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On leak-free slurry containers

German agriculture has a continuously large demand for slurry storage capacity associated especially with the numerous new developments related to the agricultural concentration process involving livestock farming. Regarding building permit applications for erecting slurry stores, these processes are complicated and thus take a long time, the building permit authorities can involve as many other specialised authorities in their decision making as they like and, through this, often exaggerated regulations emerge to the disadvantage of the applicant.

The Institute for Farm Machinery and Building Research, FAL, Brunswick-Völkenrode conducted a survey of building planning permission systems and their regulations in 2002 from various rural building societies in north Germany with the aim of establishing where the building permission authorities see the time-robbing problems. It was apparent that, increasingly, not only the constructional-technical aspects of leak resistance with storage containers and their constructional appendages played a major role but also that continuous operator duties were involved in the building permits.

This article reports on a post-dismantling investigation on leak resistance of a plastic-lined slurry lagoon and on the questions of leak-freedom in steel reinforced concrete slurry containers.

Problem

Worldwide, many regulations and laws apply to the building of storage containers for slurry, solid dung and seepage liquids.

In Germany doubts appeared on the reliability of slurry containers in the late 70s as individual, but serious, accidents appeared during a building boom. Caused by building support programmes in various states, during which, e.g., in Schleswig-Holstein around 1000 new slurry containers per year were built, firms and private people also become involved that did not have the required experience. In the building of slurry containers of steel reinforced concrete it was possible that the concrete produced did not have the required quality.

A few accidents also occurred as plastic-lined slurry lagoons began to be built in greater numbers in the early 80s. These occurred because inexperienced farmers attempted to mix the slurry with unprotected agitator propellers. The result was that a major part of the lining wrapped itself round the propeller shaft, allowing the slurry to leak into the ground. Such mistakes are no longer possible nowadays because propellers are always delivered with impact plates or pipes.

All federal and state laws have the main aim of confirming leak freedom in containers.

Leak freedom of reinforced concrete slurry containers

In Landtechnik 1/2001 there was a report over experiments on the penetration of slurry and of the reference liquid water into concrete used in the manufacture of slurry containers.

It was able to be mathematically demonstrated that B35 WU standard concrete had in total a slightly better resistance against penetration of liquid (max. ~ 3%) which, from the environment protection aspect, offered a better concrete.

In that the B25 WU showed completely satisfactory characteristics in respect of impermeability it appeared from the point of view of improving environment safety not to be worth investing more money in a better concrete. However this did not affect the choice of concrete material according to the constructional calculation.

Table 1: N_{min} (kgN/ha) in a dry soil layer under a plastic lined slurry lagoon

Sample	Depth [cm]	Dry matter [%]	NO_3-N [kg/ha]	NH_4-N [kg/ha]	Total/ha $\sum N_{min}$ [kg N/ha]	Total abs. $\sum$ 0-80 [kg N/ha]
1.1	60-80	95.6	7.9	5.4	13.3	69.5
1.2	40-60	94.0	10.0	7.5	17.5	
1.3	20-40	93.5	12.0	8.9	20.9	
1.4	0-20	93.1	7.5	10.3	17.8	
2.1	60-80	96.5	10.2	6.6	16.8	107.0
2.2	40-60	94.9	17.7	4.4	22.1	
2.3	20-40	95.6	25.9	3.6	29.5	
2.4	0-20	95.9	23.7	3.9	38.6	
3.1	60-80	93.1	26.6	5.8	32.4	84.1
3.2	40-60	96.3	18.6	2.8	21.4	
3.3	20-40	96.2	10.2	2.1	12.3	
3.4	0-20	94.1	12.9	5.1	18.0	

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Keywords

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Table 2: Evaluation of permitted construction projects for reinforced concrete slurry stores in four different states

Regulations	Farm 1	2	3	4	5	6	7	8	9
Permission according to § 75 NbauO v. 13.07. 1995 (Nds. GVBl. S. 199)	+	+	+	+	+	+	+	+	+
- Validity loss after 3 years (possibility of extension)								+	+
Site insurance	+	+		+		+	+	+	+
Site borders	+	+						+	
Protected building laws (Nds. GVBl. S. 517)	+	+						+	
Acceptance:									
Steel concrete evaluation (3 days before cementing) (§ 80 (1) NBauO)	+	+	+		+	+	+	+	+
Leak identification drainage/7 days before filling-in trenches (§ 80 (1) NBauO)	+	+	+			+	+	+	+
Slurry container/slurry pit/7 days before going into operation (§ 80 (1) NBauO)	+	+	+			+	+	+	+
Slurry container or slurry pit of impermeable concrete					+				+
- DIN 1045, Abschn. 6.5.5					+	+	+	+	+
- Confirmation by suppliers					+	+	+	+	+
Floor plate of impermeable concrete DIN 1045, Abschn. 6.5.7.2.	+	+		+					
- Confirmation by suppliers	+	+							
- Floorplate must be jointless (minimum thickness 18 cm)					+	+	+	+	+
- Cemented joint between walls and sole must be made impermeable (control by Water Board)						+	+	+	+
- Security system for filling and emptying					+	+	+	+	+
- Special safety measures for the filling point (watertight concrete plate)				+	+	+	+	+	+
Establishment of ring drainage DIN 100				+		+			+
- With welded sealing ring (d ≥0,1 mm) and ≥0,2 % slope							+		
- With control shaft or control pipe (d >250 mm)							+		
Walls of shuttered concrete panels				+					
- Confirmation by supplier	+	+		+				+	
- Joint between walls and plate with hollow cement mortar hollow groove (Fill-concrete DIN 1045)	+	+		+				+	
- Sealing against slurry or seepage liquid according to DIN 11 622 Bl. 2, Abschn. 4	+	+	+	+				+	
- Sealing outer walls against moisture (water pressure, weather influence, plastic reinforced liquid cement)	+	+		+				+	
- Security system for filling and emptying				+					
Joint fillings and prefabricated protection parts sealed with permanent elastic filler	+	+	+	+	+	+		+	+
Regular controls of construction condition (functioning, impermeability)	+	+	+	+	+	+		+	+
- Annual reporting to area civil engineering authorities	+	+	+					+	
Impermeability testing (before going into operation by the responsible building company)	+	+	+	+			+	+	
- Visual	+	+	+	+	+		+	+	
- Filling test (50 cm over 24 hours)	+	+	+	+	+			+	
- Control after first filling with slurry after 48 hours, visual)	+	+	+	+				+	
Pressure testing of permanently laid pipeline (before operation)									
- With 1.3 times working pressure (protocol to the building authorities)	+	+	+	+	+			+	
Wastewater from milking facilities may be piped into the container	+	+							
Free capacity for precipitation water 40 cm/y	+	+	+	+	+			+	
Minimum freeboard 20 cm	+	+	+	+	+	+	+	+	
Connecting pipelines (e.g. livestock building) to be built as pressure pipeline MD6	+	+						+	
Final acceptance (§ 80 NBauO)				+	+	+	+	+	+
Instructions for transport and spreading (Immission values)					+	+	+	+	+
Artificial floating cover					+	+		+	+
Minimum distance from drinking water sources, surface water					+	+	+	+	+
Landscaping plan (begin at latest 1 year after going into operation)	+	+	+	+	+	+	+	+	+

Post-completion investigation of leak-freedom of slurry lagoons

In 1984 two 750 m^3 capacity plastic-lined slurry lagoons were built at the experimental station of the Federal Research Institute for Agriculture in Brunswick. At that time there was no long-term experience of this method of slurry storage. It was decided to use the containers for 15 years whereby the feeling was that this was the outer limit of long-term reliability. Capital for the replacement investment would then be available in time. But while the containers indicated no damage, even indirectly through the leak identification system, the containers were used for a further two years and have now been dismantled and replaced after 17 years use while a new integrated slurry system with biogas plant is established.

This gave a welcome opportunity to carry out a post-operational investigation on the earth layers under the dismantled lagoons.

It was planned to push the sensors one metre deep into the underlying ground but this had to be given up because the gravel-filling proved to be extremely hard – having been packed with a vibrator and consolidated further through yearlong lagoon filling. This ground compaction – which is often underestimated – had as lowest layer under the lagoon a leak-resistance role. The boreholes were stopped at t = 80 cm and samples for every 20 cm were taken from the hollow core so that the laboratory had enough material to work with.

They were analysed by N_{min} method at the FAL Institute for Crop Production and Pasture Research for types and amounts of nitrogen in the different soil depths. The laboratory results are gathered in *table 1*. In general the following deductions can be made:

- In agricultural areas there is no absolutely clean ground
- At no point was the maximum nitrogen value unusually high, as would have been the case with a leak in the plastic lining
- The nitrogen content was in general very low in comparison to that on arable land

Summary

The post-dismantling investigation of ground under a plastic-lined slurry lagoon after 17 years of use showed no leaks had occurred. The technical usable lifetime is obviously substantially longer than assumed so far. From the point of view of the required impermeability it is not necessary to use a higher quality of concrete that B25 WU for steel reinforced concrete slurry lagoons. A variety of requirements are made in the case of new plans for building slurry containers.