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INNOVATIVE HEAT STORAGE CONCRETE SYSTEMS FOR SOLAR POWER PLANTS

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ABSTRACT

An experience of R&D in the field of new technologies for solar energy exploitation within the Italian context is described. Concentrated Solar Power systems operating in the field of medium temperatures are the main research objectives, directed towards the development of a new and low-cost technology to concentrate the direct radiation and efficiently convert solar energy into high temperature heat. A *multi-tank sensible-heat storage system* is proposed for storing thermal energy, with a two-tanks molten salt system [1-3]. In the present approach, the typology of a below-grade cone shape storage is taken up, in combination with nitrate molten salts at 565°C maximum temperature, using an innovative high performance concrete (HPC) for structures absolving functions of containment and foundation. Concrete durability in terms of prolonged thermal loads is assessed using the approach presented in [4]. The interaction between the hot tank and the surrounding environment (ground) is considered in [5], where the developed FE model simulates the whole domain, and a fixed heat source of 100°C is assigned to the internal concrete surface. The development of the thermal and hygral fronts within the tank thickness are analysed and results discussed for long-term scenarios in the same Reference. Within the medium temperature field, an innovative approach is then presented in [6] for the conceptual design of liquid salts concrete storage systems. The adopted numerical model accounts for the strong coupling among moisture and heat transfer and the mechanical field. The basic mathematical model is a single fluid phase non-linear diffusion one based on a suitably modified theory starting from Bažant; appropriate thermodynamic and constitutive relationships are supplemented to enhance the approach and catch the effects of different fluid phases (liquid plus gas).
In this paper the design is extended to incorporate the seismic actions, to check the performance of the conical concrete storage settled on a given ground, under an assigned earthquake. As a first insight, linear dynamic modal analysis is performed to find dominant frequencies, modal shapes and participations factors of the complex

structural system, for assigned damping properties. Then, due to the particular contact interface between concrete and surrounding soil, a nonlinear dynamic step-by-step technique is applied to assess the evolution of the system under seismic action. The structural response of the conical storage, of the soil and of the interface region are analysed and discussed, to upgrade the engineering design. It is shown how the more refined and realistic hypotheses of the nonlinear dynamic system can help in understanding the mechanical behaviour and improve safety of the system at reasonable costs.

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