SPECIFIC FEATURES IN DESIGN IN FOOTBRIDGES, LOCATED BETWEEN ROOFS OF ABOVEGROUND STEEL TANKS

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Abstract: *In 2011 has finished design of 16 aboveground steel tanks for Oiltanking Terneuzen B.V, the Netherlands. These tanks are with double shells, single bottom and dome roofs. On level of top angles of the tanks, between tanks are mounted pedestrian steel bridges for inspection and maintenance. They have various spans, as follow: L = 18 750 mm, L = 18 450 mm, L = 18 000 mm, L = 16 688 mm, L = 11 550 mm и L = 9 450 mm.*

As a result of weak soils under the tanks and lack of reinforced concrete foundations it is expected extremely high levels of settlements - 500 mm in vertical direction and ±200 mm - in horizontal. These significant settlements lead to specific decisions such:

- use of moving bearings with large scope of horizontal deflection;
- stationary bearings should have large capacity of rotation;
- steel bridges should have as many degrees of freedom;
- to ensure a walkway without gaps in case of horizontal deflection of supports in opposite directions.

1. Introduction

The design of 16 aboveground steel tanks for Oiltanking Terneuzen B.V, the Netherlands, was finished in 2011. The tanks have double shell and single bottom, and the capacities as follows: 2 x 40 000 m^3, 7 x 25 000 m^3, 5 x 10 000 m^3 and 2 x 6000 m^3. Steel footbridges have been mounted between these tanks at height of 20 m in order to facilitate the work of the staff. The spans of the bridges depend on the distance between the tanks and are as follows: L = 18 750 mm, L = 18 450 mm, L = 18 000 mm, L = 16 688 mm, L = 11 550 mm и L = 9 450 mm. The entire bridges are made of steel and the floor surface is made from hot dip galvanised gratings. These bridges "step" on the spot where the main tank's shells are joined to dome roofs i.e. they span over catching basins.

2. Loads on the bridges

2.1 Dead loads

- welded hot dip galvanised gratings SP 240–34/38–3 – 28 kg/m^2;
- pipelines, cables, installations - 15 kg/m^2.

2.2 Live loads caused by the staff

Determined according to the requirements of standard EN 14015:2004 [1]:
- distributed load - Q = 2,4 kN/m^2 ;
- concentrated load on a random point of the floor surface - P = 5 kN.

2.3 Wind load

By order of Purchaser design value of the wind speed is v_b = 160 km/h. As a result design value of the wind load is $q_{b,0}$ = 126,5 kg/m^2.

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2.4 Snow load

By order snow load is $s_k = 1{,}2\ kN/m^2$. Considering the type of floor surface of the bridges which is made by hot dip galvanised gratings, when there is a load from snow on it a load from moving staff should not be added.

3. Type of the footbridges and statistical scheme

Catching basins have the same height as the main tank's shells. Because of it is impossible to use main girders with lower chords bellow hot dip galvanised gratings. On other words these footbridges should be with way bellow. On the other hand considering serious distances between supports, the use of web main girders is ugly and heavy. Because of it truss main girders are used (Fig.1) made from closed box-sections. The trusses are with a free upper chord which is stiffened in transverse direction by U-frames (Fig. 2). The main girders have bearing function and in the same time enclosing function i.e. the upper chord is also a handrail and on the internal frames of the truss are put protective belts.

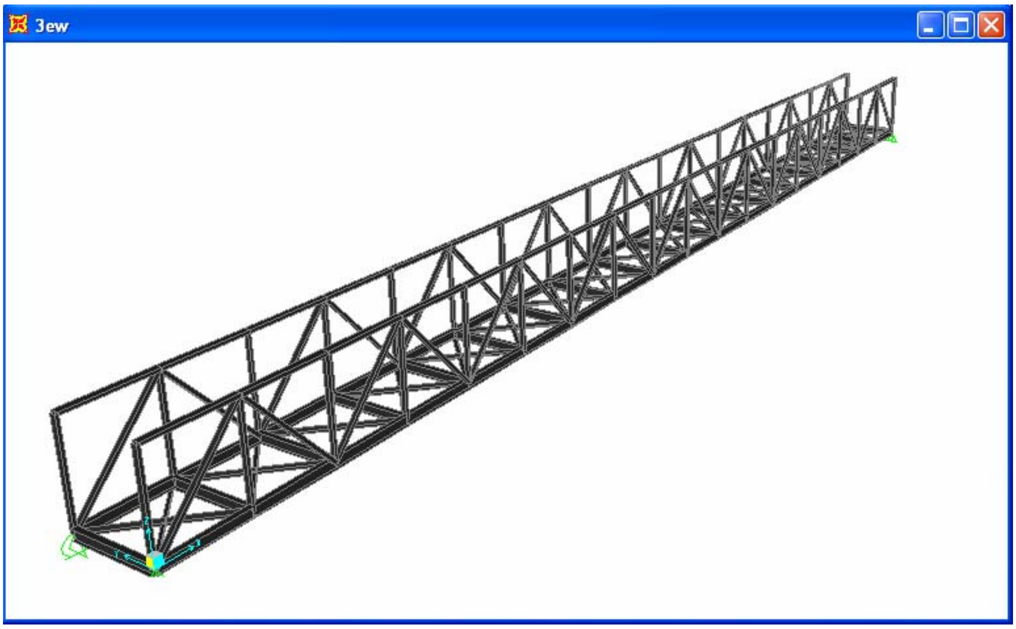

Fig. 1. Isometric view of the steel footbridge

The accepted distance between the main girders is 1075 mm in order to facilitate the staff moving and crossing each other. On this way large1000 mm gratings can be used and put between the internal frames of the truss (Fig. 2). The increased width is favourable to the stiffness of the footbridge in transverse direction.

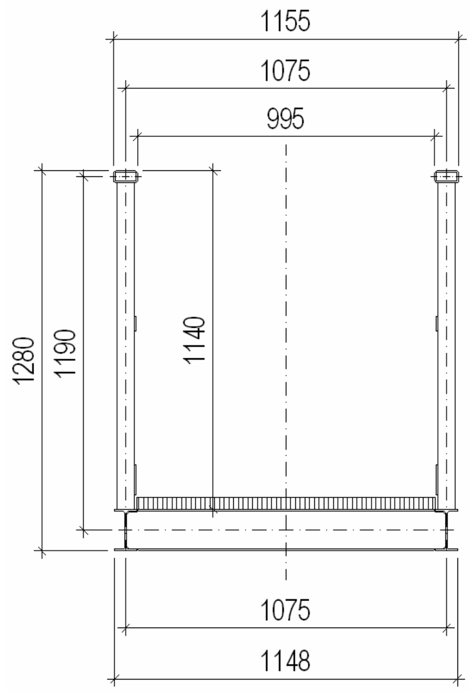

Fig. 2. Transverse "U"-frame

In order to resist the wind pressure which impact transverse to the bridge, on the lower chord of main girders, bellow the gratings, is developed single X-brace (Fig. 3). Its diagonals are formed by single hot-rolled angle sections L50x5 which pass without interruption.

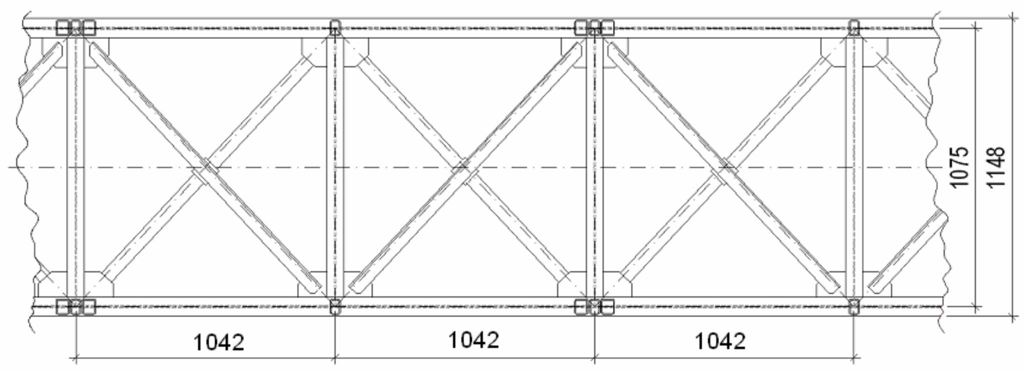

Fig. 3. Horizontal X-brace on lower chord of the main girders

The steel tanks under the footbridges are constructed in the Netherlands on an area, reclaimed from the sea. In order to save recourses they are made on the earth type foundations, which together with weak soil conditions are a precondition for considerable deformation in the earth basement. Expected maximum movements of supports of bridges are for 500 mm – vertically and ± 200 mm – horizontally. Especially these considerable values of estimated movements of the supports are the reason for following engineering decisions:

- use of the moving bearings with a large capacity, enough for a free movements of the ends of the main girders to their supports (Fig. 4);

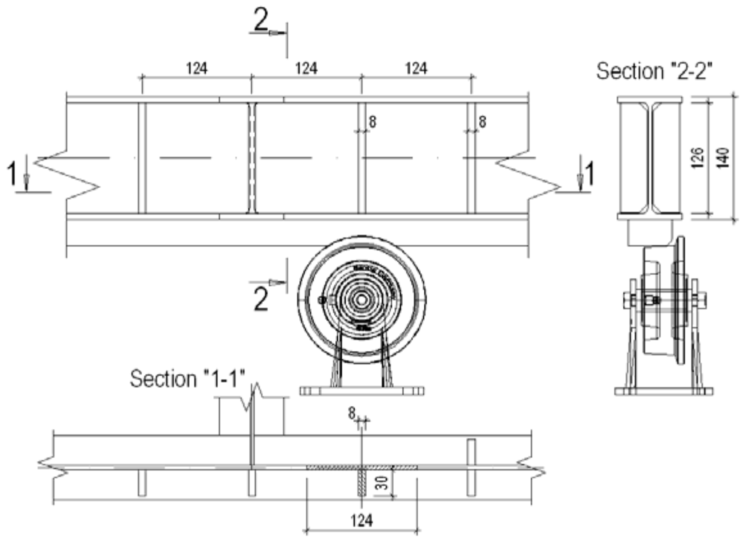

Fig. 4. Scheme of 'stepping' of lower chord of the truss girder on moving roll bearing

- large enough capacity of rotating of immovable bearings - on this way will be compensated different settlement of the neighbouring tanks;
- to assure maximum degree of freedom of construction and on this way to minimize the effect of uneven settlement of the supports in longitudinal and transverse direction. Because of it the immovable support (bearing) is only one;
- considering the need to assure pedestrian walk without to be possible the appearance of the 'holes' at the end of the bridges, the last enter under the platform around the tanks (Fig. 5). This provides additional longitude which can compensate the increased distance to the neighbouring tank shell;

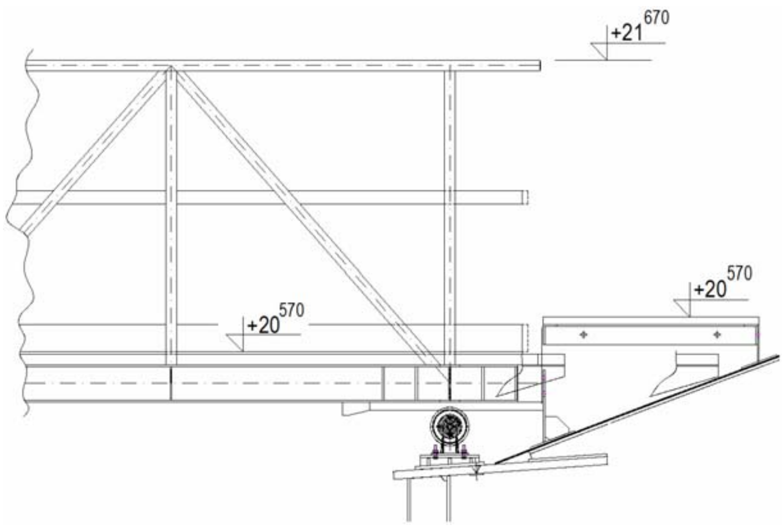

Fig. 5. "Shove under" of the end of bridge under the platform around the tank

After the analysis and accepting of engineering decisions necessary in view of expected serious movements of the supports, research and design of the bridges follows its logical succession:
- choice of the type of hot dip galvanized gratings which can bear the estimated loadings;
- choice of necessary section of hot-rolled transverse beams;

- estimation of the necessary sections of hot-rolled lower chord and box-section upper chord, and internal frames in main truss girders;
- proofs that the free upper chord which is stiffened by U-frames in transverse direction (Fig. 2), will not loose stability due to the compressive efforts on it;
- checking of the needed section of single X-brace's elements in the bridge;
- checking according to БДС EN 1993-1-5 [2] of web the lower chord of the main girders (Fig.4), which 'slides' on the roll bearing, for concentrated force of the supporting reaction;
- checking of the maximum deformation in the horizontal and vertical directions;
- determining own oscillation frequencies of bridges in order to control the comfort of passing staff.

Research and design of the footbridges is done by use of computer 3D models. In the first models bridges are horizontal (when there is not settlements). In the models done later, bridges are inclined – when one of the tanks is moved due to a considerable settlement.

4. Conclusion

At first sight it is a trivial engineer task. Underestimation of its particularities can cause the considerable decrease of period of its exploitation or can make exploitation impossible.

ЛИТЕРАТУРА

[1] EN 14015:2004, Specification for the design and manufacture of site built, vertical, cylindrical, flat-bottomed, above ground, welded, steel tanks for the storage of liquids at ambient temperature and above, November 2004;
[2] БДС EN 1993-1-5:2007, Проектиране на стоманени конструкции. Пълностенни конструктивни елементи, февруари 2007.