Optimization procedure for horizontal tank prestress

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Optimization Procedure for Horizontal Tank Prestress

Optimisation de la précontrainte horizontale des réservoirs

Optimierungsverfahren für die horizontale Vorspannung von zylindrischen Behältern

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INTRODUCTION

From the beginning of the use of cylindrical liquid retaining structures literature has made reference to discussions about the detailing of the wall-to-base connection: shall it be a sliding, a hinged or a monolithic one [1]. The major drawback of the monolithic alternative would be the high fixed-end forces under either hydrostatic load (non-prestressed tank) or under prestress (empty prestressed tank). Reduction of the troublesome fixed-end forces could be reached by adoption of ring force balancing prestress (RBP) instead of load balancing prestress (LBP). For the determination of an RBP several procedures have been proposed [2,4,5,6]. Most of these procedures focus on minimizing the fixed-end forces. Not less important, however, are the ring forces in the bottom meters of the wall, which might be tensile ones in the operational stage (fig. 1). These forces may cause vertical through-cracks, resulting in leakage and loss of durability [5,disc.]. Several authors have also pointed to an often disregarded increase of the fixed-end forces due to vertical cracking of the wall [3]. Above summarized problems compel to searching for a prestress function $F_p(x)$, which ensures a. compressive membrane forces and b. fixed-end forces as low as possible under relevant load combinations.

RING FORCE BALANCING PRESTRESS

The procedure for the determination of a RBP $F_p(x)$ starts with a prestress function with a shape identical to the course of the tensile ring forces under a fictitious hydrostatic head h_1^*. In formular form [2] (see also fig. 2):

$$F_p(x) = N_{\theta\theta,1} = (h_1^* - x).\gamma_1.R - \frac{E_c.h_w}{R} . \frac{e^{-\lambda x}}{2K\lambda^3} \{(\lambda.M_{xx}^*(o) + N_{xz}^*(o)) \cos \lambda x - \beta.\lambda.M_{xx}^* \sin \lambda x\} \qquad (1)$$

in which $M_{xx}^*(o)$ and $N_{xz}^*(o)$ are fixed-end forces under the fictitious hydrostatic pressure, E_c is Young's modulus of concrete, K and λ cylinder coefficients. The factor β describes the shape of the prestress function $F_p(x)$ in the bottom part of the wall (fig. 2a). The fixed-end shear forces are linear functions of β (fig. 2b). By varying β the shape of the prestress function can be so determined that the absolute values of the positive and negative shear force under different load combinations are equal and thus minimal (intersection point β_o in fig. 2b). For the value of β_o the shear resistance of the wall at the base is checked. If no sufficient shear resistance can be realized with an initially adopted wall thickness h_w, the optimization procedure is started anew with a 50 mm thicker wall. Once the shear resistance criterion is met, it is checked whether the membrane ring forces are compressive ones in the operational stage. In case tensile ring forces are found, the value of β is adjusted so that tangential compression is ensured over the full height of the wall. The procedure finishes when tangential compression is ensured and the shear resistance criterion is fulfilled under all relevant load combinations. For the thus obtained prestress configuration the costs of the tank are determined. For a given diameter/height ratio of a tank the effects of variations in input parameters (e.g. subsoil conditions, pile characteristics, bottom slab thickness, bottom prestress, vertical wall prestress) on the structural behaviour and the costs can easily be analysed with the procedure just outlined.

DISCUSSION

The analytical optimization procedure, programmed and implemented on a personal computer, is a powerful design tool, which facilitates the designer's choice for the most cost effective alternative. Most important is that the established alternatives meet the stringent requirements for membrane stresses and fixed-end forces, thus ensuring serviceability and high durability.
Limitations: linear elastic behaviour, constant wall thickness and $H > 3\lambda^{-1}$.
It is remarked that thermal loads (temperature gradients) should preferably be carried in a partially prestressed mode [3].

REFERENCES

1. Breugel K. van, Problems associated with wall-to-base connections. Proc. Int. Symp. Design, Construction and Maintenance of Concrete Storage Structures. New Castle upon Tyne, December 1984.
2. de Boer R., Optimization of horizontal prestress of cylindrical tanks. Delft, February 1988 (in Dutch).
3. Breugel K. van, Partial prestressing for cylindrical liquid retaining structures. 10th FIP-congress, New Delhi 1986.
4. Buyer K., Zur Berechnung der Vorspannung geschlossener Kreiszylinderschalen im Stahlbeton-Behälterbau. Beton- und Stahlbetonbau, Mai 1987.
5. Brøndum-Nielsen T., Prestressed tanks. ACI Journal, July-August 1985 (Discussion: Close S.R., ACI Journal, May-June 1986).
6. Steinecke M., Ermittlung wirtschaftlicher Vorspanfunktionen für zylindrische Behälterwande. Baupl.-Baut, Mai.

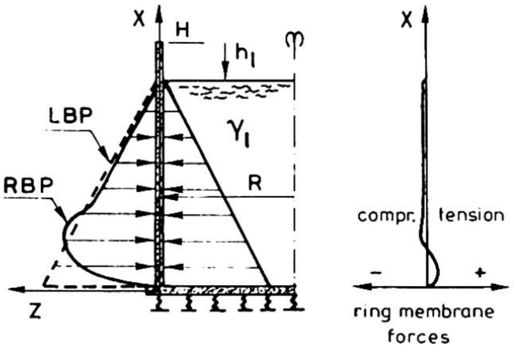

Fig 1 Load Balancing vs. Ringforce Balancing Prestress (L.B.P. vs. R.B.P.)

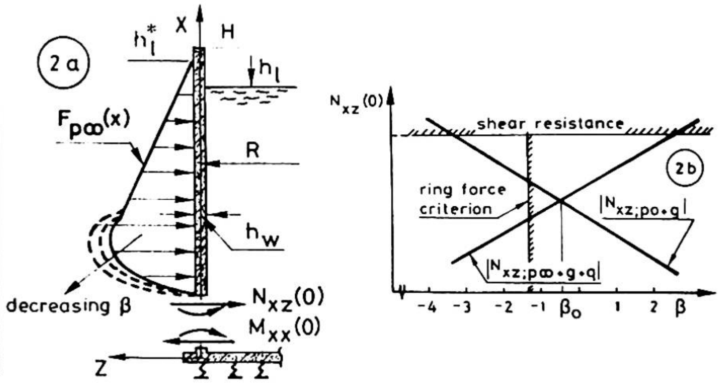

Fig 2 Schematic presentation of design procedure for determination of R.B.P. (in 2b; refrained from load factors: g = dead weight; p_o and p_∞: prestress at t=o and t=∞; q=hydr. pressure)