Excursion to the METHA Treatment Plant for Dredged Material and the Silt Disposal Site Francop

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Abstract
The treatment of contaminated dredged material on land is an important element of the sediment management concept of the Port of Hamburg. Up to one million m³ silty, silty/sandy sediments are processed by the METHA plant (Mechanical Treatment of Harbour Sediments) annually.
Contamination of sediments is primarily governed by the grain size distribution. The technology aims on the separation of the different grain sizes of the sediments by using hydrocyclones, upstream current classifiers and spirals. Dewatering is accomplished in an additional treatment step.
A beneficial use of the treated material is one of the main objectives of the concept. The sand and fine sand fractions can be used as construction material. Additionally the silt fraction can be used as sealing material as a substitute for mineral clay on the disposal sites. Further the application in dyke construction is under scientific evaluation.
During the excursion a detailed overview on the METHA treatment plant will be given. Furthermore the tour will take participants to the Francop disposal site for dredged material which in large parts is already under the land rehabilitation process.

1 METHA Treatment Technology

One of the most important results of the Dredged Material Research Programme conducted in the early 80ies was that the content of heavy metals and organic contaminants is primarily governed by the grain size. The finer the particles and the higher the content of organic matter in the sediment, the higher will be the content of contamination. Thus, the separation of the Elbe sediments into several fractions is required for reliable processing of dredged material taking into account the sediment particle size and the contaminant distribution. After preliminary laboratory and pilot scale tests had yielded promising results, a project was commissioned with the aid of the German Federal Ministry of Research and Technology in May 1984. This project concerned the construction of the METHA I test plant (Mechanical Treatment of Harbour Sediments), to demonstrate the applicability of the preliminary tests to plant scale operation. As a logical consequence of the development of a new process, the METHA II pilot plant became operational in May 1987, for optimising the process, development of measurement and control engineering and testing individual assemblies in terms of operation and function.

Fig. 1. Aerial photograph of the METHA plant

Since March 1993 the large scale METHA plant has been in operation (see Figure 1: Aerial photograph). The METHA plant has an annual throughput rate of up to 550,000 t (dry substance), corresponding to 1,000,000 m³ in situ with 50% by weight of silt and 50% by weight of clay. The capital investment for the plant, including mechanical, chemical and electrical equipment as well as surface and subsurface construction and deep foundation, amounted to about € 70 Million. The operation of the METHA-plant requires a total of 96 persons and annual expenditure of approximately € 17 Million including staff costs, depreciation and payment of interest. Corresponding to the throughput rate of the METHA plant the reasonable costs of classification and dewatering are about 17 €/m³.

Figure 2 shows the simplified process flow sheet of the METHA separation plant. Dredged material is transported to a suction unit where the dredged material is pumped intermittently to a stock with a total volume of about 250,000 m³. The discharge stream of the suction unit is conveyed to one of four bar-screens at the embankment of the stock basin. Coarse fractions above 60 mm are separated to avoid clogging in the following process stages. A successive change of the discharge point is necessary to ensure a sufficient distribution of dredged material in the storage basin. Owing to the different settling velocities of the particles, zones are formed consisting of coarser and finer sediments respectively. Therefore, two floating suction dredgers are used to re-extract the sediments and to feed the METHA plant. The positions of the dredgers are controlled with the aim to ensure as constant a process feed as possible. To avoid clogging again the dredged material is screened in a rotary screen, now at a cut size of 10 mm.

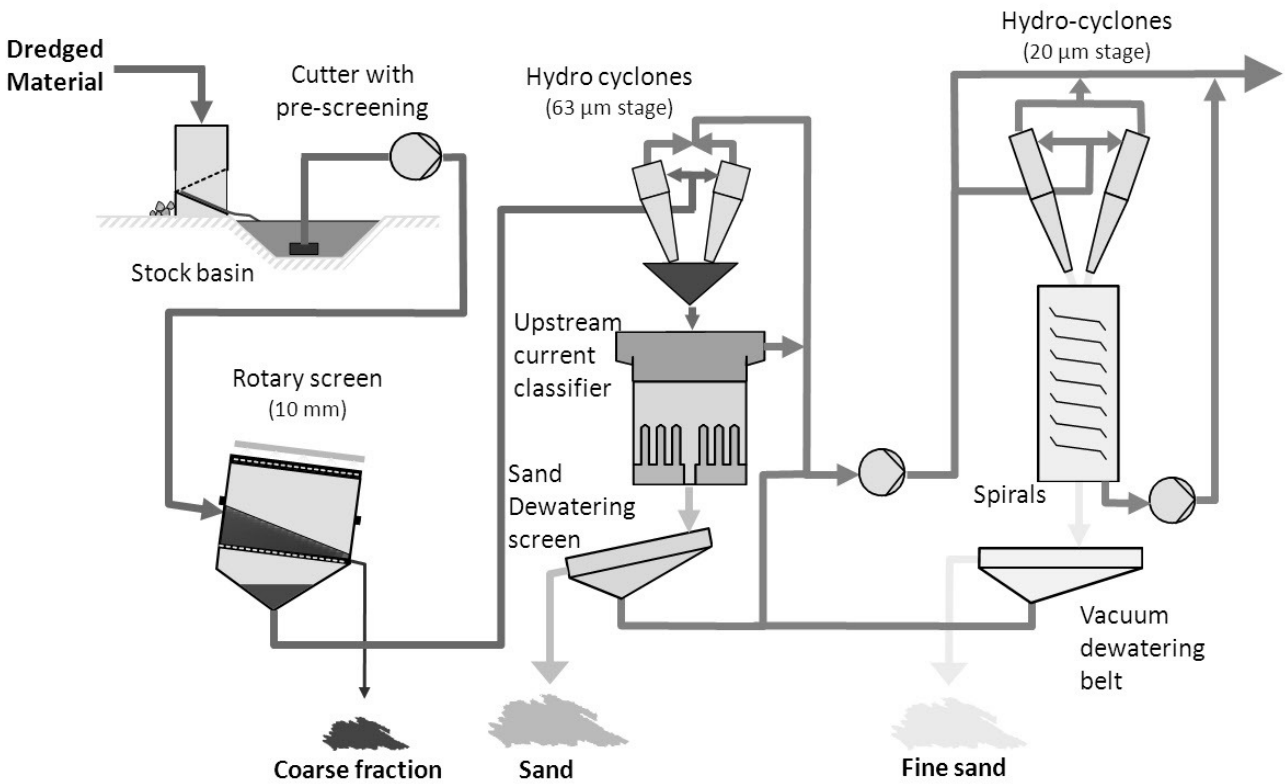

Fig. 2. Simplified process flow sheet of the METHA separation plant

The suspension is then pumped to two parallel operating lines with a total capacity of 200 t/h (dry substance) for the first separation of sand and silt at 63 µm and for subsequent sand dewatering. The feed suspension of the dredged material is separated by hydrocyclones into a silt overflow and a sand underflow. Fine silt particles as well as coal, wood and plant remainders discharged in the underflow of the hydrocyclones are subsequently separated in the upstream current classifiers. Earlier investigations showed that in addition to separation, upstream sorting is necessary for optimum separation into clean sand fraction (> 63 µm) and the silt fraction containing the harmful substances. In order to get a sand product with a consistency meeting the requirements of construction materials, the coarse product of the upstream current classifiers is dewatered on a vibrating screen to a residual moisture content of 10 - 15 % by weight.

50 % of the silt suspension from the first separation stage, hydrocyclone and upstream current classifier overflow, is the input material into a second separation process at 20 µm. The suspension is pumped again

to two parallel operating lines with a total capacity of 50 t/h (dry substance). Again a two step separation is carried out. The suspension is first separated by hydrocyclones into a fine silt fraction (< 20 µm) and into a fine sand fraction (20 – 150 µm). In addition to the separation by hydrocyclones a further sorting process is necessary to produce a clean fine sand product. Fine silt particles as well as coal, wood and plant remainders are now separated using a spiral concentrator. The further cleaned fine sand is dewatered by a vacuum belt filter to a residual moisture content of 15 - 17 % by weight to reach a consistency that is meeting the requirements of construction materials.

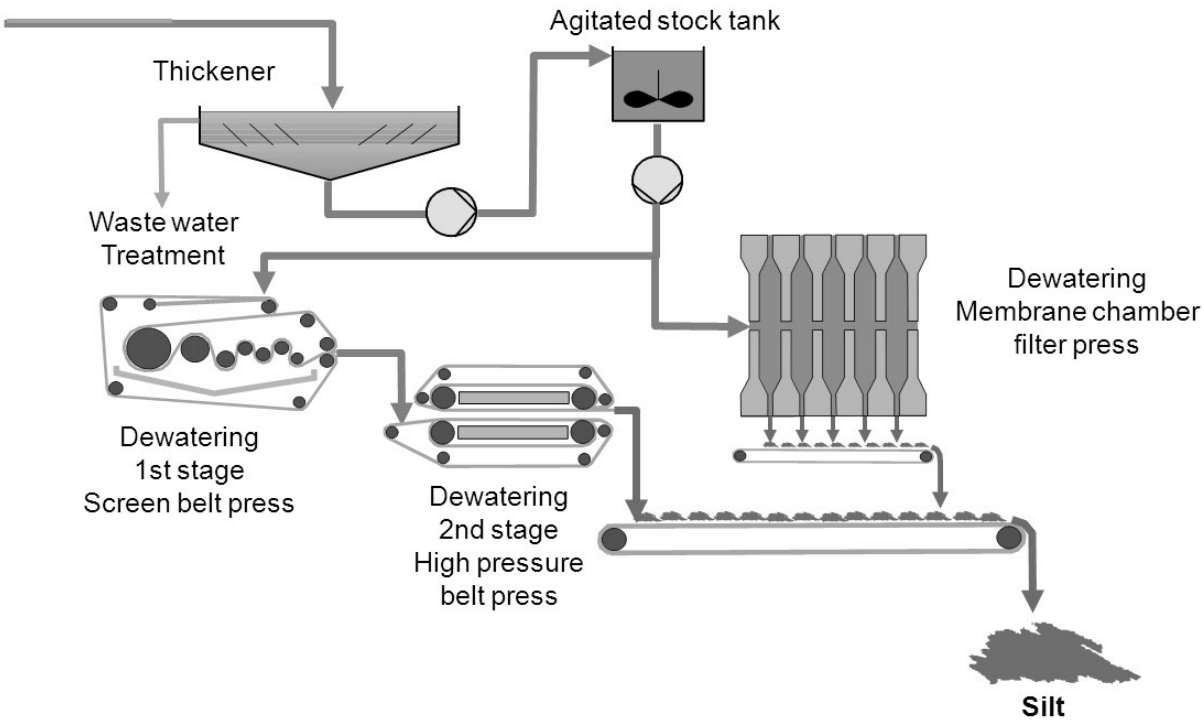

Fig. 3. Simplified process flow sheet of the METHA dewatering plant

Solid / liquid separation of the silt suspension is difficult due to its contents of organic material and clay minerals. Figure 3 shows the simplified process flow sheet of the METHA dewatering plant. In a first step the silt suspension is thickened in two lamellar clarifiers. In order to improve the settling behaviour of the silt particles, the feed of the thickeners is subjected to a flocculation by the successive addition of cation- and anion-active flocculants. Thus, a clear thickener overflow is obtained which can be fed back into the process. The solid content of the thickener underflow is about 200 - 250 g/l. This discharged suspension has to be stored in two agitator tanks with a volume of 2,500 m³ each for homogenising and bridging the different operating times of the classification (16 hours a day) and the dewatering facilities (24 hours a day).

The subsequent dewatering of the flocculated silt suspension is carried out on one hand in two stages by a screen belt press and a high intensity press. Six lines are operated parallel and the capacity of each dewatering line is about 9 -10 t/h (dry substance). Furthermore two additional large scale membrane chamber filter presses are in operation each with a dewatering capacity of 10 t/h (dry substance). A sufficient flocculation of the screen belt press and membrane chamber filter press feed is required for optimum filtration results. Recent investigations revealed that the best flocculation is achieved by the addition of a high molecular cation-active polyelectrolyte. The silt is dewatered to a solid content of at least 55 – 60 % by weight. This value ensures a shear strength of at least 25 kN/m^2 which is required for sufficient stability of the silt product e.g. in the disposal sites.

2 Dredged material disposal sites

With the construction of two special disposal sites at Francop (see Figure 4: Aerial photograph) and Feldhofe an option is available for environmentally safe disposal that meets all legal and technical requirements. The Francop disposal site is located in the west of the harbour, directly next to the METHA plant, and the Feldhofe disposal site in the east of Hamburg. Formerly these locations had been used as flushing fields.

Restoration of the old site was not a sensible alternative from either an economic or environmental viewpoint. After careful examination of alternative sites, the planning authorities therefore decided to use these sites for disposal. Establishing disposal sites above the old flushing fields meant that the base seal of the disposal site was ensured and avoided the use of other areas of land. Only silt that has been dewatered in the treatment installation METHA and in the dewatering fields in Moorburg is deposited here.

Fig. 4. Aerial photograph of the silt disposal site at Francop (2009)

The principle of the construction of a dredged material disposal site is shown in Figure 5. The design principle of the landfill site is that the silt is built up in layers, each 1.5 m thick. To make sure that the free water can be conducted away safely during the consolidation process, sand drainage layers are installed between the disposal layers, each 30 cm thick. The material to be deposited comes directly by dumper or by lorry from the discharge heap of the METHA plant or from the stacked heaps in the dewatering fields.

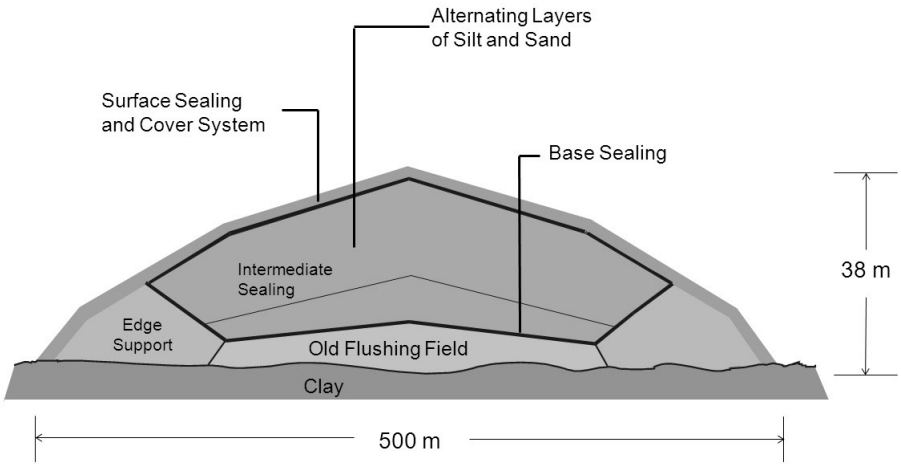

Fig. 5. Construction principle of the Francop disposal site

The landfill site is secured at the base with a double seal, consisting of a 2.5 mm strong, watertight and extremely resistant synthetic seal of high density polyethylene (HDPE) and a 1.5 m strong layer of silt as a mineral seal. An upper sealing to the mound inhibits, to a large extent, ingress of precipitation into the body of the landfill. It consists of a 1.5 m strong silt seal layer, and on top of a multiple layered base construction:

sand for drainage, loamy soil as natural root barrier against deep rooted plants and an arable soil layer. The landfill sites are landscaped by a richly diversified recultivation and installation of a road system and, after completion, can be made accessible for the public.

In Francop the drainage water is collected in wells and transported by a pipe system to the technical wastewater treatment plant on site. In Feldhofe the drainage water is conveyed to a newly installed pond purification plant.

The construction meets the strict requirements of the German Landfill Decree. Nevertheless there are emissions from the disposal sites. In order to monitor the functional efficiency of the disposal site safety systems, the emissions are measured at various positions around the mound as part of a monitoring programme. These measurements are evaluated by the relevant authorities and published each year in environmental reports. Once the capacity of the disposal site will have been exhausted and operations ceased, the aftercare phase begins. In this phase the disposal site is ultimately recultivated. Technical systems such as drainage pipes, shafts and pumps must also be serviced and emissions monitored. Only when the relevant authorities establish that all operational activities have ceased and that no negative long-term effects on the general wellbeing will result from the disposal site, the aftercare phase will be officially terminated. After the disposal sites are ultimately recultivated they will be available to the public officially as a recreation park.

The annual disposal capacity reaches up to 700.000 m³ dewatered silt material and the costs are about 15 €/t original disposal material.

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