

大型现浇钢筋混凝土水池无温度伸缩缝设计法

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提要 介绍了我国大型水池结构考虑温度应力时的设计方法及对于超长水池的各种处理办法。通过长春西郊污水处理厂曝气池(90.5 m × 103.7 m × 7 m)工程简要介绍了无粘结预应力无温度伸缩缝水池的设计方法,以及无缝水池在经济性、耐久性和抗震性等方面的优点。

关键词 现浇钢筋混凝土水池 清水池 温度伸缩缝 无粘结预应力

1 大型水池设伸缩缝的处理方法

对于大型矩形现浇钢筋混凝土水池构筑物,当长度、宽度较大时,宜设置适应温度变化作用的伸缩缝。伸缩间距如表 1 所示。

表 1 矩形构筑物的伸缩缝最大间距

| 地基类别 | | 岩 基 | | 土 基 | |
|-------|-------|-----|-----------|-----|-----------|
| | | 露天 | 地下式或有保温措施 | 露天 | 地下式或有保温措施 |
| 砌 体 | 砖 | 30 | | 40 | |
| | 石 | 10 | | 15 | |
| 现浇混凝土 | | 5 | 8 | 8 | 15 |
| 钢筋混凝土 | 装配整体式 | 20 | 30 | 30 | 40 |
| | 现浇 | 15 | 20 | 20 | 30 |

注:表中数据单位为 m。

构筑物的伸缩缝或沉降缝应做成贯通式,即在同一剖面上连同基础或底板断开。

以某污水处理工程的曝气池为例。曝气池平面尺寸为 100 m × 100 m,深 7 m,按我国《给水排水工程结构设计规范》(GBJ 69 - 84)的要求(现在新的给排水规范已通过审查,即将出版问世,但在伸缩缝间距方面没有变化),土基露天结构每 20 m 设一道伸缩缝,则该曝气池将被分割成 25 块。

2 大型水池结构不设伸缩缝的处理方法

分缝设计的整体性差、抗震性能不佳、易漏水、修复困难等弊端是显而易见的。因此,现在有些工程技术人员正在积极探索新的解决途径。

2.1 设置混凝土后浇带

当池体(或地下车库)长度超过国家规范的要求时,不设温度伸缩缝,而设置 1 ~ 2 m 宽的后浇带。待后浇带两侧混凝土浇筑完毕后 2 个月左右再行浇

注。

但后浇带只能解决施工期间混凝土的收缩问题,并不能解决季节温差(湿差)所产生的温度应力的问题。因此应根据构筑物使用地点、地基条件、气候条件等因素综合考虑来确定。

2.2 使用混凝土膨胀剂

掺加膨胀剂的目的就是在混凝土中产生膨胀应力。其产生的膨胀应力值是有限的,也就是说超过一定的界限就起不到应有的作用。

以某水池为例,施工条件:夏季施工温度为 30 ,冬季使用温度(极少发生) - 30 。由于混凝土的特性,其在 - 4 左右时,混凝土收缩最大。当温度再降低时,混凝土则开始膨胀。因此,水池或地下室等钢筋混凝土结构最容易在 - 4 左右产生温度收缩裂缝。

此时产生的温度应力 是

$$= E \quad t = 2.8 \times 10^4 \times 1 \times 10^{-5} \times (30 + 4) \\ = 9.52 \text{ N/mm}^2.$$

式中 E —— 砼弹性模量, C25 为 $2.8 \times 10^4 \text{ N/mm}^2$;

—— 砼线胀系数,取 $1.0 \times 10^{-5} \text{ K}^{-1}$;

t —— 温差, K。

若考虑混凝土的徐变及底板的非完全约束等因素,最后在混凝土中产生的拉应力至少也为: $0.4 \times 9.52 = 3.81 \text{ N/mm}^2$,远大于混凝土的抗拉强度设计值 1.3 N/mm^2 。

若水池或地下室底板厚度为 600 mm,其配筋率为 0.5 % (上下总计),这些钢筋所能承受的拉应力为 0.8 N/mm^2 。因此,水池或地下室底板也承受不了温度应力所产生的拉应力。即 $1.3 + 0.8 = 2.1 < 3.81 \text{ N/mm}^2$ 。也就是说当池体较长,池体在温度应

力作用下将被拉坏。

2.3 预应力技术

用有粘结或无粘结预应力钢绞线来解决温度应力问题。当池体长度和宽度都较长时,不设温度伸缩缝,而在池壁、底板水平方向均施加预应力来解决温度应力问题。

3 大型水池无温度伸缩缝整体设计

长春西郊污水处理厂曝气池平面尺寸为 90.5 m × 103.7 m, 深 7 m。为解决温度应力问题,同时考虑工艺运行的合理性,原设计分为 4 个独立的池体,每个池体之间用 30 mm 宽伸缩缝完全隔离开来,而在另一个方向每 25 m 左右设 1 道温度伸缩缝(见图 1)。为了克服传统水池的缺点,我们与美国公司合作设计了无粘结预应力曝气池,取消了 4 个并排水池的 3 道双池壁,而用单个池壁代替,整个曝气池设计为一个整体结构,没有任何伸缩缝(见图 2)。

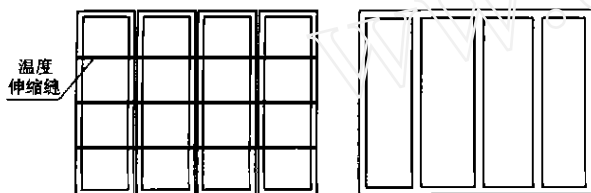


图 1 传统曝气池平面

图 2 预应力曝气池平面

该曝气池均使用国产材料。混凝土为 C35, 钢筋为Ⅱ级钢, 1 860 MPa 钢绞线。底板两个方向施加无粘结预应力, 底板厚度为 160 mm。池壁水平方向及竖向均施加无粘结预应力, 池壁厚度为 400 mm。混凝土裂缝控制在 0 ~ 0.1 mm 之间(我国传统水池一般控制在 0.2 mm 左右), 采用预应力无缝整体水池设计, 建造出来的水池结构耐久性更强。

采用后张预应力技术进行水池结构设计, 对于不同的场地、地震烈度, 预应力整体水池比传统分缝水池节约造价 7 % ~ 20 %。

表 2 为预应力曝气池(裂缝控制在 0 ~ 0.1 mm)与传统曝气池(裂缝控制 0.2 mm)的工程经济比较。

该曝气池 2000 年 5 月开始施工, 由于种种原因, 2000 年只完成了曝气池底板的施工, 经过一个冬季(2000 年长春冬天最低气温为零下 40 ℃)没有发现任何问题。现在, 该曝气池已完成池壁的浇注、预应力张拉工作, 而且已通过试水验收。在施工期

表 2 污水处理工程曝气池工程造价比较

| 项 目 | 传统钢筋混凝土水池 | 无粘结预应力水池 |
|------------|-------------------|--------------------------------------|
| 池壁费用/元 | (C25 砼) 3 340 972 | (C25 砼) 553 900 (C35 砼) 1 135 384 |
| 底板材料费/元 | (C25 砼) 1 137 024 | (C25 砼) 699 552 (C35 砼) 699 453 |
| 底板素砼配重费用/元 | (C15 砼) 377 146 | 0 |
| 碎石垫层费用/元 | 72 280 | 273 455 |
| 普通钢筋费用/元 | 2 836 200 | 1 670 400 |
| 钢绞线费用/元 | 0 | 1 195 400 |
| 橡胶止水带费用/元 | 246 400 | 0 |
| 钢板费用/元 | 35 000 | 0 |
| 预埋角钢费用/元 | 38 710 | 0 |
| 滑动层费用/元 | 59 000 | 106 200 |
| 砼外加剂费用/元 | 252 000 | 192 000 |
| 合计/万元 | 840 | 653 |
| 节省直接费/万元 | | 187 |
| 节省造价/万元 | | 187 × 1.40 = 262 |

间美国工程师进行了施工指导。

4 重视施工质量

土建构(建)筑物是由承包商来完成的, 施工人员的技术水平, 劳动态度, 施工队伍自身的管理水平, 将直接影响结构的质量。不按设计要求及规范执行, 将会增加开裂渗漏的机会。因此, 设计单位应对施工单位做好技术交底工作, 使施工技术人员明确设计意图, 以确保构筑物的质量。否则再好的设计也会因为施工不当而造成开裂渗漏, 这对于我们设计、施工、业主来说都是功亏一篑的。

5 结语

长春西部污水处理工程的无粘结预应力无缝曝气池是我国第一座按新的设计概念设计的无缝整体水池。其整体性、抗震性、耐久性都是传统分缝水池无法比拟的。但我们以后还有很多工作要做, 如预应力清水池, 地下停车场如何设计, 如何指导施工等, 这些都要求我们结构设计人员不断探索, 不断总结, 不断提高。

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UASB Biological Contact Process Treating Beer Brewery Wastewater Shi Lihe et al (38)

Abstract : It has been proved by an engineering example that the beer brewage wastewater can be treated by UASB-biological oxidation process at high-cold area. In this paper the experiences in design , construction , trial-run and operation of a practical facility are presented , especially the start-up at most unfavorable condition of winter frost and the operation expenses of a unit.

Water Saving Program in Gangue Power Station of Pubai Coal Mine Fang Xi et al (41)

Abstract : In the program , the former ion-exchange unit was replaced by a reverse osmosis facility for water desalination. Therefore the pollution of waste acid-base discharge was avoided , the water quality improved , and the overall utilization of circulating water upraised. For further advance the biological contact oxidation was added and the economical benefits analysis on water saving program was done.

Engineering Practice on Niclosamide Wastewater Treatment Huang Tianyin et al (44)

Abstract : A composite process composed of complex extraction , Fe/C reduction , neutralizing sedimentation , anaerobic hydrolysis , contact oxidation and filtration was adopted to treat niclosamide wastewater. The process scheme , operation parameters and performance are presented in this paper. The monitored results show that the effluent of the full-scale facility could meet the requirement of Class I of the national integral wastewater discharge standard (GB8978 - 96) . Mean removal ratios of 98 % , 95 % , 99.6 % and 86 % have been obtained for COD , BOD , TP and NH_3 - N respectively.

Tourist Scenery Swimming Pool in Venice Hotel in Shenzhen Lai Guanyu et al (56)

Abstract : The project of Venice Hotel in Shenzhen is a five star holiday inn subjected of water scenery. The water system design of the scenery swimming pool , including the water circulation , water supplement , water disinfection , the heat exchange of warm water swimming pool , the application of underground heat and pipeline layout to the swimming pools at different flats in the building are described.

Study on UV Disinfection in Clear Water Tank Yang Yunan et al (59)

Abstract : UV disinfection was researched experimentally at the clear water tank , a unit of the high-pure drinking water station in a vacation villa in Harbin City. For this pure water station the composite ozone and biological activated carbon processes are applied. The disinfective effect of UV irradiation and the influence factors to them were investigated. The experimental results show that that the amount of bacteria was obviously restricted while UV irradiated the surface of water , though the remained bacteria kept a certain number under the allowable level of the water quality standard. This method might be suitable for water supply system with short distribution distance and that the output water will be consumed in duration less than ten hours.

Design of Large Cast-in-situ Water Tank without Expansion Joint Liu Zhigang (68)

Abstract : Various normal procedures used in this country against the temperature stress for large size extra long water tanks are presented briefly. Taking the aeration tank ($W \times L \times H = 90.5 \text{ m} \times 103.7 \text{ m} \times 7 \text{ m}$) in the West WTP in Changchun City as a practical example , the design of large size water tank with unbonded prestressed concrete structure without expansion joint is presented and the economic , durable and earthquake-protective advantages of this kind of structure are indicated.

Problems on Application of Expansive Cement Joint of Pipeline Li Xinzhou et al (72)

Abstract : The advantages and working mechanism , and the problems appeared in practical application as well of expansive cement joint of pipeline are discussed deeply in this paper. Also the attentions in normal construction of pipeline with this kind of joints and assumes for improvement are indicated.

Application of Variable Pore Fiber Filter Yuan Shiping et al (78)

Abstract : Filtration device is one of the principal equipments of all kinds of water treatment system. In this paper , the structural feature , working principle and main technical parameters of a new type filtration device called Variable Pore Fiber Filter are introduced with practical application examples.

Understand and Carrying out of Stipulation 2.2.10 in Building Water System Design Norm Guo Shangming (87)

Abstract : The Stipulation 2.2.10 in Building Water System Design Norm is discussed. It is concluded that the water tanks for drinking and non-drinking water should be constructed separately , then the capacity of drinking water tank will not be too large and it will have independent structure from the main body of the building. For the non-drinking water tank the space of the basement is usable and it could not be separated from the main structure of the building.