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Reconditioning of silage clamps

Practical trials have shown that the treatment of silage clamp floors with a second layer consisting of aerated concrete applied with the aid of a newly developed surface-finisher gives a long-life and cost-efficient renovation.

Fig. 1: Concreting preparations on the Meiereihof

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Keywords

Concrete renovation, silage clamps, surface-finisher

Literature information is available from the publishers under LT 00107 or via Internet at http://www.landwirtschaftsverlag.com/landtech/local/fliteratur.htm

Because of the extreme chemical, physical and mechanical demands made on the flooring of silage clamps these show effects of considerable surface damage even after a short time. Up until now, this wear and tear was tackled by treating the concrete surface with brushed-on applications of plastic or bitumin. These relatively expensive coatings had, however, to be reapplied every one or two years. Despite this, the floors continue to be eroded. The application of a poured asphalt layer is not possible with farm-labour and this results in the process becoming notably more expensive [1, 2, 3, 4].

Target

Existing silage clamps are to be renovated through an additional concrete layer applied to the cleaned original concrete flooring. Aerated concrete, such as used in road construction, has a considerably higher resistance against silage juices than conventional concrete types [5]. The additional concrete layer is to be regarded as sacrificial material. Applied as a layer of 10 to 15 cm, this can lengthen the useful life of a silage clamp by from 12 to 17 years without time and cost-intensive brushed-on protective coatings. This effect is conditional, however, to the concrete being sufficiently-well consolidated and smoothed during application. For this purpose, a simple surface-finisher was to be developed with which the application of a sacrificial layer could be skillfully done as an economical repair operation with farm-labour.

Development of a surface finisher

Requirements

The necessary surface-finisher for treating the flooring represents in principal a vibrating beam. Its concrete-consolidating effect is based on direct application of the vibration onto the concrete surface. The concrete area is pressed forward through continuous application of this equipment. Its operation within silage clamps requires a basic conception involving the following components (*fig. 1*):

- an extendible base frame
- an electric vibration motor
- vibration-absorbing frame outrunners fitting into guiderails
- clamp-width wooden beam for smoothing-out concrete

The working width of the equipment should steplessly fit the width of the silo being renovated as concreting over the total width allows the dependable achievement of consistent consolidation and smoothing.

The prototype

An extendible aluminium roof shuttering frame (firm Thyssen, model Telemax) was used as basic chassis for the equipment. This consists of an aluminium outer frame with steplessly-adjustable aluminium inner profile frames. The available length of 2.75 m of the outer and inner supports and the weight of only 13 kg represent a lightweight basic construction for application in all required working widths.

The vibration motor is a normal frequency outer vibrator for 220 V (firm Wacker-Werke). This motor is fixed to a frame so that it can be tilted about its axis as well moved along the guiderails for positioning in the middle of the working area. An improved compacting result takes place through horizontal armature spindle positioning giving vertically-opposed vibrations. This compacting is important with a floor plate of over 15 cm depth. The vertical position of the motor and its armature spindle achieves a better surface-smoothing effect. Even where the working width changes, however, the motor should always be sited in the middle in order to distribute the vibration effect over the entire width of the beam.

The outrunner rollers allow the implement be moved over the new concrete with little effort and thus the transference of as little vibration energy as possible to the guiderails. For pulling the equipment, cables are attached right and left to the supports. The guiderails are of 50 mm U-profiles. To achieve a stepless working height for simple silage clamp flooring the rails can be laid upon commercially-available vehicle rest blocks. The guiderails can be attached to existing clamp walls through welded-on ties which are then screwed into the walls. After the

Treatment	Material costs [DM/m²]	Working man-hours [Aph/m²]	Labour costs* [DM/m²]	Total capital-investment** [DM/m²]
Sacrifice concrete (8 to 10 cm)	~26,-	0,135	2,02	~28,-
Poured asphalt (3 to 5 cm)				~43,-
Annual bitumen application	0,80	0,150	2,25	(3,05 x 15) 45,75
Plastic dispers. every second year	3,00	0,125	1,90	(4,90 x 7,5) 36,75

* Hourly rates applied for own labour 15.00 DM/h   ** Lifetime of 15 years

Table 1: Costs of different renovation methods (Blöcker 1998, own calculations)

concreting, the guiderails can be dismantled and the screw holes filled with silicon. It was shown in the trials that motor frame, basic frame, outrunners and transport components could withstand the resultant strong vibrations without problems [6].

The choice of the concrete mix was made with the help of Prof. Neubert, FH Stuttgart and Dipl.-Ing. W. Preis, Bauberatung Zement from a standard concrete type list. B 35Wu concrete mixes were chosen because of the special demands of agricultural use and according to availability and cost. They are especially resistant against frost-thaw alternations as well as chemical attack. In order to simplifying the work, expansion joints should be done without.

First concreting trial featuring a silage clamp

The first concreting trial took place in September 1998 in the silage clamp of the University of Hohenheim's Research Station for Farm Animal Biology and Ecological Rural Building. The workforce was unpractised and had no special skills and knowledge in working with concrete. After thorough cleaning with a high-pressure washer of the considerably-damaged original flooring (22m•6m), the longitudinal silage juice drain was shuttered so that it could continue to carry out its function with the additional flooring. Through the resultant lengthways splitting of the floor, concreting against the shuttering could take place in two working operations. This involved the following of two modes of action. In one case the guiderails were screwed to the clamp wall and in the other attached to the shuttering through height-adjustable threaded rods. The guiderails were mounted at a constant distance from the clamp floor surface so that the original longitudinal slope was retained. The lateral slope of the clamp floor, i.e. from each wall towards the centre drain, was also retained in this manner. The concrete was introduced through the reversing of concrete mixer trucks into the clamp and depositing of the load in 10 m^3 portions which were then distributed with appropriate implements by two helpers. The truck moved forward after each portion in order to leave a new area free for concreting. The concrete was then smoothed by a third helper pulling slowly on the cable of the finisher machine (*fig. 1*).

Once the brought-in concrete was smoothed, the operation was repeated with the next load. In this way, a complete stretch was seamlessly concreted. Working time for the 22 m long and 3 m wide stretch was around 1.5 hours. Plastic sheeting was laid over the concrete for complete hydration and for protection against the weather (*fig. 2*).

The second concrete trial was also carried out on a considerably damaged clamp floor (26m•5m), this time on a private farm. This time the total working width of 5 m was treated in a single run. The guiderails were attached to both walls. An existing lateral slope to the longitudinal axis was ignored and this meant a difference in flooring thickness of from 8 to 14 cm. The surface-finisher was adjusted to fit the breadth of the clamp with around 5 cm distance from each wall. This larger gap was necessary because of the unevenness of the clamp walls. The working process was changed on this site. After each concrete delivery (~ 7 m^3) the load was distributed and smoothed-over. For half the clamp area, around 1.5 hours were required. This equalled roughly the time for the first trial. After two hours, the surface had hardened to an extent that plastic sheeting for hydration etc. could be laid over the surface.

The concrete used should be able to achieve the hardness class B 35 Wu or B 25 Wu. The first hardness test with the bull-nosed sledge hammer six days after concreting gave an average hardness reading of 25 N/mm^2. The sample cubes prepared at the time of concreting were stored with the silage for testing after the first clearing of the clamp (nine to ten months later). This test, carried out by the building materials testing station in the college of higher education (FH) in Stuttgart, gave a hardness reading of between 44 and 70 N/mm^2. The emptied and cleaned clamp floor areas were also inspected. Despite having no expansion seams the floorings were free from expansion cracks. The surfaces had kept their integrity almost completely. Only in a few spots where workmanship mistakes had been made was powdering to be seen. The expansion joint grouting between clamp walls and floor plate was also completely sealed.

Costs

With a concrete thickness of 10 cm, the material costs were around 26 DM/m^2 (Stuttgart area). Additionally, labour costs for the construction and dismantling of the surface-finisher, the guiderails and the finishing work had to be included. Comparing the concrete renovation with the application of a layer of pouring asphalt means that respective lifetime, labour time and wages would have to be considered. The cost comparison indicated a clear reduction in costs in the case of farm-labour renovation with special concrete against the repairs with asphalt. Even in the case of flooring with surfaces which meet the requirements for a brushed-on protective layers, the application of a sacrificial concrete layer of special concrete can be practical and competitive. In such cases, the economic advantage of no longer having to carry out periodic time-consuming brushed coatings was clear (*table 1*).

Conclusions

The trials confirmed the suitability of the surface-finisher. With the developed prototype it is possible to carry out a renovation of silage clamps through the application of a second flooring layer of concrete with farm-labour. The renovation can be carried out without any problems by unskilled labour. The suitability of the working system for concreting new silage clamps, farmyards or walking surfaces is proven. The work operation has been optimised through a further concreting trial. Working with single loads of a maximum 9 m^3 was shown as advantageous in the achievement of a continuously smooth finish. Where concrete supply is consistent, working speeds of around 0.3 to 0.5 m/min were achieved. An application has been made for a patent for the surface-finisher.

Fig. 2: Post-concreting treatment through covering

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