Concrete core activation
Working principles and general applications
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1 Introduction

This module goes into the possibilities for implementation of concrete core activation systems in various applications. Concrete core activation can be used for heating and/or for cooling purposes. It is even possible to integrate the ventilation requirements to obtain a complete HVAC (Heating, Ventilation and Air Condition) system. The motivation for using this type of installation concept can be derived from a different points of view, for instance:

- a high point of comfort
- energy saving and specific environmental issues as CO_2 neutral design
- integrated design

2 Working principle

In general, the working principle of concrete core activation is based on accumulation (temporary storage) of heat and or cold (energy) in the concrete of the building. This heat or cold can be used to obtain the required temperatures in a building space. This way of heating and/or cooling of a room is based on a low level of heating or a high level of cooling temperatures in combination with a large surface (ceiling, wall and/or floor). It is obvious that buildings like blobs, without heavy mass and a glass-façade with a high g-value, cannot be cooled only with concrete core activation without running into problems of discomfort.

2.1 Basic principle

As shown in the diagrams figures 4 and 5, one shows the heating mode and the other the cooling mode, water will be pumped through a piping system. The various loops (groups) could be integrated in a concrete ceiling, wall and/or floor. These loops are connected to small headers located throughout the building layout. These headers, capable for approximately maximum 15 groups each, can be located in corridors, working closets, wardrobes, kitchen blocs, archives or above suspended ceilings. It is from a viewpoint of flexibility, very important to place the headers on well-selected places. For instance, partition walls are always subject to change in location due to the possible change in function and or use of the building layout. These headers will be connected by a main distribution (supply and return) pipe system to an energy source. In case of heating and cooling the distribution system will often consist of three pipes. Supply warm water for heating, cooled water for cooling and a combined return. In some case(s) an area needs to be heated and the area next to it has to be cooled. This is all in compliance with the internal and/or external heating and or cooling loads.

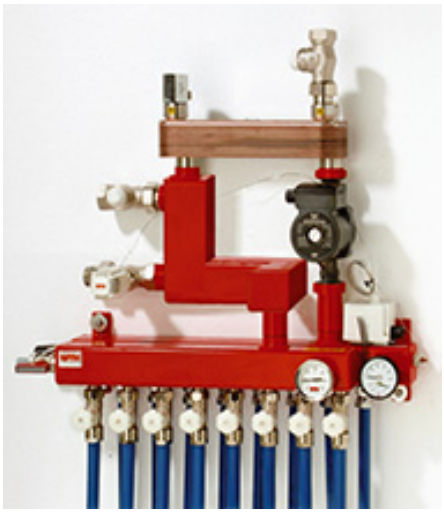

Figure 1: Eight groups header with pump and heat exchanger

Figure 2: Traditional casting of concrete on concrete core activation piping.

2.2 Energy source

In order to obtain the required energy for heating and/or cooling an aquifer can be used. The system consists out of a number of essential elements. The wells itself, the depth is depending on the level of the two different aquifers and can be around 100 m[1]. A heat exchanger must be used to obtain a barrier between the water out of the ground and the water in the installation system. The purpose of the heat exchanger is to transfer only energy and to prevent direct contact between the two water systems. Pumps have to be installed to distribute the water from the wells to the heat exchanger. Additional pumps have to be used for distribution the heated and or cooled water from the heat exchanger to the various headers throughout the building. From the headers there are connections to the installation pipes (loops) casted in the concrete floors, ceilings and or walls. The efficiency of this system is limited and can be increased by a heat pump. See item 3.1.

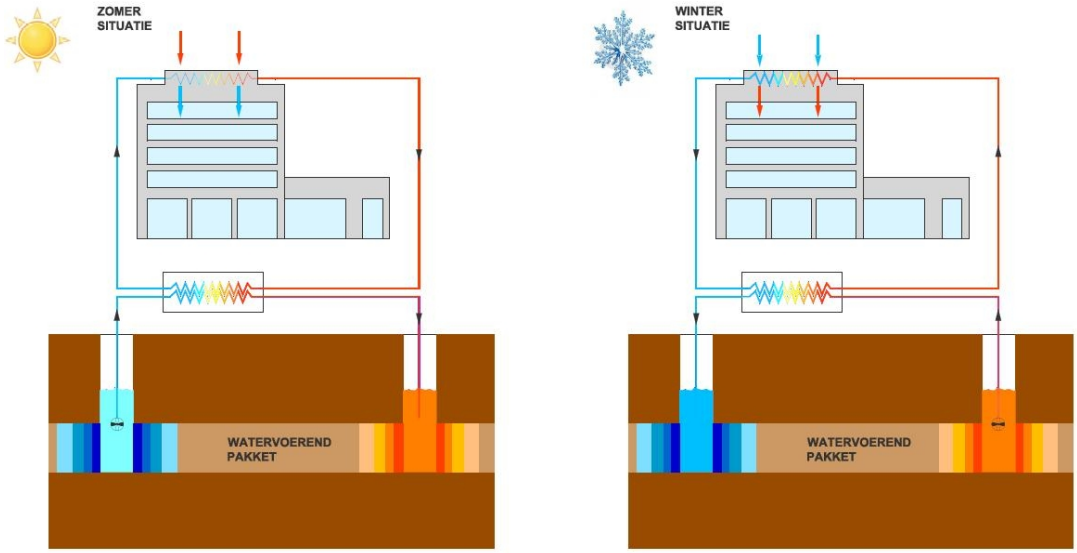

Figure 3: Building connected to an aquifer for energy storage and -use in the summer and winter situation.

3 General Applications

3.1 In combination with a heat-pump

In order to know how much heating or cooling energy is needed for a project, heating load and cooling load calculations have to be made. On the TUD-blackboard basic calculation programs based on excel sheets can be found (the equations are explained in Module I-380).

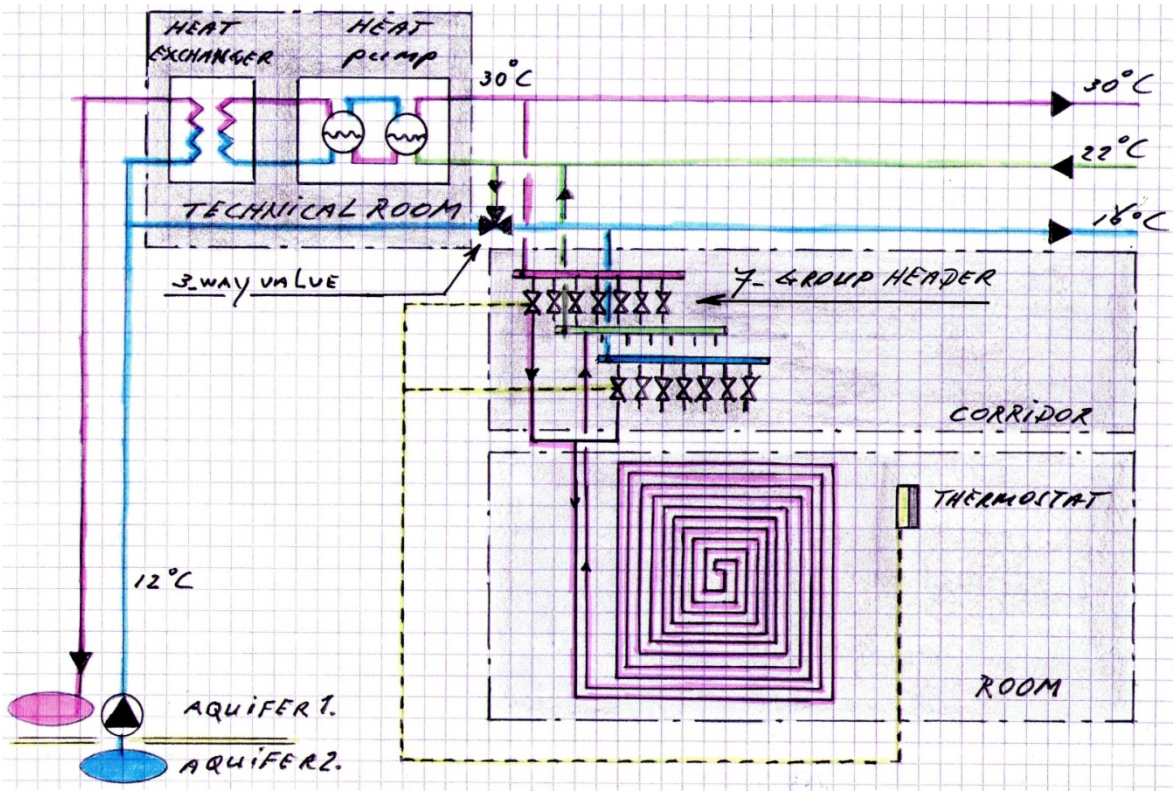

Figure 4: Heating mode.

In the diagram one loop casted in the floor is presented. In order to obtain a maximum of flexibility, each room should have its own loop. In this way it is possible to place patrician walls and to heat up one room (office) and cool down the adjacent one. A point of attention is that one room can have a low internal heating load and needs to be heated and the adjacent room may have a high internal load by the presence of many persons (meeting room) and needs to be cooled. By placing thermostats in each room individual temperature control of the indoor climate in various rooms is possible. In case of a landscape office thermostats should be connected to zones and prevent that one loop is in the heating mode and another in the same zone is in the cooling mode.

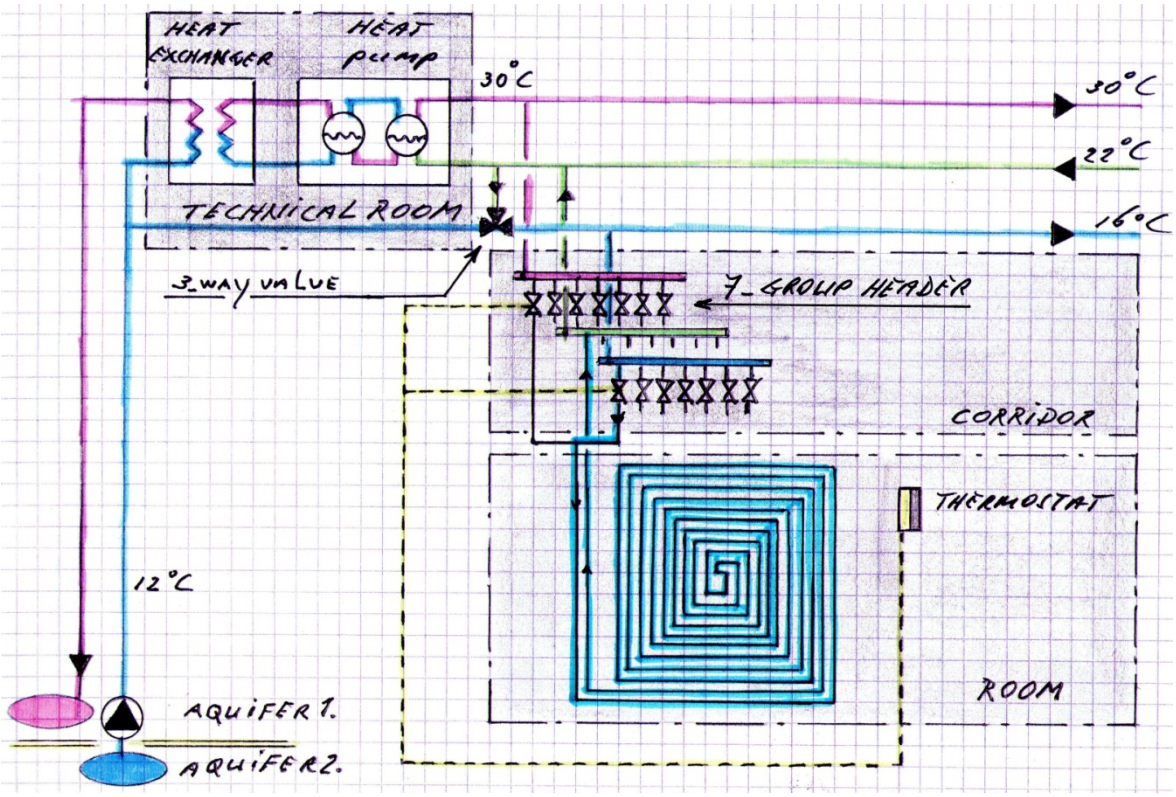

Figure 5: Cooling mode.

3.2 Supported by a climate roof

In order to obtain a balance between storage and withdraw of energy of the aquifer in the ground (by regulation) a climate roof can be used. The generated energy (warm and cooled water) can be stored as long as required for maintaining an energy balance over an period of a year. For generation of warm water, piping or cassettes can be installed direct under the black coloured roofing material. The sun will heat the water that can be stored in the ground.

Other options to store cold energy are:

- convectors on top of the roof of a building through which cool ambient air can blow (mostly during the night);
- a heat exchanger that uses the cold from the river water or a deep lake.

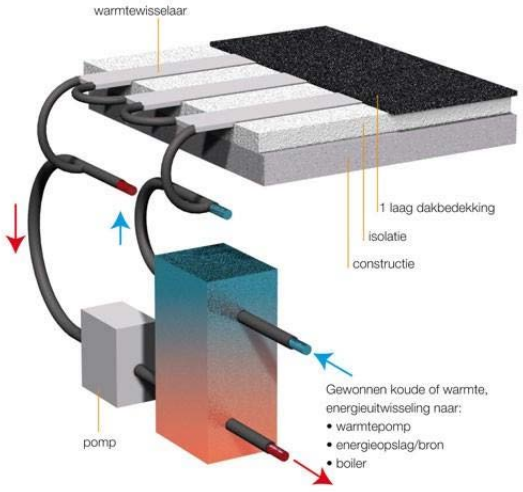

Figure 6: Detail of a climate roof for heat generation.

4 Special Applications

Most of the concrete core activation systems use water as a medium to transport and store the energy in the concrete mass of the floors, walls and/or ceilings. Generally, concrete is casted in formwork in which the piping has been fixed. Different applications are introduced on this more or less standard principle.

4.1 Pre casted floor slabs

From the point of cost reduction and gaining building space a lot of projects have used precast concrete floor slabs and or elements. That was interfering with the wish of using concrete core activation that requires concrete of concrete floors at the spot. In order to make concrete core activation possible by pre casted building elements as well, special pre casted floor slabs have been developed.

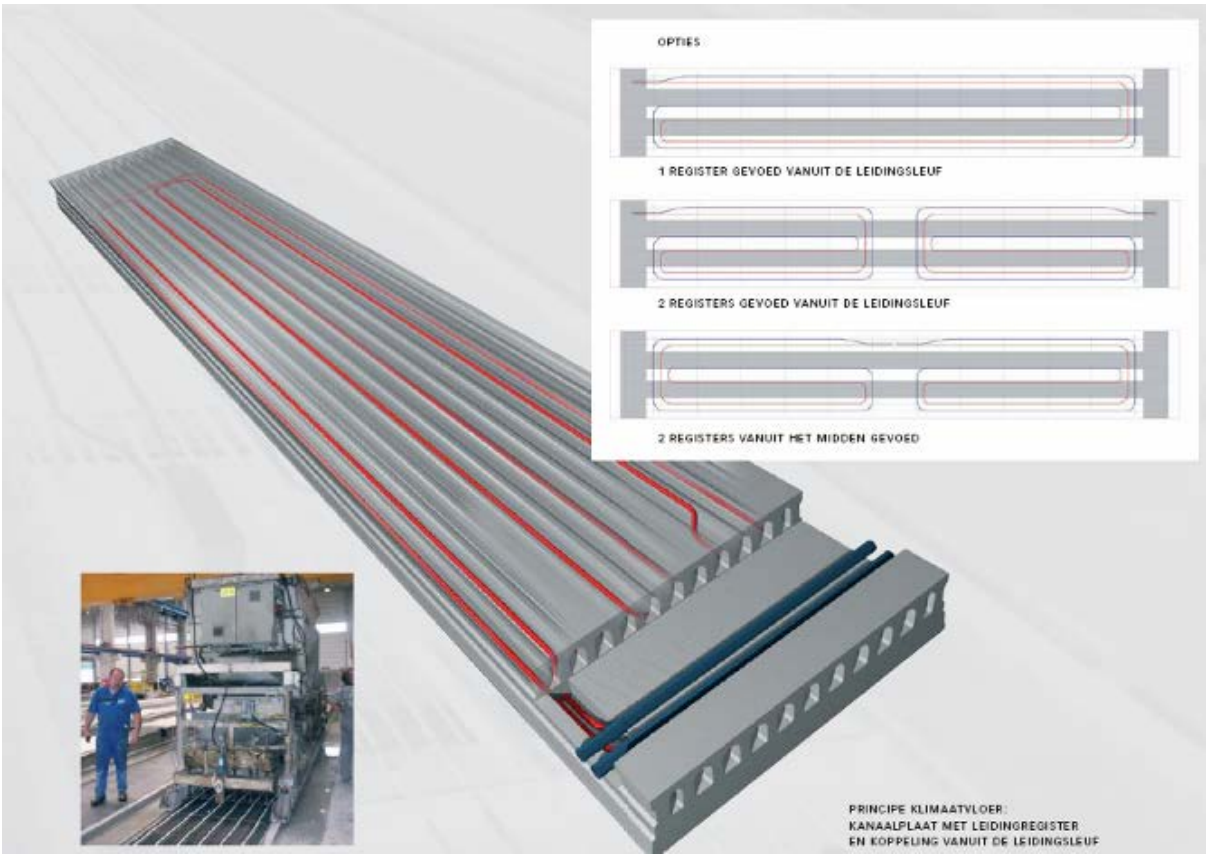

Figure 7: Pre fabricated concrete floor slab.

4.2 Outside air as medium for concrete core activation

In some cases outside fresh air for concrete core activation is used. This fresh outside air can be used for ventilation purposes at the same time. However, it should not be forgotten that the main purpose for ventilation is obtaining a good air quality. And that temperature is part of the required thermal comfort. Generally an additional heating system wil be necessary[1].

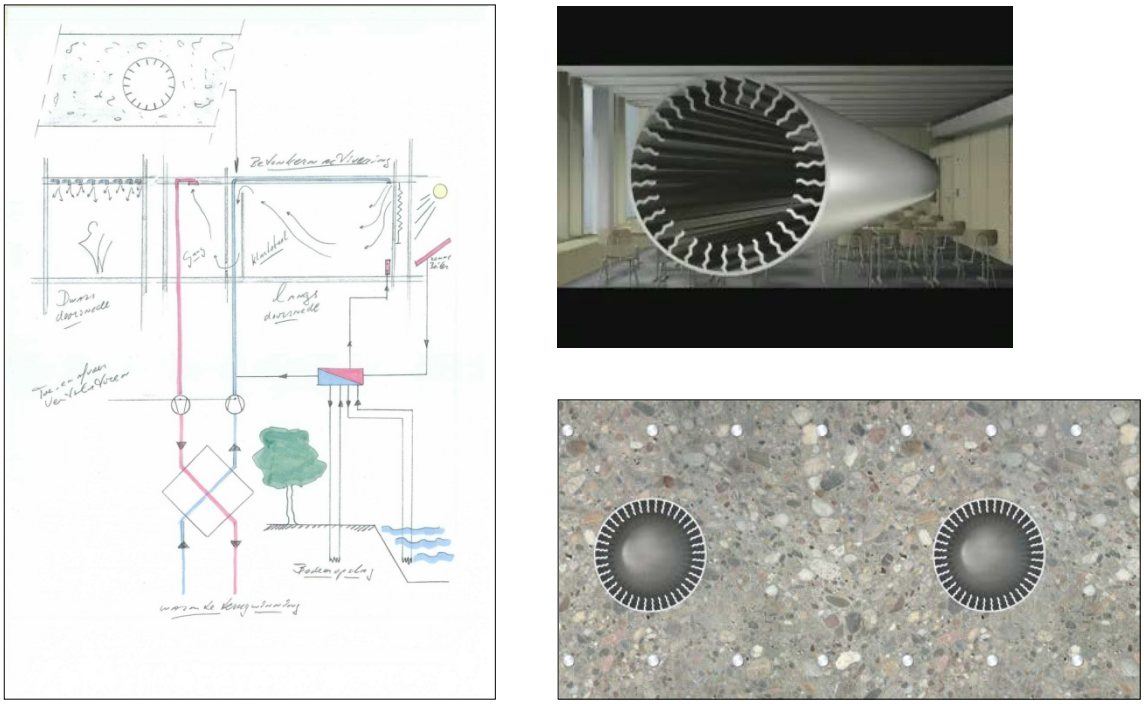

Figure 8: Schematic diagram and detail of the aluminium pipe for concrete core activation with air.

4.3 Concrete surface activation

Another way of heating and cooling rooms by storing energy in floors, ceilings and or walls, is concrete surface activation. One of the options is the usage of small tubing (4 mm in diameter) that will be casted into the concrete located at the outside surface of the concrete. The tubing fixed to the ceilings and or walls has to be covered by plaster. An advantage is that it reacts much faster due to its location (on the surface) and the great number of tubes next to each other. A disadvantage of using it in walls is the possibility of damage done by nails or screws when framing something against the wall.

[1] In case of fresh air supply via the ducts, an important point of attention is the air quality and the prevention of dust in the ducts. If necessary, it should be possible the clean the ducts regularly.

Figure 9: Tubing for concrete surface activation in the ceiling on the left and in the floor on the right.

4.4 Thermal Borehole Thermal Energy Storage

An alternative for an energy source base on low temperature groundwater is the borehole thermal energy system. Probes are installed (as a closed circuit) in the soil boreholes at a depth of approximately 150 meter to obtain the energy out of the earth (with a characteristic capacity of 40 W/m). This system can be used in combination with a heat pump and concrete core activation.

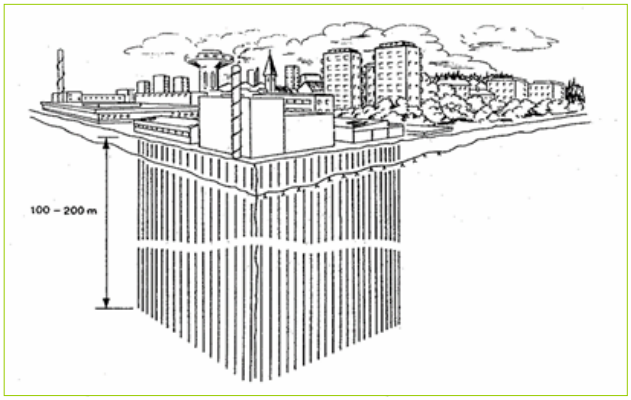

Figure 10: Borehole Thermal Energy Storage by using probes of approximately 150 meters deep.

5 Literature and sources on interest

1. See also module Concrete core activation I-431
2. Pre fabricated concrete floor slaps www.vbi.nl
3. Concrete surface activation www.bioclina.de
4. Concrete core activation with air www.berufskollegs-recklinghausen.de