Evaluation of the observed damage and rehabilitation study of two underground R/C biological treatment tanks

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Abstract

This paper focuses on the evaluation of the damage observed on two adjacent reinforced concrete tanks, part of the Biological Treatment complex of Thessaloniki, Greece, after their abrupt evacuation that occurred while the water table level was relatively high compared to the initial design assumptions. These tanks exhibited large vertical displacements (up to 0.90m at certain locations) and extensive radial cracks at their bottom. Based on the observations made right after the damage, a detailed assessment was performed aiming at: a) obtaining an insight on the cause and the mechanisms of failure b) investigate the rehabilitation potential as compared to the complete reconstruction cost of the tanks, and c) propose the rehabilitation scheme towards the functionality restoration of the tanks. Along with detailed design and assessment calculations based on the existing evidence and damage patterns observed, a set of refined non-linear finite element analyses was performed for all successive stages of water evacuation. The implemented static nonlinear analysis approach accounts for plastic deformations of both reinforced concrete body and soil, gradually increasing uplift load as well as varying gapping properties at the soil-tank interface. It is concluded that the plastic behavior of the reinforced concrete tank substantially affected the force redistribution during the evacuation process, resulting to an actual, self- balanced condition that was significantly different as compared to the deformation predicted on the assumptions of linear elastic behaviour of the system.

STATEMENT OF THE PROBLEM

The paper is a brief report of the damage assessment and retrofit proposal following the damage and deformation observed at two of the four underground final consolidation tanks of the sewage biological treatment plant of Thessaloniki

The tanks consist of a perimeter wall with a depth t=0.45m, a bottom slab with a depth t=0.38m (excluding the area adjacent to the perimeter wall where it increases to t=0.50m) and an internal central tower. The tanks have a diameter of 54,00m and a depth varying from 4.84m at the perimeter to 6.80m at the center (outer perimeter of the central tower, as seen in Fig.1,3). They have been constructed with grade C20/25 concrete and steel reinforcement S500s.

During Electro-Mechanical (E&M) works those tanks were evacuated without prior checking of the water table level, the latter being in fact significantly higher than that assumed during design (i.e 3,60m to 3,80m instead of 2.00m respectively). This condition resulted into deformation of the bottom slab equal to 30cm and 90 cm in the two tanks as well as cracking of the top surface of the bottom slab in a hairline random pattern which was transformed into radial cracks along the perimeter. Moreover, vertical cracks developed along the first meter of the outer perimeter wall and tilting of the center tower was observed

Following the above damage, the two tanks were refilled while monitoring the level and grade of restoration of the deformations of the bottom slab. The latter were indeed reduced to