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Template Design and Leveling Installation of Circular Cell Cofferdam Using the Space Structure and Pipe Piles on the Bahmanshir River

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Abstract
Three branches is the intersection of the Karun, Haffar and Bahmanshir Rivers that barrages should be made to safe fresh water against salty water in the NW of the Persian Gulf. Also, sweet water will be transferred by the Mared pump station to increase fresh water in the splash zone of sea water. Bahmanshir dam will be designed to execute through web sheet piles. Cell dam should be connected to build the steel ship lock with length 60m, mid point and perpendicular to the dam axes.

Work limitations are forced to consider template structural weight less than 15tons. Design load is considered using the vertical live load 70tons, bending moment 140ton.m and wind load. Concepts of design are explained by workers accessibility, barge transmissibility, reinstallation, pipe piles adaptability, twistability and plump line accessorily. Web sheet piles should be constrained into the template temporary and is needed to made mechanical parts with fixing joints.

Original design is based on the deep foundation and space structure. Pipe piles will take the safe platform to construct the template. Template has three casing pipe that could be fixed around the piles through the three bolt and nuts at each level to produce leveling simulation.

Keywords
Template, Cell dam, Ship lock, piles and simulation

1. Introduction

Big and related structures of cell dam are made using the complex and heavy frames that will be installed by great crane and barges. This method is belonged to the overseas countries and special accessories. Template structure and sheet piles (100tons) should be installed to transfer by crane on the barge with nominal capacity 600tons. It is needed to expend a lot of money and procurements and special men that would be paid by client and letter of credit (LC). New method is simple and very accurate that could be reduced the total cost of project to install cell dam in the river. It will be explained into the three phases that must execute in the watershed separately. The first is belonged to the deep foundation and dam toe modification by steel pipe piles and inside grouting. The second phase will consider the space structural and biologic simulation. Final phase will refer to installation and deflection absorbing of template system.

2. Europian and Standard Templates

This work is based on the fabrication of members in the dry lands that heavy crane should be transported to install the template and sheet piles. Figure 1 and Figure 2 would be demonstrated to represent the big structures of template and related frames.

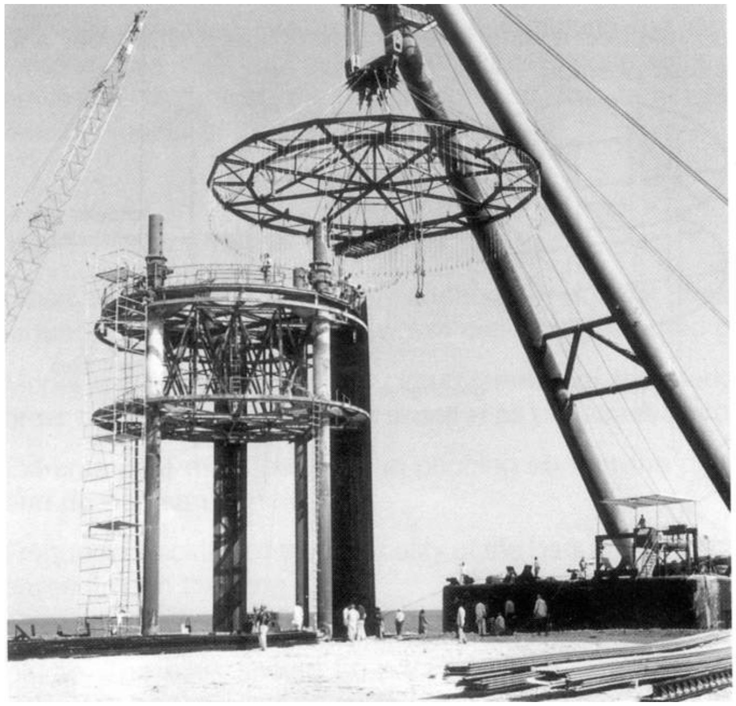

Figure 1: transporting of template and cell dam into the sea

Green big barge will appear the problematic and difficulty of this work. First step is belonged to the sheet piles installation on dry land around the template and total work should be transferred into watershed.

Figure 2: European template and cell dam installation

3. Iranian Template (Turk 2007)

This template is designed to carry lateral loads and undesired settlements where the critical torsion will apply on space structure. Steps design is based on the biologic behavior of knee and self simulation.

3.1 Deep Foundation

Template should be constrained to resist against the radius tensions and variable bending moments through soil of the Bed River. Economic and safe designs are dictated to increase frictional forces using the hollow pipe sections. Steel pipes will produce the desired depth and grouting.

3.1.1 Steel pipes piles

Maximum friction stresses could be obtained to exert loads by template and sheet piles. It is strongly recommended to open the tip of pipe that will increase the ultimate load and buckling resistance. Surface of pipes should be screened to produce facility for grouting operation at 2m below the cell toe.

Figures 3 is demonstrated the vertical driving to provide plumb line for template that will be fixed by the three pipe piles and pipe index at center point of circular.

Figure 3: driving pipes through pile template

3.2 Structural Analysis

Required test are obtained from the field test to recognize the optimum depth of steel pipe piles. Equations 1 to 3 are computed to indicate the desired length. Figure 4 is referred to the critical load condition by 180 degree sheet piles instillation. (34 sheet piles =36 tons, Template= 14 tons)

$$\sum F_Z = 0$$

$$F_I + F_{II} + F_{III} = 50\ (tons) \qquad (1)$$

$$\sum M_{O-III} = 0$$

$$\Rightarrow -f_{ii}.R.Sin\theta + 2\int_0^{\pi} R.d\theta.R.Sin\theta = -f_{iii}.R.Sin\theta$$

$$-f_{ii} + f_{iii} = \frac{-4R}{Sin60^\circ} \qquad (2)$$

$$\sum M_{O-II} = 0$$

$$\Rightarrow f_{iii}.R.Sin60^\circ = f_i.R.Sin60^\circ + \int_{60^\circ}^{60+60} 2R.d\theta.R.Sin\theta$$

$$-f_{iii} + f_i = \frac{+4R}{tg60^\circ} \qquad (3)$$

$$\Rightarrow \begin{cases} f_{iii} = +12 \quad tons \\ f_{ii} = +37.4 \\ f_i = 0.6 \end{cases}$$

$$pipe\ \ pile \rightarrow \varphi\, 300mm, \quad t = 6mm$$

$$P_{allowed} = \pi.D.t.\sigma_{allowed} = \pi \times 0.3m \times .006m \times 1000\left(\tfrac{kg}{cm^2}\right) = 56\ (tons) \rangle\ 38\ (tons)$$

$$f_{c,o} = 0.35\left(\tfrac{kg}{cm^2}\right) \quad \rightarrow outside\ \ friction$$

$$f_{c,i} = \%35\left(f_{c,o}\right) \quad \rightarrow inside\ \ friction$$

$$L_{\min} = \frac{p_{allowed}}{\pi.D.f_{c,o} \times 1.35}$$

$$\Rightarrow L_{\min} = \frac{56000(kg)}{\pi \times 30(cm) \times 0.35\left(\tfrac{kg}{cm^2}\right) \times 1.35} \cong 12.6m$$

$$tip\ level\ of\ \ pipe\ \ pile :\rightarrow h = \underbrace{-2.0}_{bed\ \ River}\ \underbrace{-12.6}_{pile\ tip} = -14.6m$$

$$L_{total} = \left|-14.6m\right| + \left|\underbrace{\pm 0.0}_{normal\ sea} - \underbrace{(-2.0m)}_{bed\ \ River}\right| + \underbrace{7.0m}_{template} = 23.6m \cong 24.0m$$

$$level\ of\ \ cell\ dam\ toe : -13.2m$$

$$\therefore -14.6m \langle -13.2 \quad o.k$$

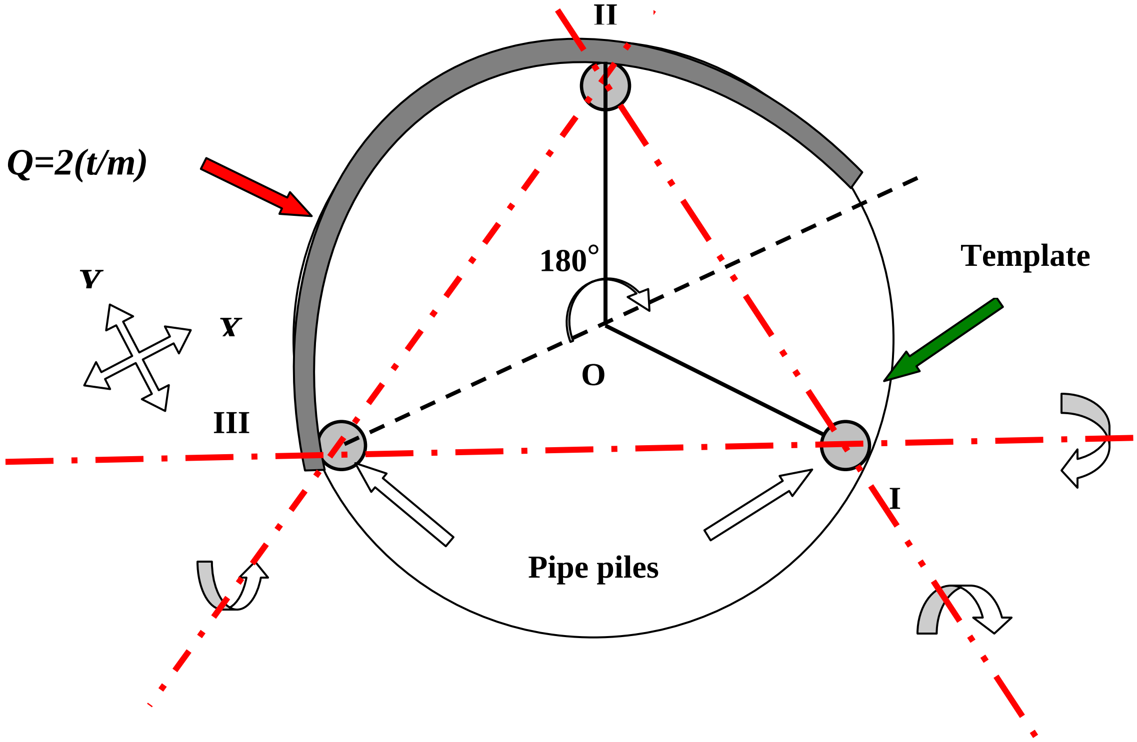

Figure 4: Load diagram of sheet piles installation around the template

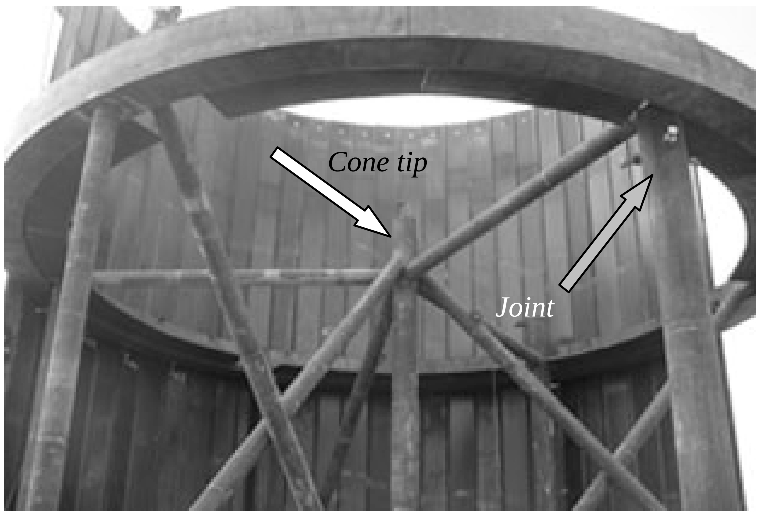

Figure 5: Cone frame at top and bottom

3.3 Template Design

Structure should be recognized to resist against torsion and bending moments by sheet piles installation procedures. Also, required design is preferred to minimize the weight and elasticity behavior that will be produced to adapt through deep foundation and connection joints (simulation).

3.3.1 Rigidity

Rigidity is the index of designing that will be obtained through members and joint locations using the Figures 5 and 6. In fact the two cones will sketch in template symmetrically. The first cone provides stability in upper level and the second cone shall complete rigidity at lower level.

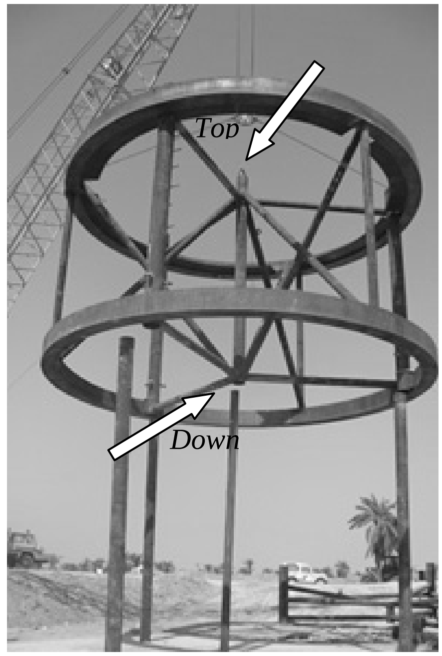

Figure 6: Plan of complete template with cones space structure

3.3.2 Installation stability

The first experience provides suitable knowledge in the Toreh-Bokhah pump station (40km from three branch of Karun River). Pile driving is extended from the base level into 7m by 300mm diameter that will be acted to transfer movement into he soil deeper layers. Template is fixed to increase the rotational resistance and deflections.

3.3.3 Leveling

Referring to Figures 4-6 can be demonstrated to make leveling instruments by the three nut and bolts in each joint and connection of pile and pipe casing. Space deflections of template would be fixed to desire the plumb line using the static stability and determine space structures theory.

4. Simulation Behavior

Dynamic behavior is simulated to control the undesirable deflection around the plumb line and center line of the cell dam by the freedom degrees at joints. Template is defined using the three casing and the two joints at each casing. Total connections are fixed through the six joints with 18 freedom degrees. Each joint is constrained by rotational movements and it is fixed by movements at space. Figures 4-6 and Equations 4-7 will be explained to indicate the simulation behavior and fixed points.

$$\Delta_i = \lfloor \delta_x, \delta_{y,} \delta_z \rfloor_k \quad , k = 1,2,3 \tag{4}$$

$$\Delta_{i'} = \lfloor \delta_x, \delta_{y,} \delta_z \rfloor_{k'} \quad , k' = 1,2,3 \tag{5}$$

$$\zeta_i = \vec{\Delta}_i \cdot \vec{\Delta}_{i'} = \left[\delta_x \cdot \delta_{x'} \cdot Cos(xx') + \delta_y \cdot \delta_{y'} \cdot Cos(yy') + \delta_z \cdot \delta_{z'} \cdot Cos(zz')\right]$$

$$\eta_i = \begin{cases} \lim\left\{\zeta_i = \vec{\Delta}_i \cdot \vec{\Delta}_{i'} = \left[\delta_x \cdot \delta_{x'} \cdot \alpha_{xx'} + \delta_y \cdot \delta_{y'} \cdot \alpha_{yy'} + \delta_z \cdot \delta_{z'} \cdot \alpha_{zz'}\right]\right\} \approx 0 \\ \Delta_i \to -\Delta_{i'} \end{cases} \tag{6}$$

$$\eta_{Turk} = \sum_{i=1}^{3} \eta_i \le 40mm \tag{7}$$

4.1 Simulation Iteration

Equation 6 should be applied to make the convergence values of deflection into plumb line where it is needed to control by the crane movements and three bolts of joints in the workshop (Figure 7). The result of iteration would be represented through Equations 8-9.

$$iteration\,1: \quad \eta_{Turk}\Big|_{it:1}^{\leq 10} = \sum_{j=1}^{3}\sum_{i=1}^{6}\eta_{i,j} = 90mm \tag{8}$$

$$iteration\,5: \quad \eta_{Turk}\Big|_{it:5}^{\leq 10} = \sum_{j=1}^{3}\sum_{i=1}^{6}\eta_{i,j} = 30mm \tag{9}$$

Figure 7: Load diagram of sheet piles installation around the template

Figure 8: Final installation of cell dam

5. Cell Dam Dredging Template

Inside the cell dam should be excavated to fill by draining materials. Passive forces will be pushed to warp the sheet piles using the out side surcharge and river bed mud. Depth of dredging should be more than 4m under the river bed that special template is designed to prevent the disturbing and inverse tensions. Figure 9 will explain the plan and installation inside the cell dam before the dredging operation.

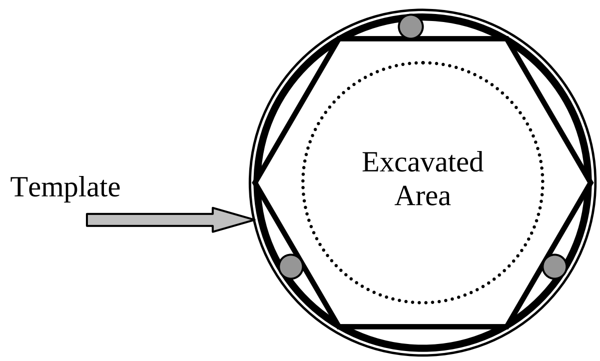

Figure 9: Template to control inverse stresses

6. Conclusion

Template is the main structure of the cofferdam installations and it is provided to fix the movements and rotations through designing and operation. It is the great facilities for water works that will be dictated to decrease cost and time. Cell dam could be driven to act the separator flat dam using the new design of template that will be installed by the sheet piles with accuracy less than 30 mm. the first cell dam in the Toreh-Bokhah was installed by extra movements. Innovative design should be solved the problem to start the new project in the SW of Iran. Simulated template will be designed to minimize the vertical and horizontal deflection of cell dam in the Bahmanshir River that it is very difficult for native contractors and skill workers. Template will provide workability for final sheet piles (No.68) in each cell that shall be slotting between the sheet pile No. 1 and No. 67 without extra welding and cutting steel sheets.

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