Innovative thermal activation of container terminals

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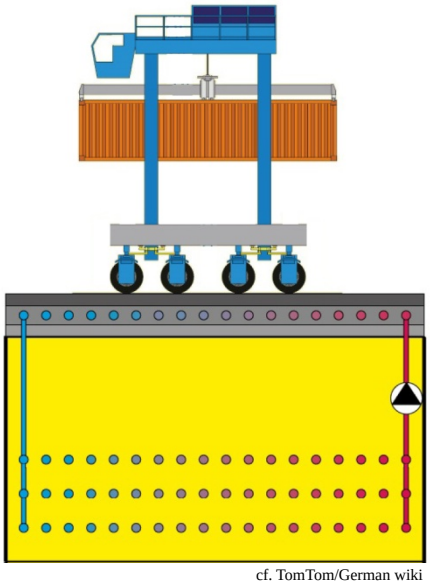
The increasing transport volume of goods worldwide leads to a growing number of containers which have to be handled at ports. This handling is often done by heavy straddle carriers which transport the containers from one location of the terminal to another. Therefore, the pavement of these areas experiences very high loadings during the whole year. The top layer has to be constructed for high mechanical loads caused by crossings as well as thermal stresses due to high temperature changes throughout the year. These requirements increase the construction and maintenance costs. Deformations of the pavement caused by loads and temperature changes require repair work periodically. This results in a down time of the terminal which leads to expensive operational disruptions. In regions with a high temperature change between cold winters and warm summers the top layer has to be constructed with respect to resistance against brittling and temperature deformations.

A temperature control of the pavement of container terminals could decrease operational costs by increasing the availability of the terminal as well as the operating life of the top layer and by ensuring an interruption-free accessibility during the wintertime. However the temperature control by conventional energy is far too expensive due to increasing energy costs of fossil fuels. Furthermore the common shallow geothermal systems are too expensive and inefficient. Drilling holes across the terminal are too time consuming combined with high investment costs.



cf. TomTom/German wiki

Figure 1 - Design of a geothermal activated pavement for container

The main idea is to develop a geothermal system that uses the shallow geothermal potential through horizontal ground heat exchangers which are build on a large area, deeper as conventional ones and if possible in several layers (see figure 1). The installation of these deep and layered horizontal heat exchangers is feasible if they are build in combination with the extension of existing harbours to create new terminal or industrial areas. This is planned for regions in the harbour of Hamburg. Hereby it is possible to install such systems efficiently resulting in a minimum of effort and expenses. With this method it is possible to distribute the change in temperature in a much bigger volume instead of having the effects of temperature change only located in the pavement.

The pavement has to be modified to be able to meet the requirements of such a technology and therefore be able to conduct the heat. Two main methods seem to be possible. One of these integrates pipes into the pavement. The other one integrates a porous layer into the pavement. Both methods will be located in the upper part of the pavement to reach a proper thermal conductivity and if possible to create an insulating layer beneath. Such a modified pavement is called thermal activated. Major components of the whole system are the installation across a large area as well as the good ability of the asphalt to absorb the sun light. During the summer month heat can be conducted through the thermal activated pavement into the ground where storage is possible. The whole area is working like a solar collector. Beside the effect of collecting solar energy it also cools the pavement and therefore

increases the life time of top layer exposed to high stresses. This effect seems to be the major advantage for an economic use of the system. Due to a lower temperature of the asphalt during the summer the mixture of it can be designed to a smaller temperature range. This leads to a better resistance of the pavement. Caused by the properties of asphalt the challenge is to determine a compromise between temperature and stress resistant. Decreasing the temperature range enables a stiffer mixture which improves the resistance against deformation. The same advantage is valid for the winter months when the pavement can be heated with help of the stored heat. The increase of the temperature level in the winter of the top layer allows also an improvement of the mixture based on a smaller temperature range. The main attributes can be designed for a smaller range of environmental influences which results in a special mixture for the pavement. This improvement can reduce the maintenance costs for a terminal area significantly and leads to an important environmental aspect, the reduction of CO_2 emission due to fewer renewals of the pavement. The best suitable design of the horizontal heat exchanger in the ground has to be determined by numerical simulations. The goal should be to activate a volume as huge as possible. The harbour location becomes an advantage for the system due to the higher heat capacity of saturated sand which will be the main material of the storage.

Beside the use of the stored energy in the ground to heat the pavement of the container terminals an integration into a district heating system is possible. For years it was observed that the residential areas are growing closer to industrial areas. This provides the opportunity to use waste heat from the industry to support a district heating supply. Especially during warm periods the horizontal heat exchanger cannot conduct the complete heat flow into the ground. Hence forwarding the flow into a district heating system is a very feasible solution. The heat can for example be used to cool business buildings and private houses by adsorption refrigerators. This requires an intelligent energy management but offers an excellent energy distribution and a significant reduction of emissions.

One of the geotechnical challenges besides the energy supply is the settlements during and after the construction. The whole system has to be tolerant to settlements. All connections and pipes have to be resistant against a movement of the soil and also have to be compatible with drains. This requires a well designed system and numerical simulations to determine the behaviour of the ground in an early stage of the project.

The idea of a thermal activated container terminal will be presented. The challenges for this technology as well as a first example of how this method can work as an economic technology for container terminals will be explained.