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Slurry containers of steel-reinforced concrete

Investigations on technical safety

A large number of regulations aimed at avoiding environmental pollution apply in the storage of slurry, dung and silage. Among the competing construction materials for such containers the favourite in Germany is steel-reinforced concrete. For years there have been complaints from farmers about planning permission procedures, that they take too long, are too difficult, involve too many specialist officials, and often feature apparently over-strict building regulations added as appendices to the building permit. The central question is whether the containers are impervious. In a series of trials, the effects of slurry on concrete were investigated. Water was used as reference material.

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Keywords

Slurry containers, concrete, environmental safety

As part of liquid manure handling slurry containers of sufficient size have to be built.

A further important aspect of the building permission procedure for slurry container construction is the repeatedly asked question as to whether the container is really "safe" and "tight" according to the law. With reference to the vast amount of existing regulations as to the manufacture of concrete containers, the point of view of the building industry is that there should be no problem here.

In practice it has, however, been shown that the suspicion of a possible danger in the construction of these containers is sufficient for the production of added regulations, for instance in the form of extra leak identification. In a series of trials new to this sector, the effects of slurry, and water as a reference material, when applied to concrete under high pressure were investigated.

Legal requirements

The most important requirements created for protecting both soil and water from pollution are contained in the federal water management law (WHG); here, various paragraphs rule on the storage of farm manure. According to § 19g par. 2, facilities for storing and receiving slurry, liquid/solid manure mix, and seepage liquid must be so constructed (.......) so that the best possible protection from surface/ground water pollution is achieved. In § 26 par. 2 (surface water) and § 34 par. 2 (groundwater) it is stated that material may only be stored in such a way that there is no danger of pollution damage. To add more effect, § 22 includes definite compensation requirements for such damage.

The next important legal source is the fertiliser statute which pays particular attention to the storage capacity of any facility. The main point here is that distribution of farm manure must take place "according to good management practice". In principle, the aim should be to deliver to the plant nutritive materials only when the plant requires them. Moreover, excessive nutritive material should not be applied so that no oversupply occurs which could then end up in the groundwater.

Definitive regulations for the building of silage silos and slurry containers are included in DIN 11662. Also regulated for, in DIN 11832, are filling and extraction facilities. All the points mentioned here are specified through state laws, especially the state water laws, building regulations, ordinances and legal requirement catalogues.

The problems, materials and method

Doubts about the technical reliability of slurry containers first appeared at the beginning of the 70s. During a veritable boom in the building of such containers following legal requirements of individual federal states (in Schleswig-Holstein alone, more than 1000 per year were built), companies surging onto the market included some that did not have the required experience. This led to some accidents – low in number, but serious in effect. Occupying news media space for an especially long time was the bursting of a full 1000 m^3 container in north Germany. Later, a detailed investigation showed that the concrete added onto one of the container sides had not the legally required pressure resistance; thus, the accident was without doubt due to construction error.

Subsequently, new building regulations were introduced in the different federal states concerning, for instance, the joint between the ground plate and container wall, and various other actions relating to leakage identification. Going still further were individual regulations which reappeared in appendices to building permits. The construction of leakage detectors, as far as the author knows, revealed no negative results.

In this context, the effects taking place in concrete during slurry storage were investigated. A first step towards this, the extraction of concrete bore cores, was dropped. Whilst the cheapest tender estimated only DM 40 per sample, the too-long period between emptying the slurry and taking the bore samples was seen as a great disadvantage.

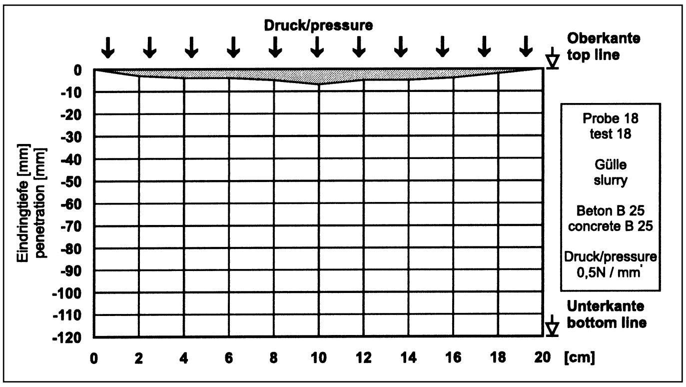

Fig. 1: Tests on permeation depth of slurry

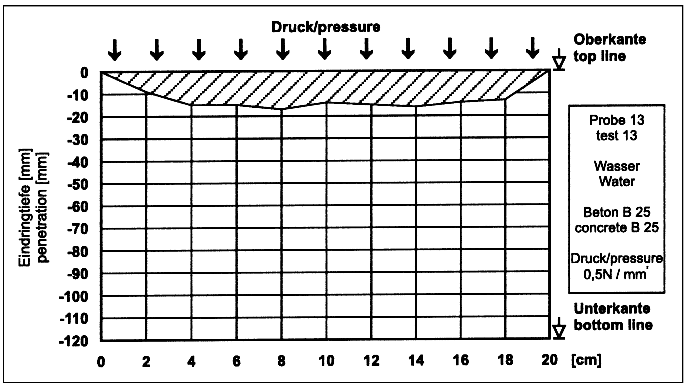

Fig. 2: Tests on the permeation depth of water

Talks at the Institute for Building Material, Massive Construction and Fire Prevention at the TU, Brunswick led to the concept of applying slurry under pressure to concrete samples of defined quality. Water was to be used as reference liquid. Subsequently, the samples were to be broken open by hydraulic high pressure press so that penetration depth could be measured.

Investigation procedure and results

In order to carry out the trial with the same quality of concrete used in practice, the samples were not produced by the testers but instead were ordered from two competing construction concrete works in the Brunswick area. The trial samples delivered were of concrete type 41430.F, quality B 25 (manufacturer L) and the type 61433, quality B 35 (manufacturer L) and samples of the same type and quality from manufacturer (W). All the concrete had the property WU (watertight).

The trial took place in the Material Testing Institute for Building in Brunswick to which the above-mentioned TU Brunswick institute is organically associated. A water penetration test plant was used at the Test Institute. The investigation was carried out according to DIN 1048. According to this, the samples were secured and put under pressure. As required under DIN 1048, the trial was started after the concrete was 28 days old (because of the hardening process). Then, a pressure of 0.5 N/mm2 was applied to the liquid and, therefore, to the concrete for a period of 72 hours. This is ten times the pressure that would normally be present in a 5 m high container and reflected the effect of a long-term trial. According to DIN 1048 part 5, the value to be determined is the average of the greatest penetration depth (up until now only with water) from three concrete samples.

The composition of the slurry used in the trials must also reflect that in practical farming. For this, cattle slurry from the FAL research station was used. It was highly-homogenised in order not to block the trial machinery. First, the density of the slurry was determined gravimetrically and this was 1.012 g/dm^3. The investigation results are tabulated in *table 1*.

After concluding the pressurised period, the concrete samples were broken-open and the different penetration depths measured and tabulated. From this, it was possible to depict graphically the progress of the penetration depths over the cross section. *Figure 1* shows the typical result of a measurement with cattle slurry and class B 25 concrete. It is notable that even the maximum penetration depth is less than the concrete surface coating, so that the reinforcement was not even reached.

Figure 2 shows under conditions which are otherwise the same the penetration of water under pressure. When compared, it is clear that the penetration of the slurry is substantially less than that of the water. This supports the point of view which was also help by agricultural building colleagues in the former DDR that a measurement of the container according to the development of crack width is senseless in that slurry has a self-sealing effect in such conditions.

Conclusion

Considered on the whole, the penetration performance measured with water to that with slurry was from 2:1 to 3.4:1. This gives an average of 2.4:1. This means that the classification of slurry as “dangerous material” from the storage aspect can no longer be supported. Further investigations are already planned. Recommended is that the quality of slurry container construction should be controlled by continuous monitoring during erection and subsequent documentation. In the future it would be desirable, as far as farmers are concerned, when the manufacturers gave a guarantee as to the impermeability of the containers.

Table 1: Tests carried out

Concrete works	Sample No.	Concrete type/ density class	Date of manufacture	Trial beginning/ concrete age	Penetration depth Water	Slurry
L	1-3	41430.F		15.4.2000	3x	-
	4-6	B 25	16.3.2000	(30)	-	3x
	7-9	61433		18.4.2000	3x	-
	10-12	B 35	16.3.2000	(33)	-	3x
W	13-15	41430.F		7.4.2000	3x	-
	16-18	B 25	8.3.2000	(30)	-	3x
	19-21	61433.F		11.4.2000	3x	-
	22-24	B 35	14.3.2000	(28)	-	3x
W	25-27	61333.F	17.4.2000	15.5.2000	3x	-
		B 35		(28)		

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