LOAD CAPACITY OF MASONRY MADE OF FLAT-BRICKS AND COVER UP THIN LAYER MORTARS

ZUM TRAGVERHALTEN VON MAUERWERK AUS PLANHOCHLOCHZIEGELN MIT ABDECKENDEN DÜNNBETTMÖRTELN, DEN SOG. DECKELMÖRTELN

CAPACITÉ PORTANTE DE MAÇONNERIE FAITE DE BRIQUES PERFORÉES À HAUTE PRÉCISION AVEC MORTIER À COUCHE MINCE

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SUMMARY

In order to improve thermal insulation of external walls, bricks with a high content of holes and thin vertical plates are frequently used. Today, to reduce construction costs, many brick types are produced as flat-bricks and lain with thin layer mortars.

At present, thin layer mortars are developed which show a high capacity of cohesion and which are spread in such a way, that also greater holes are covered, to balance differences in height within the measurement tolerances of flat bricks, to improve the acoustic insulation and to reduce convection currents.

A high cohesion of the fresh thin layer mortar to “cover up” greater holes may be reached by especially chosen additions using suitable agents and concrete additives, as e.g. fibres.

The results of the research show that the load capacity of masonry made of flat bricks with the new cover up thin layer mortars with a high capacity of cohesion is improved considerably. Using these so called cover up mortars in brick masonry, a convection currency in holes lying on top of one another is stopped and the acoustic insulation is partly raised considerably.

ZUSAMMENFASSUNG

Zur Verbesserung der Wärmedämmung von Außenwänden werden Ziegel häufig mit hohem Lochanteil, großen Löchern und dünnen Stegen verwendet. Zur Reduzierung der Baukosten werden heute zahlreiche Ziegelarten als Planziegel hergestellt und mit Dünnbettmörteln verlegt.

Zum Ausgleich von Höhendifferenzen innerhalb der Maßtoleranzen von Plansteinen, zur Verbesserung der Schalldämmung und zur Reduzierung von Konvektionsströmungen werden zur Zeit Dünnbettmörtel entwickelt, die ein hohes Zusammenhaltevermögen aufweisen und die so aufgetragen werden, dass auch größere Löcher abgedeckelt werden.

Ein hohes Zusammenhaltevermögen des frischen Dünnbettmörtels zum "Abdeckeln" größerer Löcher kann durch besonders ausgewählte Zuschläge bei Verwendung geeigneter Zusatzmittel und Zusatzstoffe, wie z. B. von Fasern, erzielt werden.

Die Ergebnisse der Forschungsarbeit zeigen, dass das Tragverhalten von Mauerwerk aus Planhochlochziegeln mit den neuen Dünnbettmörteln mit hohem Zusammenhaltevermögen wesentlich verbessert wird. Bei Verwendung dieser sog. Deckelmörtel wird eine Konvektionsströmung in übereinanderliegenden Löchern im Ziegelmauerwerk unterbunden und die Schalldämmung z. T. nennenswert erhöht.

RESUME

A fin d’améliorer l’isolation thermique des murs extérieurs, des briques avec une grande part de trous, grands trous et des âmes minces sont souvent utilisés. A fin de réduire les coûts de construction, des nombreuses catégories de briques sont fabriqués comme à haute précision briques et mise en place avec des mortiers à couche mince.

Des mortiers à couche mince qui montrent une grande capacité de cohérence et qui sont appliqués de telle manière que des trous plus grands sont couverts également sont développés à présent à fin de balancer les différences d’altitude dans les tolérances de mesure des briques à haute précision, à fin d’améliorer l’isolation acoustique et à fin de réduire les courants convectifs.

Une grande capacité de cohérence du mortier frais pour couvrir des trous plus grands peut être atteint par des additions particulièrement choisis, utilisant des adjuvants et agents appropriés comme par exemples des fibres.

Les résultats de la recherche montrent que la capacité portante de maçonnerie faite de briques à haute précision avec les nouveau mortiers à couche mince tenant une grande capacité de cohérence est amélioré considérablement. Utilisant ces mortiers couvrants, un courant convectif dans

les trous superposés les uns sur les autres dans la maçonnerie de briques est arrêté et l'isolation thermique est en partie élevé notablement.

1. INTRODUCTION AND OBJECTIVE

Today, masonry is mainly produced out of large sized masonry units with normal masonry mortar of light weight masonry mortar or large sized flat blocks with thin layer mortars.

The application of standardised masonry units is settled in DIN 1053-1 [1]. The field of application of flat masonry units made of concrete, light weight concrete or ceramic is generally lain down in the general construction supervision's approval.

In order to fulfil the again tightened requirements on thermal protection, the majority of masonry units have been further developed in order to contribute to the further improvement of thermal insulation of external walls. An improvement of thermal insulation of autoclaved aerated concrete- and light weight concrete masonry units is predominantly achieved by reducing the density, with regard to light weight concrete masonry units additionally by placing thin air slits. For bricks, an improvement of thermal insulation is mainly achieved by increasing the content of holes and by reducing the density of earthenware.

In order to reduce construction costs, nowadays for all kinds of masonry units large sized flat masonry units are offered and glued with thin layer mortars. This economical construction method is determined by a smaller mortar quantity necessary for thin layer mortar masonry and shorter building times.

For autoclaved aerated concrete flat masonry units, calcium silicate flat masonry units and light weight concrete flat masonry units the thin layer mortar is spread with a so called tooth spatula on the mostly closed bearing surface. After laying the next row of stones a surface covering, 1 to 3 mm thick bed joint of thin layer mortar is produced.

For flat-bricks the straps of the bricks are moistened with mortar by dipping the lower bearing surface into the thin layer mortar or by rolling out the thin layer mortar on the straps to glue the flat-bricks.

Doing this, the bricks are only joined in the area of the touching straps. In unfavourable cases, the open, uncovered holes produce drains above the height of a wall which may reduce considerably the sound protection. In order to shut these drains a special method was developed to cover up the bearing surface with glass fibres fleece and thin layer mortar.

At present, new thin layer mortars are developed which show a high capacity of cohesion caused only by their composition and which cover also greater holes when spread on the bearing surface of flat-bricks.

By means of the cover up thin layer mortar bedding, the sound protection possibly as well as the thermal protection, may be improved, convection current may be reduced and the load capacity may be increased.

The objective of the examinations was to gain information on the load capacity of masonry made of flat-bricks with the new cover up thin layer mortars, in order to contribute to the establishing of calculation strength values for flat-brick masonry, e. g. for revision of DIN 1053-1.

Moreover, it should be shown if the thermal protection is changed essentially by using these new cover up thin layer mortars.

2. TESTING PROGRAMME

In the tests, 4 cover up thin layer mortars were included, whose the capacity of cohesion is achieved by especially chosen aggregates by using suitable additives and/or special admixtures, as e. g. fibres. With a practical application method, the cover up effect was tested on the fresh thin layer mortar.

On the hardened mortar, the bulk density, the compressive strength, the bending strength and the split tensile strength as well as the modulus of elasticity were determined.

For the bricks, such ones were chosen, that show a high content of holes and a low thermal conductivity. These bricks are produced as block-bricks but as well as flat-bricks, their field of application is lain or will lay down in the construction supervision's general approval.

On the flat-bricks, the dimensions, the content of holes, the size of holes, the thickness of straps, the density of the bricks and the straps (density of earthenware) as well as the compressive strength and thermal conductivity were examined. In addition to that, the greatest arch of the surface as well as the greatest difference in height were measured.

The influence of the new cover up thin layer mortars on the load capacity of flat-brick masonry was tested on pillars (50 cm x 36,5 cm x 125 cm) and some walls (124 cm x 36,5 cm x 250 cm).

The result of the tests was compared with the masonry strength, which had been detected on the same flat-bricks, but with rolled out thin layer mortar and on comparable block-bricks with light weight- or normal masonry mortar.

The load capacity tests on flat- and block-bricks performed at Otto-Graf-Institut, University Stuttgart, are listed in table 1 and 2.

Table 1: List of tests to determine the load capacity T and the thermal conductivity W of masonry out of flat-bricks and thin layer mortars

Specimens[1)] (walls-W and pillars-P) out of flat-bricks and thin layer mortars					
	RB	DB	DM	DP	DS
PT	TP TW WW	TP TW WW	TP -- --	TP -- --	TP -- --
PU	TP TW WW	TP -- --	-- TW WW	-- -- --	-- -- --
PB	TP	TP	TP	TP	TP

[1)]TP pillars to determine the load capacity
TW walls to determine the load capacity
WW walls to determine the thermal conductivity

Table 2: List of tests to determine the load capacity T and the thermal conductivity W of masonry out of block-bricks and lightweight mortars or normal mortar

Specimens[1)] (walls-W and pillars-P) out of block-bricks and mortars				
	LP	LO	LL	NM
BT	TP TW WW	TP -- --	TP -- --	TP -- --
BU	TW	--	--	--
BB	TP	TP	TP	TP

[1)]TP pillars to determine the load capacity
TW walls to determine the load capacity
WW walls to determine the thermal conductivity

3. MATERIAL'S CHARACTERISTIC VALUES OF FLAT- AND BLOCK-BRICKS

The 3 masonry bricks included in the examinations were new developed stones of low thermal conductivity whose field of applications has been lain down recently, or respectively, will be lain down in the construction supervision's general approval shortly.

The masonry units showed a high content of holes with numerous rows of holes and thin straps, mostly made of porous earthenware in order to obtain a high thermal insulation. The 3 masonry units are delivered in different heights as block- and flat masonry unit, whereas there are additional requirements on the bearing surface's accuracy of flatness. The properties of the masonry units used, indicating the test methods, are compiled in table 3.

Table 3: Properties of the flat- or block-bricks

Properties	Designation of the flat(P)- or block(B)-bricks						Test-methods
	PT-6.0	BT-6.9	PU-7.7	BU-8.5	PB-5.8	BB-6.4	
dimensions, length, mm	246	247	241	242	248	248	[2]
width, mm	364	364	363	362	366	366	
height, mm	249	238	249	238	249	239	
density, kg/dm^3	0.57	0.60	0.69	0.68	0.61	0.62	[2]
density of earthenware, kg/dm^3	1.26	1.33	1.51	1.55	1.31	1.33	[2]
part of holes, %	55	55	54	54	55	55	[2]
thickness of the innerstraps, mm	4 to 7	4 to 7	5 to 7	4 to 6	3 to 5	3 to 5	[2]
thickness of the outerstraps, mm	8	7	9	10	9	9	[2]
number of rows with holes	25	25	23	23	25	25	[2]
thickness of all straps in one row, mm/m	129	125	155	141	110	112	[2]
compressive strength, N/mm^2	6.0	6.9	7.7	8.5	5.8	6.4	[2]
thermal conductivity, W/(m·K)	0.110 to 0.119		0.124 to 0.130		0.112 to 0.114		[3]
sorption moisture U_m, 80 %	0.4	0.2	0.3	0.4	0.2	0.2	[4]
greatest arch, mm	0.6	--	0.9	--	0.7	--	[5]
greatest difference in height, mm	0.4	--	0.6	--	0.7	--	[5]

The masonry units short term according to the kind of bed joint design as block(B)- or flat(P) masonry units as well as according to the compressive strength were chosen as follows:

PT-6,0 BT-6,9
PU-7,7 BU-8,5
PB-6,1 BB-6,4

The thermal conductivity measured according to the testing method developed at Otto-Graf-Institut as well shown in table 3 must not be consulted to determine a brick masonry’s arithmetic value; this thermal conductivity measurement is used up to now for the development of new masonry units in order to guess the thermal insulation.

4. PRODUCTION, PROCESSING AND MATERIAL’S CHARACTERISTIC VALUES OF MASONRY MORTAR

The thin layer mortar RB regulated up to now for flat-brick masonry is mixed with a whisk and processed in “soft” consistency, moistening the masonry brick’s bearing surface by dipping or applying the thin layer mortar with a special roller on the bearing surface’s vertical straps (picture 1).

Picture 1: Apply of thin layer mortar with a mortar roll

The cover up thin layer mortars included in the examinations were new developed building products, whose field of application has just been lain down by approval or whose approval is done at present.

These mortars still were mixable with a whisk as well, but the consistency of all mortars was more “stiffly”, in comparison with the above mentioned. The cover up thin layer mortars DM, DP and DS were spread in 3 mm thickness (picture 2) with a mortar sledge fitted with a vibratory device. The mortar DB was spread with a special roller, the layer thickness of the fresh thin layer mortar coming up to about 1 mm (picture 3). The light weight masonry mortars LA, LO and LD as well as the normal masonry mortar NM were mixed according to the producer's instructions in rotary mixers and spread on the block-bricks' bearing surfaces up to 15 mm thickness.

Picture 2: Apply of cover up thin layer mortar with a mortar box

Picture 3: Apply of cover up thin layer mortar with a mortar roll

The properties of the cover up thin layer mortars as well as the comparison mortars are compiled in table 4 and 5, mentioning the test methods.

Table 4: Properties of the thin layer mortars

Properties		Designation of the thin layer mortars					Test-methods
		RB-18.9	DB-9.2	DM-11.0	DP-15.0	DS-23.3	
bulk density of fresh mortar,	kg/dm^3	1.76	1.05	1.12	1.35	1.74	[6]
flow table value,	cm	17.8	14.5	13.5	17.0	16.4	[6]
bulk density of hardened mortar,	kg/dm^3	1.52	0.88	0.95	1.13	1.59	[7]
bending strength,	N/mm^2	6.1	3.0	3.2	4.1	6.7	[7]
splittensil strength,	N/mm^2	3.1	1.1	1.7	2.2	3.8	[8]
compressive strength,	N/mm^2	18.9	9.2	11.0	15.0	23.3	[7]
modulus of elasticity,	N/mm^2	7300	2600	4000	5100	9700	[8]
thermal conductivity,	W/(m·K)	0.80	0.16	0.32	0.40	0.82	[9]

Table 5: Properties of the lightweight mortars and the normal mortar

Properties		Designation of the mortars				Test-methods
		LP-4.8	LO-7.8	LL-7.9	NM-14.3	
bulk density of fresh mortar,	kg/dm^3	0.82	0.86	0.94	1.93	[6]
flow table value,	cm	17.1	16.1	17.2	16.3	[6]
bulk density of hardened mortar,	kg/dm^3	0.64	0.73	0.82	1.79	[7]
bending strength,	N/mm^2	2.1	1.9	2.0	3.7	[7]
splittensil strength,	N/mm^2	1.2	1.1	1.1	2.2	[8]
compressive strength,	N/mm^2	4.8	7.8	7.9	14.3	[7]
modulus of elasticity,	N/mm^2	2000	2400	2800	11000	[8]
thermal conductivity,	W/(m·K)	0.16	0.14	0.18	0.84	[9]

In order to judge the capacity of cohesion, the cover up thin layer mortars were applied practically on the bearing surface of 5 of the above mentioned bricks and their covering behaviour was surveyed over a time of about 15 min. Although for all mortars a small, up to 5 mm deep formation of depressions over greater holes could be noticed after 15 minutes, none of the thin wet mortar layers broke off (picture 4). According to this, the here examined thin layer mortars are suitable to produce surface covering, closed layers in the bed joints, in the constancy given by the producer and with the relevant method of application.

Picture 4: Cover up thin layer mortar 15 minutes after application

Of some mortars also 5 cm thick plates, 50 cm x 50 cm, were produced and the thermal conductivity was measured on them.

According to the producer’s instruction, respectively according to the observations made when building up the pillars and walls, the masonry volume mentioned in the following compilation can be built with 25 kg ready-made mortar each. Doing this, in order to level out the brick’s height differences respectively unevenness in the bearing surfaces, the thin layer mortars are spread up to 3 mm and the light weight masonry mortars up to 15 mm thickness.

Short term of mortar	masonry volume executable m^3	Thickness of applied mortar layer mm
RB	3,0	0,5
DB	2,0	1,0
DM	1,5	2,0
DP	1,0	2,5
DS	1,0	2,5
LP/LO/LL	0,5	15,0

5. MASONRY TESTS

5.1 Load capacity

The masonry’s load capacity was determined on 50 cm wide, 125 cm high and uniformly 36,5 cm thick pillars. For some variations, the masonry’s load capacity was also determined on 125 cm wide, 250 cm high and also 36,5 cm thick walls.

When building the test objects, the lowest stone layer of the pillars was lain in a cement mortar bed (MV 1:1) on a even, sharpened steel plate, for the walls it was lain on a steel girder even sharpened on the underside. The further layers were bricked up with the mortar of the planned brick-mortar-combination. The brick masonry was build in the stretching bond with a stretch over value of a half length of stone (about 12,5 cm), the bricks always provided with groove and spring being lain touching in the range of the vertical joints. The highest stone layer was shaped with a similar cement mortar as the lowest of the pillars with even sharpened steel plates, on the walls a steel girder, even sharpened on the top side, was lain.

The bearing surface’s thickness for the mortar after bricking up the pillars or walls came up to

RB	0 to 0,5 mm
DB	0,5 to 1,0 mm
DM	1,0 to 1,5 mm
DP	1,0 to 2,0 mm
DS	1,0 to 2,0 mm
LP/LO/LL/NM	10 to 12 mm

The pillars and walls were stored until testing at the age of 14 to 28 days in a closed room with a temperature of 18 to 22 °C and a relative air humidity of about 40 to 60 %.

The pillars and walls were tested according to DIN 1052 in a 2.000 to 5.000 kN-compression tester, grade 1, with concentric , equally spread loading [10].

The compressive stress was put on the pillars in steps of 50 kN, on the walls in steps of 100 kN, according to 1/10 of the supposed breaking load. After the 4. respectively 5. load stage, the compressive stress was risen constantly until breaking. The increase of compressive stress came up to about $ß_D$/300 per sec ($ß_D$ = compressive strength of wall).

During the test, the pillars and wall panels were observed for occurring of cracks respectively changes. The first sounds of cracking occurred when reaching about 20 % (thin layer mortar R) to 40 % (thin layer mortar D) of breaking load. The first vertical cracks on front and sight panels of the walls occurred when reaching about 50 % (thin layer mortar R) to 80 % (thin layer mortar D) of the breaking load.

For the masonry with thin layer mortar R only rolled out on the straps the breaking occurred pressing the bricks in the range of one or several bed joints into one another. Doing this, the external straps split partly from the internal wall without flaking off.

For the masonry with cover up thin layer mortar D the break occurred by forming cracks on the front sides of the pillars and walls and by flaking off of the external straps.

For the masonry with light masonry mortars breaking effected by pushing the bricks with thin vertical straps in the bed joint mortar mainly by flaking off of the external straps.

The compressive strength $ß_D$ was calculated out of the breaking load F_{max} and the pillar or wall diameter A according to the formula $ß_D = F_{max}/A$ and is listed in the tables 6 and 7.

Table 6: Compressive strength of the specimens out of masonry with flat-bricks and thin layer mortars

Specimens	Compressive strength[1)] in N/mm² of masonry out of flat-bricks and thin layer mortars					
		RB-18.9	DB-9.2	DM-11.0	DP-15.0	DS-23.3
pillar wall	PT-6.0	3.1 2.1 (2900)	3.9 3.0 (3800)	3.5 --	3.5 --	4.0 --
pillar wall	PU-7.7	4.0 2.7 (3900)	5.3 --	-- 3.6 (6000)	-- --	-- --
pillar wall	PB-5.8	2.6 --	3.4 --	2.9 --	2.9 --	3.9 --

[1)]mean of 2 or 3 values
( ) modulus of elasticity in N/mm²

Table 7: Compressive strength of the specimens out of masonry with block-bricks and lightweight mortars or normal mortar

Specimens	Compressive strength[1)] in N/mm² of masonry out of block-bricks and mortars				
		LP-4.8	LO-7.8	LL-7.9	NM-14.3
pillar wall	BT-6.9	2.9 1.8 (1800)	2.3 --	2.2 --	3.7 --
pillar wall	BU-8.5	-- 3.7 (2300)	-- --	-- --	-- --
pillar wall	BB-6.4	2.2 --	1.9 --	1.6 --	3.2 --

[1)]mean of 2 or 3 values
( ) modulus of elasticity in N/mm²

On the walls, the vertical deformations on two 100 cm long sections and the horizontal deformation on a 50 cm long section used for gauging each per wall side panel with inductive measurements, after each load stage was measured.

The deformation modulus of the concentrically acted walls was calculated out of the middle, vertical deformations measured at about 1/3 of the wall compressive strength and as well listed in tables 6 and 7.

5.2 Thermal conductivity

The thermal conductivity of some brick-mortar-combinations was determined on 150 cm wide, 150 cm high and similar 36,5 cm thick walls. The walls were bricked up as described in section 5.1 and 1 wall panel of each was levelled off with a thin coat of plastering. After drying the walls at 110 ± 10 °C until constancy of weight the thermal property was measured and the thermal conductivity was calculated out of this. The results are compiled in table 8.

Table 8: Thermal conductivity $\lambda_{10,tr}$ of masonry out of flat-bricks and thin layer mortars or out of block-bricks with lightweight mortars

Designation of the brick	Designation of the mortar	Dry density of the brick kg/dm³	Dry density of the mortar kg/dm³	Thermal conductivity measured value $\lambda_{10,tr}$ W/(m·K)
PT-6.0	RB-18.9	0.57	1.47	0.110
PT-6.0	DB-9.2	0.57	0.85	0.114
PU-7.7	RB-18.9	0.69	1.47	0.135
PU-7.7	DM-9.2	0.69	0.95	0.151
BT-6.9	LP-4.8	0.60	0.64	0.105

6. EVALUATION OF TEST RESULTS

Valuating the load capacity of masonry made of block- or flat-bricks, it is generally presumed, that the load capacity of masonry increases with declining thickness of joint.

According to the results of the tests executed at Otto-Graf-Institut, University Stuttgart, with masonry made of block- or flat-bricks and normal- or thin layer mortar, this tendency may not be detected for bricks with thin vertical straps and high content of holes for masonry with high thermal insulation.

In comparison with the brick masonry with normal mortar NM-14 with 12 mm thick bed joint, the specimens with cover up thin layer mortar of a compressive strength of 9 to 23 N/mm² with 1 to 3 mm thick bed joints showed widely the same strength.

The compressive strength of masonry with thinner, no more surface covering, up to 0,5 mm thick bed joint mortar RB-19 was significantly below beyond the compressive strength of brick masonry with thicker layers of bed joint mortars.

Always the smallest compressive strength was detected with thin layer mortar rolled out on the straps of the 3 examined flat-bricks. With the cover up mortar a 1,1 to 1,5 times higher masonry strength was tested, see table 9.

Table 9: Influence of the cover up thin layer mortar on the compressive strength of masonry out of flat-bricks

Specimens	Ratio of the compressive strength of masonry out of flat-bricks and thin layer mortar					
	flat-bricks	RB-18.9	DB-9.2	DM-11.0	DP	DS-23.3
pillar	PT-6.0	1.0[1)]	1.3	1.1	1.1	1.3
wall		1.0	1.4	--	--	--
pillar	PU-7.7	1.0	1.3	--	--	--
wall		1.0	--	1.3	--	--
pillar	PB-6.0	1.0	1.3	1.1	1.1	1.5

[1)]ratio 1.2 of the pillars out of block bricks TT-6.9 and normal mortar NM-14.3

Although the flat-bricks fulfilled the regulated requirements on height (< ± 1 mm) and evenness (≤ 1 mm) the thin layer mortar rolled out on the straps is less suitable to spread the tensions occurring not regularly over inaccuracies of placing the masonry units. Above all, if the surfaces of the straps are not placed aligning, stress riser my occur in the range of the straps crossing points, which lead to an earlier failure of the flat-bricks and the masonry.

Only the regular heightening of the thin layer mortar’s thickness up to 1 mm in the range of the thin straps lead to an improvement of load spread of more than 10 %.

The measurements available so far do not yet show an ascertained influence of the cover up thin layer mortars on the thermal conductivity. However, the measurements indicate that the thin layer mortars in about 1 mm thickness increase the thermal conductivity by one class, e.g. from 0,14 to 0,16 or from 0,12 to 0,13. For the thinner thin layer mortar DB it becomes apparent that this one did not or did not considerably change the thermal conductivity in comparison with the thin layer mortar RB rolled out on the straps. The production of thin layer mortar DB with light, weight aggregates may have caused this favourable influence on the thermal insulation effect of masonry.

The modulus of elasticity gauged on the walls at 1/3 of compressive strength increased by about 30 % by using cover up thin layer mortars (brick PT), respectively with increasing thickness and strength of the cover up thin layer mortar up to 50 % (brick PU). With 3800 N/mm² for the bricks PT-6.0 and 6000 N/mm² for the bricks PU-7,7 the values were in the range of the modulus of elasticity which are known for flat-bricks with 4500 N/mm² (strength class 6) and about 5500 N/mm² (strength class 8) [12].

The thin straps significant denting of the brick of high thermal insulation into the light weight masonry mortar with porous aggregates under compressive load lead to an important reduction of the modulus of elasticity, which came only up to 1800 N/mm² for the masonry made of block-bricks BT-6,9 and light weight masonry mortar LP-4,8.

The compressive strength according to DIN 105 of the 10 mm higher flat-bricks was about 10 % smaller than the strength of the block-bricks with the same part of holes.

The compressive strength of pillars made of block-bricks and light weight masonry mortar was always smaller than the compressive strength of pillars made of comparable flat-bricks and rolled out thin layer mortar.

The compressive strength of the 2,50 m high walls was 0,68 to 0,77 times smaller than the compressive strength of the 1,25 m high pillar. According to this, the wall/pillar factor which can be estimated with 0,85 for masonry made of bricks according to DIN 105, should not be applied for masonry made of new thermal insulating bricks. In order to evaluate the load capacity of masonry made of bricks which differ considerably in their content of holes and form of straps from the regulations of DIN 105, only such results should be consulted that were detected on 2.50 m high walls.

7. SUMMARY

In order to estimate the influence of the new developed so called cover up thin layer mortars on the load capacity of flat-brick masonry, pillars and walls bricked up with the following building materials were tested:

3 flat- and block-bricks with high content of holes up to 55 % and thin internal straps of 4 to 7 mm.

1 thin layer mortar regulated by an approval which is spread on the straps by means of dipping or rolling out on the bearing surfaces.

4 new developed thin layer mortars with high capacity of cohesion which cover greater holes in the bearing surfaces as well.

1 normal mortar and 3 light weight masonry mortar for about 12 to 15 mm thick bed joints.

The tests showed that the new thin layer mortars applied in 0,5 to 3 mm thickness cover also greater holes of flat-bricks with high thermal insulation so that a convection stream in holes in the brick masonry that lie on top of the other is prevented.

Using cover up thin layer mortars in 0,5 to 3 mm thickness, the load capacity of flat-brick masonry is improved about 1,1 to 1,5 times in comparison with the thin layer mortars regulated by an approval so far. For this last-named the mortar is only spread on the straps of the flat-bricks by dipping the bearing surface into the fresh mortar or by rolling it out.

Although the flat-bricks here included in the examinations met the sharpened respectively new requirements on height and evenness it could not be avoided that some straps were not placed aligning on top of one another and/or were not fully glued together. The new thin layer mortars spread surface covering lead to an improvement of load distribution and with this to a significant improvement of load capacity of flat-brick masonry. The thermal insulation values should, according to the kind of continuous spread thin layer mortar not be changed considerably or only up to one assessment class. The arithmetic value of the thermal insulation of a masonry is to be proved by measurements for each separate thin layer mortar.

According to touching tests not executed at Otto-Graf-Institut, University Stuttgart, the acoustic insulation of flat-brick masonry may be improved up to 3 dB using cover up thin layer mortars.

In order to improve the load capacity and protection against sound and to avoid convection streams in the masonry flat-bricks with a high content of holes should be bricked up only with cover up thin layer mortars.

The thermal insulating effect of cover up thin layer mortar for flat-brick masonry should still be improved by further developing the thin layer mortars, considering the test results detected at Otto-Graf-Institut, University Stuttgart.

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