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With or without joints - advantages, experiences and feasibility for a new lock

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WITH OR WITHOUT JOINTS – ADVANTAGES, EXPERIENCES AND FEASIBILITY FOR A NEW LOCK

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ABSTRACT

Usually locks are built with joints to tolerate different deformations of neighboured parts due to temperature, different stiffnesses and different settlements. The evaluation of maintenance-reports on locks as well as expertises on elder constructions display some problems with these joint-constructions and with the deformation of the separated construction-parts. In the nineties of the former century a development of jointless constructions for bigger structural parts could be noticed, starting with big foundation plates, water basins, bridges and so on. In this way two weirs with a jointless floor and a first monolithic concrete floor of a lock with sheet pile walls were built. A few years later a monolithic floor of a concrete lock followed. Meanwhile this degree of monolithic construction is a kind of standard together with a reducing number of joints in the walls. The consequence was a suggestion to built two new locks, which are actually planned, completely without joints. The basis of this suggestion is a detailed feasibility study.

SOMMAIRE

Due to negative experiences with joint constructions in waterway constructions during the past the monolithic construction method was picked up and developed further at the BAW. Monolithic constructions are controllable from the static-constructional planning aspect as well as from the material technology point of view. The joint-reduced constructions confirm this just like the positive experiences of the implementing administration. Thus there will be a first completely monolithic lock in Germany soon with the requirement that this building will feature the same robustness as the monolithic locks, which were built more than 100 years ago.

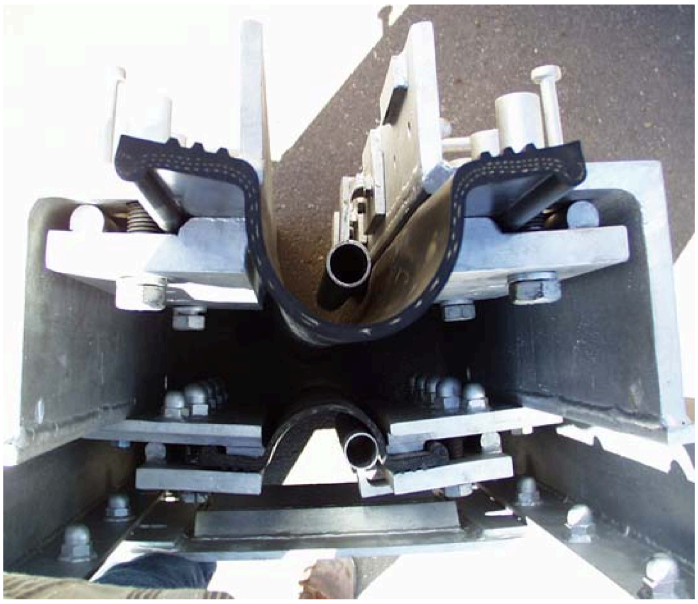
KEYWORDS: locks, concrete, monolithic, feasibiltiy

1 Advantages of jointless constructions

1.1 Static robustness

Joint-afflicted constructions behave like a link chain if different setting of individual sections occurs. The sections extract themselves from the constraint by deformation. If these deformation for different reasons cannot be beared, it is impossible to built joint-afflicted. Then it is necessary to built jointless what leads to a very strong robustness against different setting, unexpected setting (e.g. due to scour) and setting differences generally. Jointless constructions have a large relocating ability and are very durable thereby for unexpected effects. Examples are

- power plant constructions with monolithic foundation plates due to superstructural parts, which can tolerate only minimum different setting;
- weir systems, which were created deformation-poor on a monolithic floorplate due to their sensitive weir gates or weir gates control system;
- locks, which would have so large deformations of individual blocks that the jointwidth would necessarily increase 10 cm, which cannot be handled with usual waterstops. With jointless floors the problem was mastered.



Pic. 1: complex joint construction

1.2 Simplifikation during construction

Joint constructions require a high care when implementing parts and supervising the client. Mainly the following points are to be considered:

- because the waterstops are implemented in whole length already in the floor to avoid insitu fissure, a careful storage has to be ensured for the avoidance of damages - frequently over years.
- the surrounding of the waterstop requires a special configuration of reinforcement.
- the concreting in the surrounding of the waterstop has to be made very carefully, since it is not easy to concrete due to the waterstop and the reinforcement.

The jointless building method does not know these problems. The concreting sections in longitudinal direction of the lock can be separated with construction joints, which can be formed with expanded metal and continuous reinforcement. The individual concreting sections can be dimensioned more freely, which led to larger concreting sections in practice.

The shown advantages of jointless constructions are confirmed by the new building agencies of the federal german waterway and shipping administration (WSV). The sometimes increasing reinforcement as well as the partial increasing planing efforts are estimated as small compared with the total costs.

1.3 Advantages during maintenance

The big advantages of the jointless constructions are the robustness referring to the maintenance during the entire life-cycle. The federal waterways engineering and research institute (BAW) is confronted frequently with problems on joint constructions and with problems due to leaky joint constructions in the context of its experts activity. For example are enumerated here:

- tilt of individual blocks due to leaky joints
- crater at the ground surface due to scour because of leaky joints
- broken joint edges at the concrete
- a lot of repair at leaky waterstops

This statement is supported by the results of the regular inspections. The WSV performs inspections of waterway constructions every six years. Detected damages are documented. Statistic evaluations of these reports identify a bigger number of damages at joint constructions.

All shown problems do not arise with jointless constructions. The robustness of the construction during the life-cycle avoids some damage scenarios and thereby also appropriate repairs. Since the damages can be very large e.g. by tilt of individual construction units and since repairs of joints are very complex, the economical saving potential is very large.

Pic. 2: damage of a waterstop

The shown points are confirmed by a survey in the WSV. In 24 agencies (27 agencies are responsible for joint-afflicted locks) already damages at joints arose. 17 of the 24 agencies with joint-damages already accomplished repairs with adequate expenditure.

2 History of the joint-reduced construction

The joint-reduced building method does not represent a new technology for waterway constructions. Already in the 19th century locks without joints were built. German examples of it are:

- small locks in Kiel-Holtenau, year of construction: 1884; masonry, 207m long and 77m wide;
- sealock in Emden, year of construction: 1913; rammed concrete with clinker cover, 300m long
- locks at the Dortmund-Ems-channel, year of construction starting from 1910; partially reinforced concrete as a framework, 190m long
- lock in Eisenhüttenstadt, year of construction: 1924; reinforced concrete construction with monolithic floor and reduced joints in the walls, length of monolithic floor 105 m

The joint-reduced building method undergoes a kind of renaissance in the 90's of the last century. Due to further results of research on the material behaviour of concrete and due to modern, computer-assisted computing procedures the structural engineer is able to handle the construction more detailed. Foundation plates of power plants and monolithic basins are to be emphasised in this context.

In the WSV this renaissance was picked up:
- Weser-weir Bremen with monolithic floor; in use since 1993
- lock Rothensee, longer floor sections of approx. 45m; in use since 2001
- lock Hohenwarthe, completely monolithic floor; in use since 2003
- lock Uelzen II, monolithic floor with monolithic walls up to the lower edge of integrated water saving basins; start up summer 2006
- lock Suelfeld, monolithic floor and reduced joints in the walls (approx. 45m wall sections); under construction
- lock Fankel, first completely monolithic lock; start of construction shortly
- some completely monolithic locks under planning

3 Feasibility

Compared to the conventional, joint-afflicted construction only the constraint in longitudinal direction changes essentially with jointless construction. The joints are usually arranged, in order to compensate constraint by possible deformations. The main causes of this constraint are

- the load induced by discharge of hydration heat during the hardening of the concrete (early constraint),
- the settlement of the whole construction and
- load induced by seasonal temperature differences (late constraint).

When constructing jointless this constraint must be carried by concrete and reinforcement and this is the subject of the investigations which have to be performed. The early constraint is regarded thereby separately from the late constraint. Shrinking and creeping are without interest for solid waterway constructions.

The dimensioning of the reinforcement for limiting the crack width for early constraint (discharge of heat of hydration) takes place separately for the floor and characteristic wall sections in accordance with *recommendations early constraint* (http://www.baw.de/downloads/publik/merkblatt_frueher_ zwang_rev.pdf) of the BAW. Feasibility studies of the BAW prove increased amount of reinforcement for the floor for jointless constructions. Depending on the underground the rate of reinforcement reaches between 30 and 50 cm²/m for usual ground. For joint-afflicted constructions usually the constructional minimum reinforcement is enough for the floor (maximal 25 cm²/m). For the walls the missing joints are without influence, since the conventional block length of 15m is already too long, to allow the necessary movement to extract the construction from constraint.

The settlement has to be determined at the complete model and has to be superposed with a temperature load at the cross section, see pic. 3. For the computation of the ground finite element software or half space models should be used according to actual standard. With joint-afflicted building method these computations are also necessary, in order to dimension the waterstops correctly. The calculations of the bearing capacity can be performed according to the local standards, in this case in order to DIN 1045-1, the german concrete standard. Since the load is a constraint the safety factor of the action can be reduced to 1.0.

Pic. 3: framework-model of the whole lock with different cross sections

Finally it has to be proofed, that crack width limit is adhered taken into account a seasonal temperature difference (serviceability limit state). It is assumed that the cross section is cracked during the hardening process so that only stresses from the effective area of the reinforcement are able to increase the stresses in the reinforcement.

Thereby the reinforcement arises up to 60 cm^2/m in the case of 2-2,50m thick cross sections. Since the model is chosen conservatively a decreasing amount of reinforcement can be expected with gain in experience. The problem is a subject of present research and development activity, which is supported with insitu-measurements at the new monolithic locks.

4 Résumé

Due to negative experiences with joint constructions in waterway constructions during the past the monolithic construction method was picked up and developed further at the BAW. Monolithic constructions are controllable from the static-constructional planning aspect as well as from the material technology point of view. The joint-reduced constructions confirm this just like the positive experiences of the implementing administration. Thus there will be a first completely monolithic lock in Germany soon with the requirement that this building will feature the same robustness as the monolithic locks, which were built more than 100 years ago.

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