Chapter 6

Conclusions

The objective of this work were two fold. On the one hand, to investigate the role of dispersion on heat transport in porous media. On the other hand, to investigate the feasibility of using groundwater for cooling in Barcelona.

Regarding the role of dispersion, it has been found out that it is not very important in terms of dissipations but it may be tricky when it comes to temperature distribution. According to the results of this thesis, the most suitable dispersivity for local heat transport problems is the linear one. Dispersivity must satisfy Peclet number in order to guarantee the numerical stability of the problem. But dispersivity is also scale-dependant, so it is not accurate to adopt a constant value of the same order of magnitude than those used in regional transport problems. If dispersivity is too high, the heat conducted from the pipe to the aquifer through the pillar will be dispersed almost instantly. Then the temperature profile will decrease abruptly in the surface of the pile.

Regarding the actual use of groundwater for cooling in Barcelona, several conclusions have been reached. First, the thermal piles have turned out to be not so good heat exchangers. Despite this is a technology widely used in north-European countries, they would not be profitable in places with hydrogeological conditions like Barcelona.

There are several factors that condition the efficiency of the GHE. The most important one is the concrete. It is important to remember that heat transport through the pillar takes place by means of conduction. Conduction is a heat transfer process proportional to the thermal conductivity of the soil and the thermal difference between the origin and the destiny of the energy. Groundwater from the Besos river aquifer has an average temperature of approximately 18°C. This temperature is fairly warmer than the expected temperature in an aquifer of a north-European countries. There, groundwater temperature ranges between 10 – 12°C. This difference gives the system a boost in those countries since the thermal gradient will be higher thanks to better hydrogeological conditions.

Secondly, the existing hydraulic gradient(0.15%) is not too strong to help the GHE to dissipate more energy. Areas with higher flux velocities would experience better results in terms of heat dissipation. The surface of the pile would suffer a more intensive cooling due to the higher flux velocity. Consequently, that would lead to a higher thermal gradient between the surface of the pillar and the pipe. As a result, the heat transfer by conduction would increase. In addition to
this, advection and dispersion would be higher since both processes are directly proportional to the Darcy velocity (flux velocity).

All the calculations with close loop systems have been done with piles only rigged with one pipe. It was easier to keep the problem as simple as possible to avoid even more mesh restrictions. Despite the piles would be rigged with two loops instead of one, the most important thing was to get an order of magnitude and get our grips to the problem.

It should be noted that while this system is unacceptable for such a big project like the re-urbanization of La Sagrera, close loop systems could be used in single buildings with much lower energy requirements.

Then, open loop systems were conceived as the most suitable solution for this problem. One of the main disadvantages of this system is that intensive pumping is needed. Then, the aquifer suffers a double environmental impact:

- The flux conditions are severely changed as a result of the implementation of the system
- Water injected into the aquifer does not have the same quality than before since its temperature has been risen.

At last but not least, the area of influence of the GHE is much bigger than in the close-loop systems. This is not only important in terms of temperatures but also in terms of heads. So as to dissipate the important amount of energy required, high abstraction rates are needed. These intensive pumping and injection may cause important changes of the water table level. Some of the possible consequences are:

1. Flooding of cellars, parking lots and metro.
2. Creation of water pressures under foundations.
3. Differential settlements in buildings and structures.