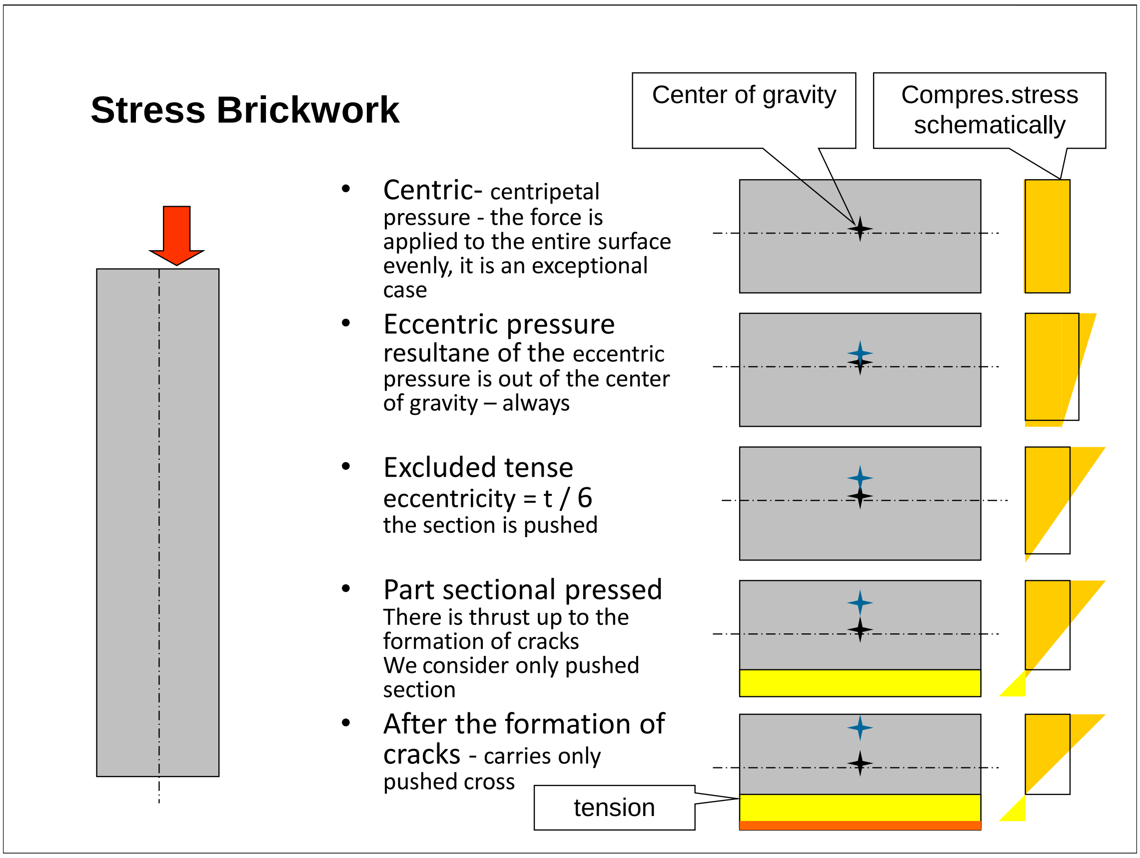


Fig. 8 - Compressive and tensile stresses induced in the masonry from load

That analysis is also used for reconstruction projects and extensions of objects in an increase in the floor can be adjusted to záakldě accurate information load factor for permanent load from the existing building

Acknowledgement

his work was supported by national financial resources of Ministry of Education Youth and Sport of Czech Republic for specific university research (SGS-2016-038)

References

Standards: CSN EN 1990, ČSN EN 1991-1-1,1-3, 1-4, CSN EN 1996-1-1