壁面温差对钢筋混凝土圆形水池池壁结构的影响

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摘 要:

Solsh190

ANSYS

关键词: ; ; ; ; ANSYS
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Effect of the Wall Temperature Difference on Reinforced Concrete Cylindrical Tank's Wall

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Abstract: According to the theory of cylindrical shell and the method of finite element analysis, this article completed the structural analysis on the wall of the tank storing hot water. With the effect of the wall temperature difference, the stresses of wall structure solved by two methods were basic consistent. It verified that using Solsh190 to simulate reinforced concrete shell structure is feasible. By using 3D thermal element and 3D shell element of the finite element software ANSYS, the stress state of the wall structure was completed with the heat-structure coupling simulation. This article discussed the wall stress distribution in maximum wall temperature difference in winter and provided a reference for the reinforcement of wall structure.

Keywords: Cylindrical tank; tank's wall; wall temperature difference; reinforced concrete structure; ANSYS

[1]

C25 HPB235 28 m 3.9 m 0.3 m 47 -16

ANSYS

1 圆柱壳体理论的池壁结构分析

1.1 温度变化对池壁结构影响

[2]

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1.2 池壁内力计算分析

1 N_θ M_θ
M_x V_x

2
[3]

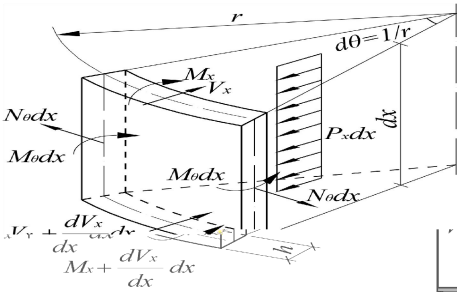


图 1 池壁微分体受力分析

Fig.1 The analysis of forces in differential body of tank's wall

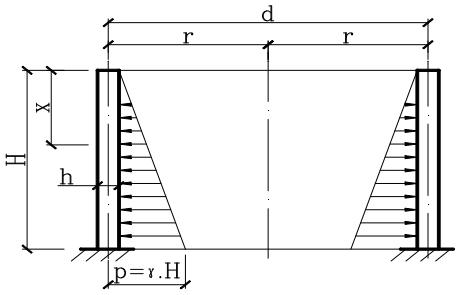


图 2 池壁计算简图

Fig.2 The calculation diagram of the tank's wall

$M_x = k_{M_x} PH^2$ $V_x = k_{V_x} PH$ $N_\theta = k_{N_\theta} P$ $M_\theta = \mu M_x$ k_{M_x} k_{V_x} k_{θ_x} μ

[4]

$M_T = 0.1Eh^2\alpha\Delta t$ $M_x = k_{Mx,2} M_T$ $M_\theta = \mu(k_{Mx,2} - \frac{1}{\mu})M_T$ $N_\theta = k_{N\theta,2}\frac{M_T}{h}$ $V_x = k_{vx}\frac{M_T}{H}$

$k_{Mx,2}$ $k_{Vx,2}$ $k_{\theta x,2}$ E h α Δt

1.3 壁面温差计算

[5]

$$\Delta t = \frac{\frac{h}{\lambda_i}}{\frac{1}{\beta_i}+\frac{h}{\lambda_i}}(T_n - T_w)$$ h 0.3 m λ_i

2.03 W/(m.k) β_i 23.26 W/(m^2.k) T_n

47 T_w -16 $\Delta t = 48.77$

1.4 池壁内力分布规律

N_θ M_θ

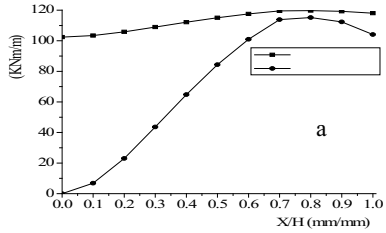
M_x 3 $E = 2.8\times10^{10} N/m^2$

$\alpha = 1\times10^{-5}/°C$

N_θ

M_θ M_x

0.8 H



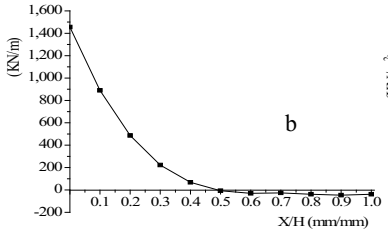


图 3 池壁内力沿壁高分布图

Fig.3 The internal force distribution along the tank's wall

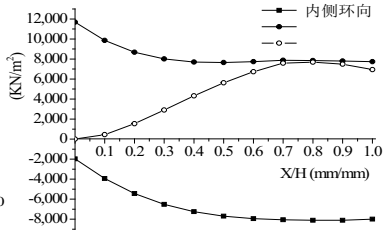


图 4 池壁正应力沿壁高分布图

Fig.4 The stress distribution along the tank's wall

M_θ N_θ

σ_x $\sigma_x = \frac{N_\theta}{A} \pm \frac{M_\theta}{W}$ A W

M_x σ_z

$\sigma_z = \pm \frac{M_x}{W_z}$ W_z

4

11.68 kN/m^2

2 池壁结构有限元分析

[6] ANSYS

2.1 建模及选择单元类型

ANSYS/Modeling Meshing Sweep

[7]

ANSYS/Thermal Solid70[8]

ANSYS/Structural “Thermal to Struc”

Solsh190

sections [9]

“From Therm Analy” ANSYS/Thermal

solve

2.2 模拟结果分析

ANSYS 1

5 6 7

表 1 壁面温差作用下池壁环向应力

Table 1 The hoop stress caused by wall temperature difference

Equal parts of tank's height	(N/mm²) The hoop stress on the inside			(N/mm²) The hoop stress on the outside		
	(S_1) Wall temperature difference only	(S_2) Wall temperature and water pressure	S_1 to S_2	(S_3) Wall temperature difference only	(S_4) Wall temperature and water pressure	S_3 to S_4
1	-2.78	-2.36	1.18	10.80	11.23	0.96
2	-4.65	-4.22	1.10	8.98	8.92	1.01
3	-6.04	-5.60	1.08	8.55	8.70	0.98
4	-7.08	-6.65	1.07	7.97	8.29	0.96
5	-7.54	-7.15	1.06	7.62	8.05	0.95
6	-7.71	-7.39	1.04	7.35	7.84	0.94
7	-7.69	-7.44	1.03	7.21	7.72	0.93
8	-7.51	-7.33	1.03	7.75	8.23	0.94
9	-7.51	-7.35	1.02	8.62	9.07	0.95
10	-7.29	-7.12	1.02	9.46	9.29	1.02

备注:环向应力以拉应力为正，以压应力为负。

Note: The value is positive when the hoop stress is tensile stress. It is negative when the hoop stress is compressive stress.

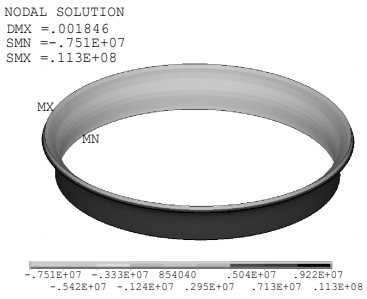


图 5 池壁的环向正应力

Fig.5 The hoop stress on the tank's wall

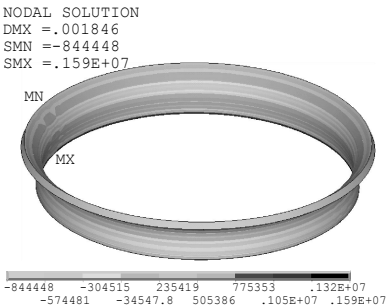


图 6 池壁的径向正应力

Fig.6 The meridional stress on the tank's wall

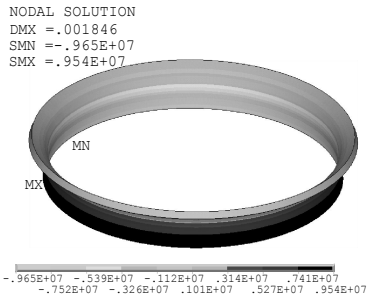


图 7 池壁的竖向正应力

Fig.7 The vertical stress on the tank's wall

1

7.72 N/mm^2 11.23 N/mm^2

7.44 N/mm^2

1 5 [10]

6 7

9.65 N/mm^2 9.54 N/mm^2

5 7 4

3 结 论

1) ANSYS

Solsh190

2)

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