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Rational methods of mortar-filling

in vertical channels in fortified walls of DIN 1053

1. Aims

In the DIN 1053, part 3, of Febr. 1990 the procedure of the filling is specified.

- Treating with small gaps in the sense of standards with cross-sections > = 60 x 60 mm to 135 x 135 mm, the gaps have to be filled in every layer of stones.

- If stones are used with big gaps with cross-sections > = 135 x 135 mm, the filling of the channel with vertical fortifying has to be done and insulated at least after every metre.

A

In case that all-round closed channel-building stones are utilized, the standardized filling-technique is - as experience shows - very effective because the stones have to be piled during the process of laying bricks into the vertical fortifying rods.

The aim of this research is to survey the necessary prerequisites. Important for the research is to test the condition of the wall, the filling-mortars and the methods.

2. Carrying out of the research

After various pre-experiments with 7 mortars with additions 0 - 1 mm and 0 - 4 mm the main experiments were taken with 110 channels in walls at heighth of a floor with cross-section of approx. 60/60 mm by using 4 types of mortar (grain-site 0 - 4 mm) in different modes, but exclusively by filling from the top.

There are different methods of filling:

a) Filling form the bottom through drill-holes
b) Filling from the top by using inserted hoses
c) Filling from the top.

As all of these methods obtain the same results concerning the density of the mortar the third version is to be preferred being the most simple and effective method.
The masonry was built up with bricks of small format (Format 2 and 4 DF), which were constituted on form stones, allowing a walling-in of the filling channels - see figure 1 to 3/annex 1.

Concerning the keeping of measurement of cross-section and the unintentional cuts, this case has to be seen as unfavourable.

Four brick layers, familiar with the production of one-sided wall aces, have been taking part to record the influence of individual technique of working.

The reinforcement bar has been introduced later into the channels, each fixed on the bottom and on the top with a ring-like, or a propeller-like distance-keeper of ϕ 60 mm - see figure 4 and 5/annex 1.

Considerating the inevitable crumbling away of the mortar (even not to prevent by taking a timber squared gauge of 60/60 mm for the walls 1 - 16) each channel hole had to be provided with a cleaning hole which as well made possible a problem-free opening of the lower distance-keeper - see figure 1/annex 1.

After > 28 days the walls have been segmented in horizontal and vertical cuts to test the measurements of the channels, the lowest covering-measures of the reinforcement bar and the density of the filling-mortar.

The most essential results of the wall segments have been:

The performed measurements of cross-section have been larger than the measurement of cross-section of 60/60 mm we strove for. By this way the following results were obtained, using slightly different working techniques for the two wall series:

walls 1 - 16	ca. 60 x 64 mm
walls 17 - 35	ca. 60 x 61,3 mm

The first measurement is constant, as formed in the brick, whereas the second measurement is influenced by the finish of the depth of the gaps which normally are thicker than 10 mm - see figure 7/annex 3.

- An examination of the smallest covering-measures in approx. 1.200 measurements obtained as result the mean of approx. 20,2 mm in measurements parallel to the constant side of cross-section, given by the brick dimension of 60 mm, and approx. 21,7 mm in measurements parallel to the variable side of cross-section, whose measure is also determined by the thickness of the mortar joints - see table 2/annex 3.

  The covering measures, occasionally kept within and in general constant above a layer height, are based on staitening of cross-section during the laying of the bricks, on influences of the mortaring of the transversal joints, and on vertical deviation of the reinforcement bar, only fixed below and above by distance-keepers.

- Valuating the singular keeping within of the minimal covering measure, it is to be determined if the minimal covering measure, required by DIN 1053, is to be seen as nominal measure in the sense of DIN 18201 - which is characterized by tolerances.

- Is the standardly required covering measure to be seen as absolute minimal measure, the observation of this requirement is not possible along with the valid design criteria of paragraph 7, DIN 1053, part 3. The observation of a given covering measure is only possible if the distance-keepers are constantly fixed layer by layer on the vertically fixed reinforcement bar, before piling the respective stone layer. This is the same for small and large openings. Generally, concerning the question of the covering measure (also for reinforced concrete construction), it is to be noted that the covering measure is constantly kept within near the distance-keepers if with the radius of the distance-keeper the minimal covering measure is still obtainde.

- In contrast to the expectations after the very good filling results (channels in chip-board slabs) of 7 types of mortar in the preliminary experiments, very good texture dense fillings in the channels built by brick masonry were only obtained with 2 (cast mortar B and C) of 4 types of mortar. These mortars are to be characterized as cast mortars in the sense of the DBV-memo.

  It is to be supposed that above a certain size of cross-section the obviously given influence of the brick masonry on the filling result is not effective anymore and that, generally, in fillings from below a tight texture is obtainable, also with the examined small cross-sections. This was not, though, part of this research.

- The need of filling mortar can be much larger than specified by the volumes of the filling channels. The additional need was up to 60 %, because the very fluid mortar can run off through unintentional cuts into the joints of the channel walls, and, moreover, also into the brick holes. Given a larger channel cross-section, where improvement of the channel wall with a trowel is easily possible, the additional amount could possibly reduced exceedingly. More details see table 1 of annex 2.

The filling is manually as well as mechanically conductable without problems. For this a large offer of mixers and pumps is available for the respective needs of efficiency.

Given the channel cross-section of approx. 60/60 mm and the channel heigtht of 2,75 m, it was obtained - exclusively for the very filling process:

- in manual filling ca. 10 - 11 l/min
- in mechanical filling ca. 21 - 23 l/min

Time for preparation and revising, putting up a scaffold, and supplying the material at the working place is not included - see also table 1/appendix 2 and figure 2/annex 3.

- In the flexural strength test, the collapseload was approx. 17 - 29 % higher than the mathematically determined load, according to the given mortar and brick density classes and to the chosen reinforcement bar. The exceeding of the determined load could be bar attributed to the higher density of mortar and brick, according to examination, in contrast to the theoretical values of the respective density class - see figure 7 and table 3 in annex 4. For deformation see as an example figure 8/annex 4.

3. Summary

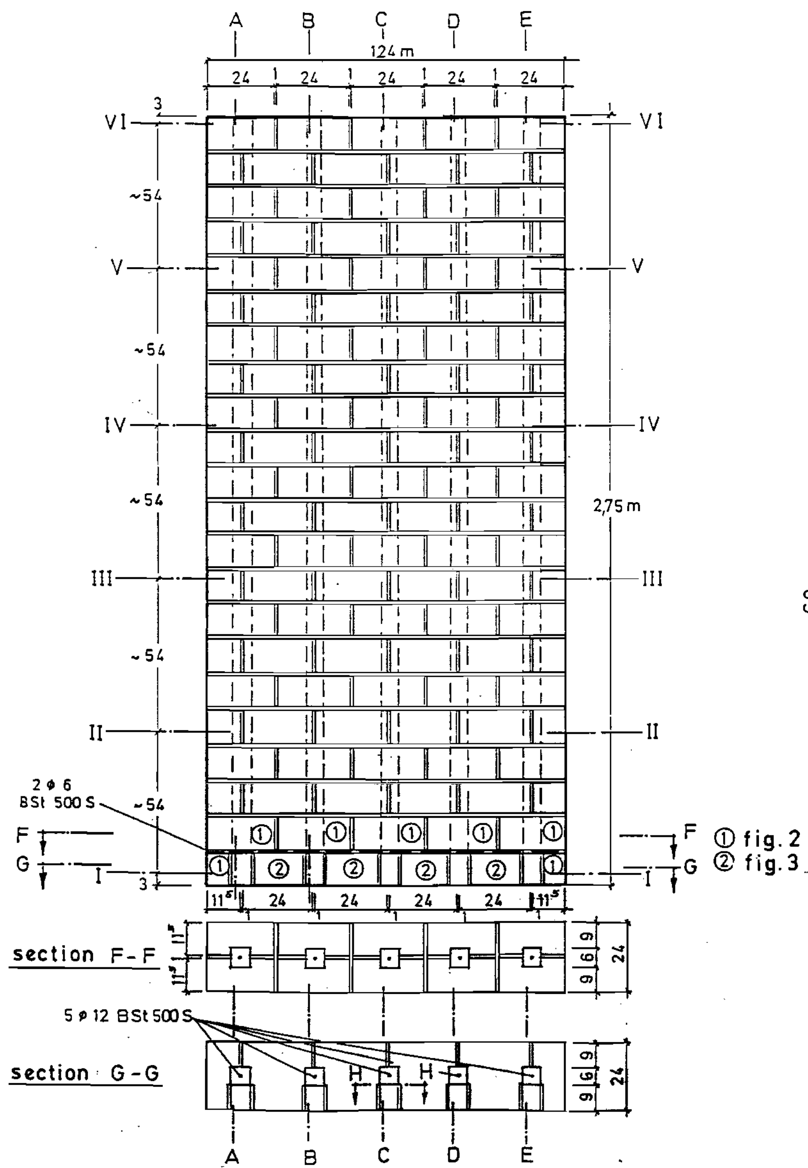
Cast mortars in the sense of the DBV-memo "Cast Mortars" have shown to be very good to obtain a texture-dense mortaring of floor-high channels with the smallest allowable cross-section of 60/60 mm. Other mortars of group III with the same flow measure have also obtained a texture-dense filling in the filling of chipboard slabbed channels with the same dimensions. Is the channel cross-section built by brick masonry, the flow measure of the mortar is not to be seen as sufficient criteria to obtain a texture-dense filling of mortar.

Obviously, the flow measure is changed by repeated contact to the brick masonry on the way from the above filling opening to the reaching of the mortar gauge in the depth of the channel, if the mortars do not have additional characteristics like the cast mortars.

Since only a small part of dry mortars of the mortar classes MG III and MG IV, offered by building-material industries, were included, it should not be excluded that in cases a sufficient dense texture is obtainable also here.

The cast mortars are in respect to their pressure tightness to some extent over-qualified, but do have the advantage that they are applicable ad-hoc without problems.

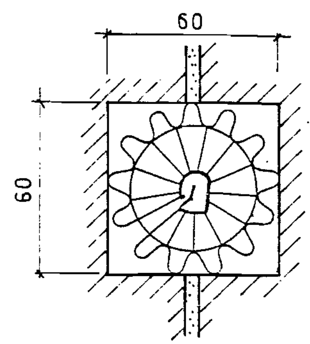
With regard to the relatively high costs of cast mortars, it is to be recommended, for the use in the sense of DIN 1053, part 3, to develop modified mortars, which, because of remarkably reduced pressure-tightness, would result in a remarkable reduction of costs. The necessary minimal requirements should be fixed in a memo.



wall 1-32 b = 0,75 m

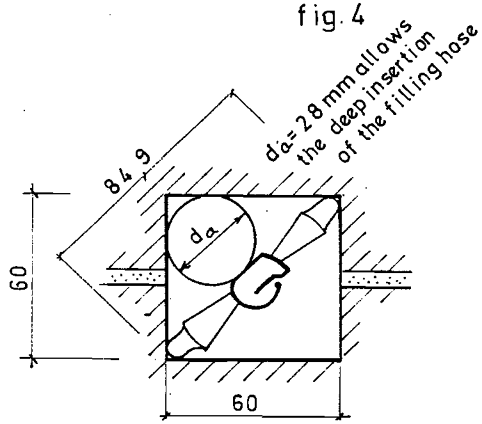
wall 33-35 b = 1,24 m

fig. 1



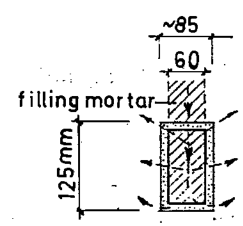
ring-like distance-keeper

fig. 4



propeller-like distance-keeper

fig. 5



section H-H

terminal stone to close cleaning hole

joints around terminal stone has to be done all around, otherwise filling mortar can run

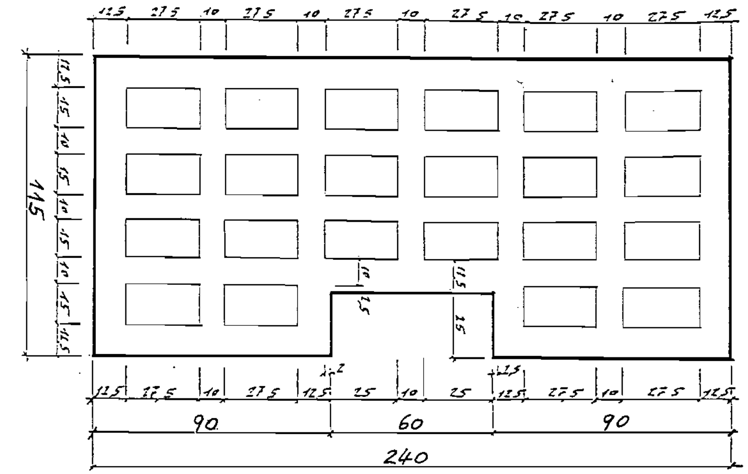


fig. 2

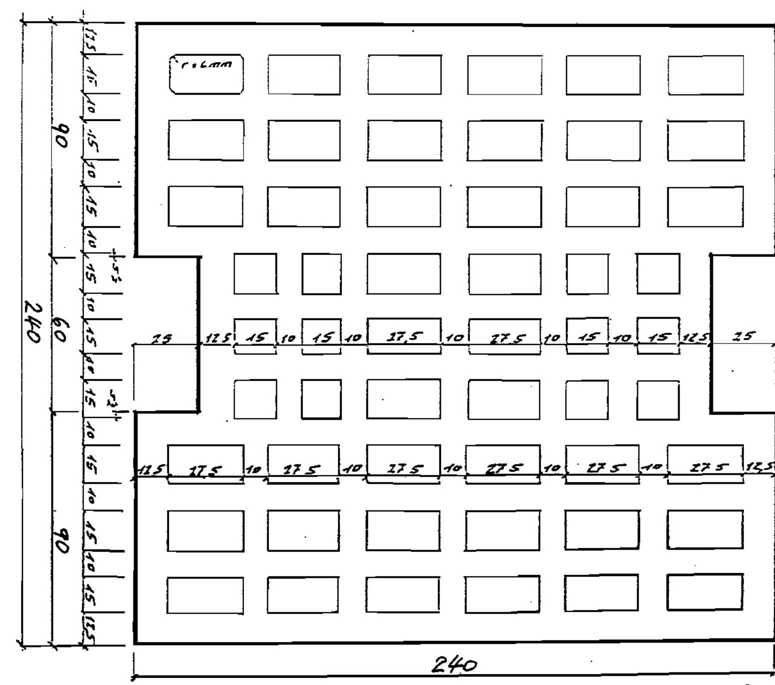


fig. 3

annex 1

wall No.	channel -cross-section theoretical value b/d	channel -cross-section actual value (mean) b/d	channel -vol. mean value MW ./.ø12	filling mortar volume for each channel and surroundings	filling mortar volume for each channel and surroundings	filling mortar volume for each channel and surroundings: rel. to channel volume	fillingtime 1) for each channel and surroundings	fillingtime 1) for 1 filling mortar	filling mode	manufacturer/type	mortar: prismatic strength 1) DIN 18555 ßD	mortar: prismatic strength 1) DIN 18555 ßB	mortar: ρ tr	mortar: flow-measure 2)	mortar: water for mixture	notes
	mm	mm	l	l	kg prefab. mortar	%	s	s/l			N/mm²	N/mm²	kg/dm³	cm	l/kg prefab. mor.	
1	2	3	4	5	6	7 col.5/4	8	9	10	11	12	13	14	15	16	17
1	60/60	60/64,2	10,3	11,7	20,0	113	49-69	4,2 - 5,9	mechanically	A/Mö1	12,04	2,3	1,80	52-54	0,23 3)	n.g.
	"	"	"	"	"	"	i.M.52	4,44	"	"	"	"	"	53	"	
2	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
3	"	"	"	"	"	"	"	"	"	"	"	"		"	"	
4	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
5	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
7	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
8				dropped and destroyed in unifiled condition during transport												
9	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
10	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
11	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
12	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
13	60/60	60/64,2	10,3	11,4	25,0	110	75	6,5	manuelly	B/Mö2	92,1	7,8	2,12	56	0,14	g.
14	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
15	60/60	60/64,2	10,3	11,7	20	113	49-69	4,2 5,9	mechanically	A/Mö1	12,4	2,3	1,80	53	0,23 3)	n.g.
	"	"	"	"	"	"	i.M. 52	4,44		"	"	"	"	"	"	
16	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	
17	60/60	60/61,3	9,8	15,6	31	159	41-51 i.M. 46	2,9	mechanically	A/Mö2	9,95	2,55	1,87	54	0,24 3)	n.g.
18	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	

g = texture dense
ng = not texture dense

1) without time for mounting and removing of equipment, electric installation, water connection, cleaning, assembling time, suplying of dry mortar at mixer, transposition of filling socket and hose resp. of funnel and scoop of channel

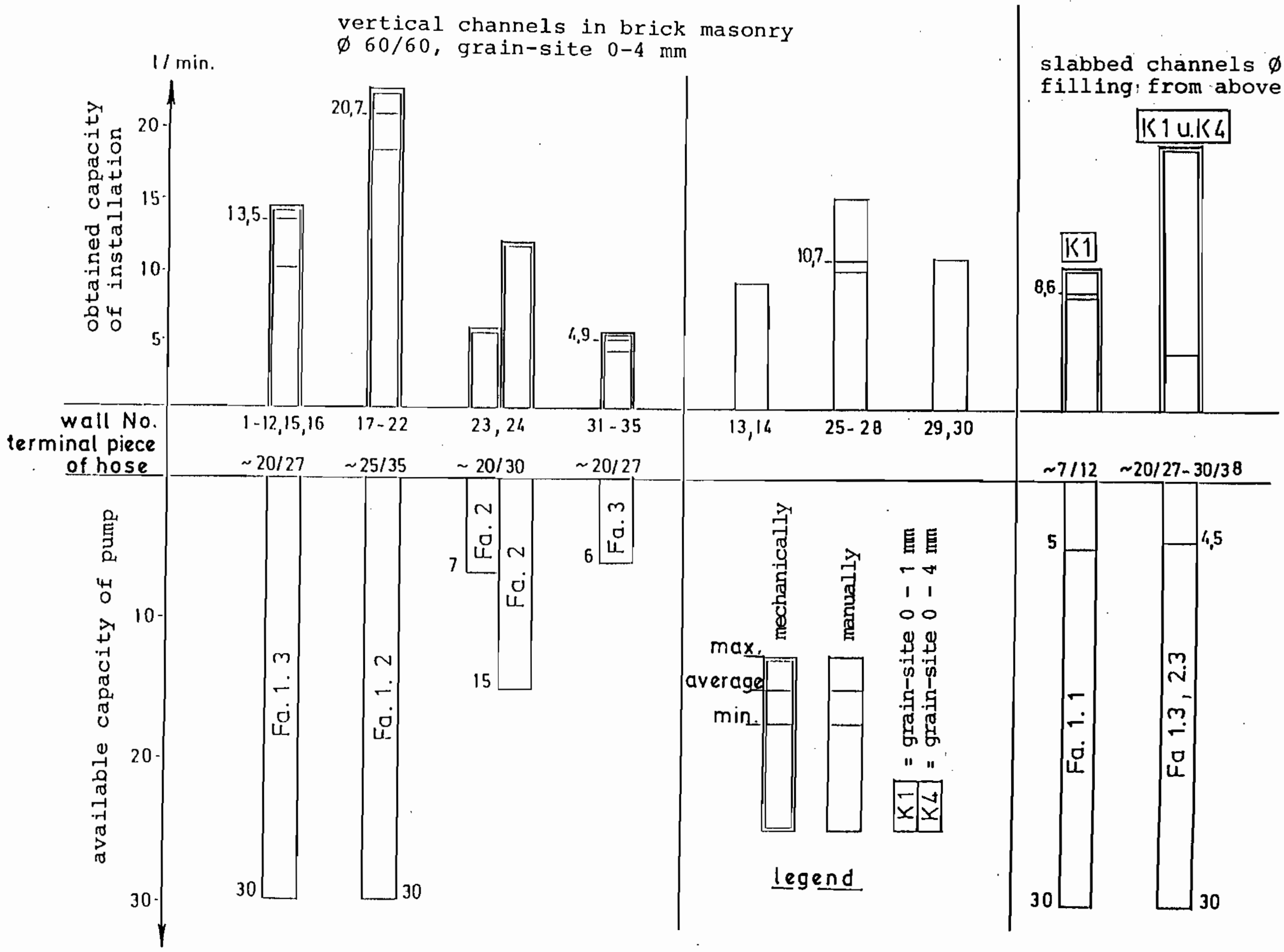
2) according to memo of "Dt. Beton-Verein e.V."

3) value in column 16 according to manufacturer information for running through mixers

Tab. 1

Filling volumes and times, mortar specifications and filling techniques

annex 2



capacity in mechanical and manual filling of vertical channels

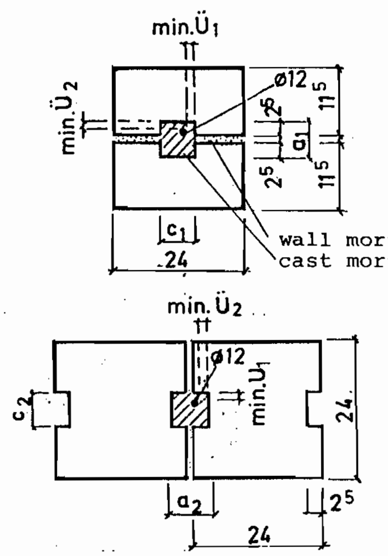
Ø 60/60 mm in brick masonry and in chip-board slabs

fig. 6

	walls No.	mean value mm	s mm	v %	number of measurements
min Ü1	1 - 16	20,41	2,12	10,4	267
" Ü2	1 - 16	22,10	2,20	9,95	267
" a1	1 - 16	64,02	2,28	3,55	59
" a2	1 - 16	64,44	2,22	3,45	206
min Ü1	17 - 35	20,0	1,98	9,92	342
" Ü2	17 - 35	21,41	2,05	9,58	342
" a1	17 - 35	60,94	1,88	3,09	225
" a2	17 - 35	62,72	1,62	2,58	117
min Ü1	1 - 35	20,17	2,04	10,15	609
" Ü2	1 - 35	21,71	2,14	9,87	609

tabular summary of mean values s an v of the smallest covering measures and of the variable side length of channel cross-sections, caused by the juncture mortaring

tab. 3



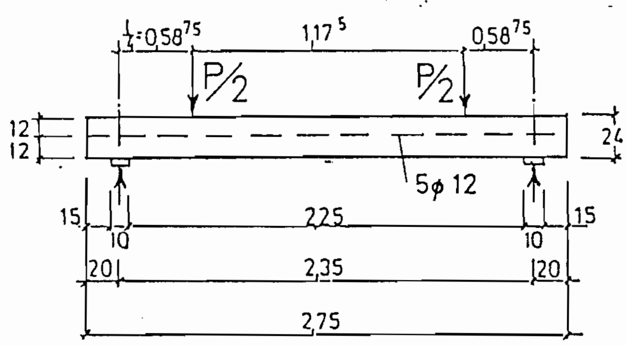
min $Ü_1$ is always valid if C_1 and C_2 = const. 60 mm

min $Ü_2$ is always valid if a_1 and a_2 with influence of transversal joint mortaring

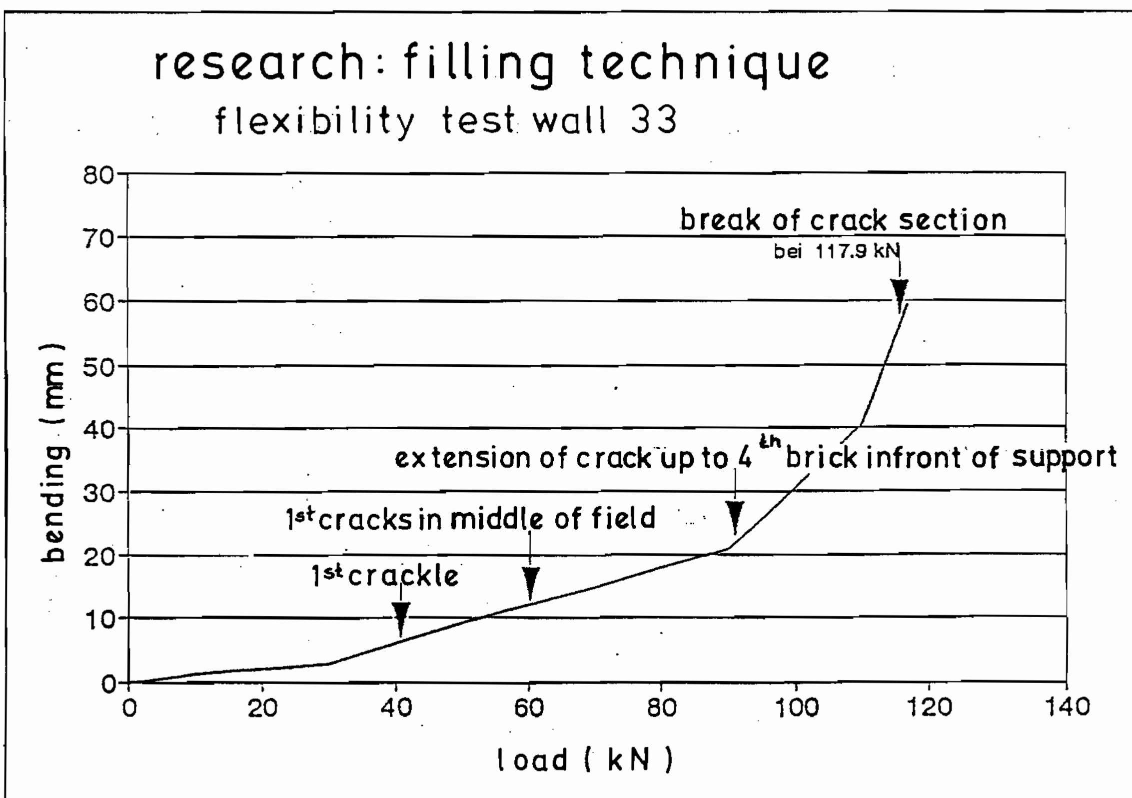
fig. 7

Wall No.	load: permissible at 5 ø 12 u. Mz 20/MG III, σ_o = 2,4 MN/m², $M_{zul.,g+P}$ kNm	$P_{zul.}$ kN	mathematical breaking load: $M_{su,g+P}$ kNm	P_u kN	test: 1st crack M_{Ri} kNm	P_{Ri} kN	break $M_{u,Pr}$ kNm	$P_{u,Pr}$ kN	relative values: $M / M_{su,g+P}$ %	P_{Ri} / P_u %	$M_{u,Pr} / M_{su,g+P}$ %	$P_{u,Pr} / P_u$ %
1	2	3	4	5	6	7	8	9	10	11	12	13
33	16,7	49,0	29,4	92,7	14,1	40	36,7	117,9	47,9	43,1	124	127
34	"	"	"	"	22,8	70	38,0	122,4	77,5	75,5	129	132
35	"	"	"	"	17,0	50	34,4	110	57,8	53,9	117	118

results of flexibility test W33-W 35 tab.3



geometry and load fig. 8



example WD.33 : curve of deflection in the middle of field, in relation to load

fig. 9