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Summary of

DIBt research assignment / contract No ZP 32-5-15.52-1050/03

"Definition check of DIN 1053 concerning the fundamental values of the allowable stress and Eurocode 6 for characteristic values of the compressive strength for masonry made of planar bricks stone of autoclaved aerated concrete with integrated handles"

"To increase the heat insulating effect autoclaved aerated concrete masonry units with modified porous structures and reduced density were produced during the last years. Additionally, handles were integrated to facilitate the processing of large-scale stones. In tests to assess the load bearing behaviour of walls made of heat insulating autoclaved aerated concrete masonry units 4-0,50 and 6-0,70 it was found that the fundamental values of the allowable mechanical strength are not sufficiently corresponding to DIN 1053 – masonry units part 1: Calculation and performance -, issue November 1996, see research assignment GZ P 32-5-15.42-556/00 of DIBt. Furthermore, it was stated that integrated handles in autoclaved aerated concrete masonry units would reduce more the load bearing behaviour additionally".

To demonstrate the influence of integrated handles in autoclaved aerated concrete bricks on the load bearing behaviour of the masonry, especially for this project there were produced the following classified planar bricks 4-0,50, 6-0,65 and 2-0,40 and half of them provided with integrated handles.

These bricks were used to built floor-to-ceiling-walls at the Otto-Graf-Institute of MPA University of Stuttgart for testing the compressive strength of masonry and their deformation behaviour after 28 days. The material characteristics of the plane stones of autoclaved

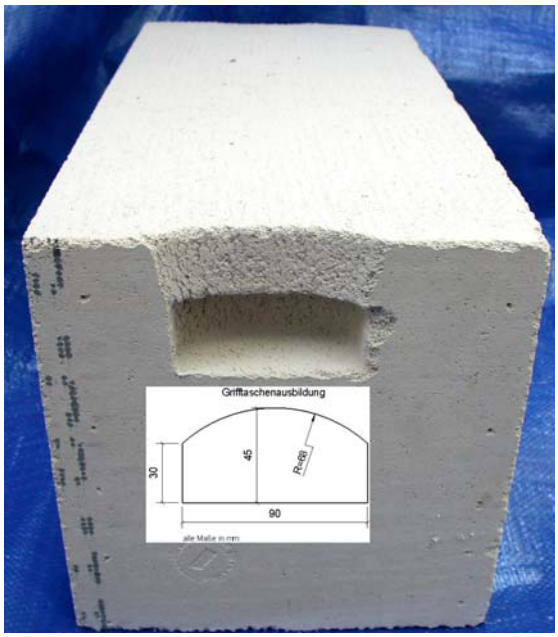
aerated concrete and the thin-bed mortar were investigated according to the relevant standards.

The following table shows the dry density and the compressive strength of the planar bricks of autoclaved aerated concrete. The requirements according to DIN V 4165 [1] are met.

item	mean of 12 planar parallel bricks	
	dry density	compressive strength
	ρ_{tr}	β_{St}
	kg/dm³	N/mm²
mean of sort 2 -0.40	0.37	3.2
mean of sort 4 -0.50	0.47	5.3
mean of sort 6 -0.65	0.64	8.3

The average compressive strength of the thin-bed mortar in the moment of testing the walls (28 days) ranged between 17.7 and 19.6 N/mm² and met the required standard of DIN 1053-1 [2] for normal-conditioned thin-bed mortar during the quality test.

A autoclaved aerated concrete brick with integrated handle is shown on figure aside. The surface area of the integrated handles in relation to the bearing surface amounts to approx. 5,8 %.
Depending on the stone type three test bodies each were provided with integrated handles and another three without. They were walled up using “YTONG thin-bed mortar” with the help of a serrated trowel. After aging for 28 days their compressive strength and the modulus of elasticity of the masonry was tested according to DIN 18554-1 [3]. The walls measured:



height: approx. 250 cm (10 brick layers λ_{across}=10.4),
width: approx. 24 cm (width of the bricks),
Length: approx 125 cm (2.5 times length of the bricks).

The compressive strength $ß_{D,MW}$ of the walls was determined by a 5000 kN-pressure testing machine at a centrifugal and evenly-distributed load. The modulus of elasticity longitudinal and the epansionmodul transversal was determined using an inductive sensor transducer. The values are summarized in the following table:

item		compressive strength	modulus of elasticity longitudinal	expansion-modul transversal	transverse-expansion-number	residual-humidity
		$\beta_{D,MW}$	$E_{L33,MW}$	$E_{Q33,MW}$	$\mu_{33,MW}$	
		N/mm^2	N/mm^2	N/mm^2	-	M-%
2 -0.40	mean	2.03	1278	5679	0.208	15.0
2 -0.40 GH	mean	1.90	1231	5471	0.206	13.2
4 -0.50	mean	3.29	1847	5643	0.204	13.9
4 -0.50 GH	mean	2.98	1810	6182	0.187	13.7
6 -0.65	mean	4.49	2702	5906	0.190	13.6
6 -0.65 GH	mean	4.30	2590	3881	0.332	13.7

Using the numerical approach according to [4] it was possible to determine the compressive strength of masonry $ß_{D,MW}$ from the resistance strength of the masonry and the determined the compressive strength of bricks depending on the shape and type according to the following form:

$$\beta'_{D,MW} = \beta_{D,MW} \cdot \left(\frac{\min \beta_{St}}{\beta_{St}} \right)^{0,84}$$

The influence of the thin-bed mortar on the walling compressive strength was not considered. The slenderness of the tested walls was $\lambda_{quer} \approx 10.4$ so that a corrective factor was not required for a deviating slenderness.

The compressive strength of masonry, $ß_{D,MW}$ was compared with the fundamental values of the allowable compressive stress σ_0 according to DIN 1053-1 [2], Table 4b.

The compressive strength of masonry $ß_{D,MW}$, the converted compressive strength of the masonry $ß'_{D,MW}$, as well as the additional safety values γ' relating to the fundamental values of the compressive stress σ_0 according to DIN 1053-1 [2] are provided in the following table:

item	means of every 3 walls		
	compressive strength of masonry	annualised compressive strength of masonry	determined saftey-coefficient
	$\beta_{D,MW}$	$\beta'_{D,MW}$	γ'
	N/mm²	N/mm²	-
2 -0.40	2.03	1.67	2.8
2 -0.40 GH	1.90	1.53	2.5
reducing because of handels [1)]	-6.8%	-8.4%	
4 -0.50	3.29	3.12	2.8
4 -0.50 GH	2.98	2.83	2.6
reducing because of handels [1)]	-9.4%	-9.3%	
6 -0.65	4.49	4.06	2.7
6 -0.65 GH	4.30	3.89	2.6
reducing because of handels [1)]	-4.3%	-4.2%	

[1)] based on version without handels

The strength-reducing share of the integrated handles of the three tested types ranged between 4.2 % and 9.3 % for the annualised compressive strength of masonry. The determined saftey-coefficient ranged between 2.7 and 2.8 for the test walls without integrated handles and for test walls with integrated handles between 2,5 and 2,6. Since there was such a small number of test bodies, the measuring results were not statistically prepared.

References:

[1] DIN V 4165 - Porenbetonsteine - Plansteine und Planelemente -, Ausgabe Juni 2003

[2] DIN 1053-1 - Mauerwerk; Berechnung und Ausführung -, Ausgabe November 1996

[3] DIN 18554-1 - Prüfung von Mauerwerk; Ermittlung der Druckfestigkeit und des Elastizitätsmoduls -, Ausgabe Dezember 1985

[4] Schubert, P.; Meyer, U.: Druckfestigkeit von Porenbeton- und Leichtbetonmauerwerk. Berlin: Ernst & Sohn. In: Mauerwerk-Kalender 25 (1993), S. 627 - 634