**STSM – Short Term Scientific Missions within the Action TU1405 – “European Network for Shallow Geothermal Energy Applications in buildings and infrastructures “(GABI)**

**REPORT**

**following the completion of STSM**

**Topic:** Thermoactive geostructure design – WG4

**Research Title:** Design procedures for energy geostructures

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**Host Intitution:** Institut français des sciences et technologies des transports, de l'aménagement et des réseaux, IFSTTAR (France)

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# Purpose of the STSM

The main goal of the STSM, in line with the task of the Working Group 4, has been to assess current state-of-the-art approach, and to prepare a draft version of the guideline concerning the design of thermo-active structures. The STSM’s objectives were to:

* Identify the main uncertainties caused by thermal actions and other factors influencing the design, including necessary input data;
* Assess how to account for additional thermally-induced loading in the LRFD framework and in the light of current European standards;
* Develop a proposal of a framework for a design procedure for energy geostructures in regard to structural and geotechnical design;
* Get acquainted with advanced monitoring techniques for gathering data about real foundation behavior.

# The work carried out during the STSM

The majority of work associated with the STSM was carried out at the headquarter of IFSTTAR during first three days (13-15.02.17); it concerned the preparation of a draft version of the guideline for further discussion and use by the Working Group 4. A review of existing publications on the subject, including these resulting from research activities conducted in France, was carried out during this time. The STSM provided an opportunity to discuss details and background information that led to results presented in those publications.

 Additionally, during this time, the STSM allowed to get acquainted with other researchers working at the Host institution, as well as to visit the laboratories and observe currently conducted research activities. This included a visit to the neighboring geotechnical laboratory at École nationale des ponts et chaussées (ENPC), which is also involved in the research activities concerning energy geostructures and the COST action TU1405.

 During the fourth day (16.02), a site visit has been arranged to see an existing and operational heat exchanger system utilizing thermo-active piles. This system is supervised by CEREMA. During the visit, design assumptions, as well as problems associated with the execution and maintenance were presented. Currently, at a maintenance phase of the project, constant monitoring is being conducted. It includes monitoring of the temperature and load distribution (derived from vibrating wire sensors’ data) throughout the entire operational cycles.

 The last, fifth day of work was dedicated for the meeting with other representatives of France involved in the Working Group 4, including its chairperson. The meeting was held at the Université des Sciences et Technologies de Lille. The purpose of this meeting was to present the draft version, as well as to discuss possible changes and issues that appeared during its preparation, which may require further consideration or investigation. This meeting allowed to finalize the draft version in a form suitable for presentation to other WG4 members at the next WG meeting in Warsaw (Poland).

 Additionally to the work directly associated with the main objective of the STSM, the meeting with the representatives of France provided a chance to discuss related matters of CEN standardization activities. As they may indirectly affect the geotechnical and structural design of energy foundations, their relation to the subject of the WG4 work has to be considered.

# The main results obtained

The main goal of the STSM has been met, namely, the preparation of a draft version of the guideline for the design of thermo-active foundations. This goal was accomplished by the preparation of a draft version composed of the main structure of the document (table of content), part of the text, and by highlighting some aspects requiring further improvement. The draft of the guideline has been prepared with the idea of supplementing existing standards and common design practices, used in the case of traditional design solutions. In order to target a highest possible number of potential users, the general concept can be used with practically any standard or code of practice utilizing the concept of limit state design.

Main technical issues related to design and operation of thermo-active foundations were identified and discussed; based on the conclusion reached during the STSM and available information from most recent publications, specific issues were either deemed as insignificant from practical point of view, or addressed in the draft version to provide guidance for engineers.

Additional information will be supplemented to the prepared draft version based on discussions with the rest of the WG4 members and results of benchmarks concerning different types of thermo-active structural elements.

The preparation of a basis for the final version of the guideline, containing main assumptions, has been a significant step in moving forward with the work of WG4. Sharing a common basis for supplementary content might provide more incentive to other members to comment on the available content and contribute in their areas of expertise.

Additionally to the main objective, the participation in the STSM provided an opportunity to get familiarized with the application of semi-empirical load transfer method for calculation of thermo-active foundations, with tools available at the Host institution. Furthermore, the data and experiences gathered in France from existing structures, utilizing thermo-active foundations, provide supporting evidence to the limited detrimental influence of heat-exchange systems on the mechanical behavior of these elements and overlying structures.

 In addition to issues directly related to the work of WG4 and the COST Action TU1405, the STSM has been vital for discussion of interrelated matters. These included current CEN activities associated with standardization and harmonization of design rules across Europe. Identifying differences in national practices on subjects such as pile design and pile testing provides better understanding on which a common framework for the design of thermo-active structures can be built.

# Future collaboration with the host institution

Due to various shared interests, possibilities for future collaboration with the Host institution were discussed and will be pursued, both as a part of the COST action activities and hopefully also beyond them.

The COST-related matters concern the activities and subjects of interest covered by the scope of the Working Group 4 on thermo-active geostructure design. Further cooperation on the preparation and advancement of the guideline is necessary; the main results of the STSM may be considered as a cornerstone giving form to the guideline, which will require additional inputs and improvements. They will be based on the progression of works conducted by the WG4 and contributions from other members. Should it benefit the outcome of the WG4, another STSM may be considered in following years of COST Action duration.

 Additionally, both the participant and the representatives of the Host institution demonstrated openness and will to look for collaboration opportunities outside the scope of the Action.

# Foreseen publications to result from the STSM

A few possible topics concerning joint publications were discussed during the STSM. The main concern has been to address specific issues regarding the mechanical design of thermo-active structures, promote their use through publications, as well as to intensify the collaboration between active members of WG4.

 The first subject to be addressed concerns a parametric analysis of a single thermo-active pile subjected to thermal loading. For most research purposes, the finite element method is frequently implemented to analyze specific behavioral characteristics; however, the use of semi-empirical approach based on load transfer method (t-z curves) is going to be considered, as this is often a method of choice for vast majority of practicing engineers. The latest benchmark example carried out by the WG4 presented that majority of research-oriented experts do not give preference to such simplified, yet, the most practical tools. Nevertheless, a preparation of the guideline, ultimately addressed to practitioners and stakeholders in projects involving thermo-active structures, may extensively benefit from explicit implementation of such methods and verification of underlying uncertainties that an engineer might face.

 Depending on the progress of work conducted by the WG4 and the results obtained for the aforementioned publication, additional subjects will be considered in the future. Furthermore, as described in previous section of the report, an overlap in subjects of interest exists between the STSM participant and the Host institution, as well as with other representatives of France. This offers significant potential for pursuing further publications involving other research subjects.

# Confirmation by the host institution of the successful execution of the STSM

The letter confirming the successful accomplishment of the STSM will be attached to this report.