Y. Spector[1], O. Denisov[1], A. Shchepetov[1], V. Alexandrov[2], A. Gruzdev[2]

[1]*Ufa State Petroleum Technological University*
[2]*JSC "Verkhne-Volzhskie Oil Pipelines"*

STEEL TANK UNDERLAY REHABILITATION IN ACCORDING TO THE TECHNICAL INSPECTION

For oil and oil products storage tank batteries are equipped with the vertical cylindrical steel tanks with the volume capacity up to 50 thousand m^3. The tanks are the complicated engineering constructions, extremely sensitive to the differential settlements of soil bases which provoke lack of parallelism, rakes and a tank form change. When a tank hydraulic testing, the differential settlements and rakes often occur that exceed the standard values.

Tank bases and pads evaluation includes settlement determination, engineering-geological survey, technical state inspection. According to the evaluation results, the conclusion on the possibility of the subsequent tank service and, if necessary, the recommendations on repair and reconstruction of the base are given. The main methods of a tank base repair and reconstruction are soil stabilization, pads strengthening, penetration of piles of different construction.

CPT USE FOR A TANK BASE EVALUATION

Data available on the engineering-geological survey of tank bases are often discrepant. For instance, soil design characteristics such as modulus of deformation, angle of inner friction and cohesion can be of different value. That's why soil CPT on site is the most preferable.

The unit C-832M provides for CPT with the equilibrium probe use which ensures the high-speed travel of a probe (3 - 5 m/min) and performs the condition of the limit equilibrium for a system "probe-soil" at the necessary levels.

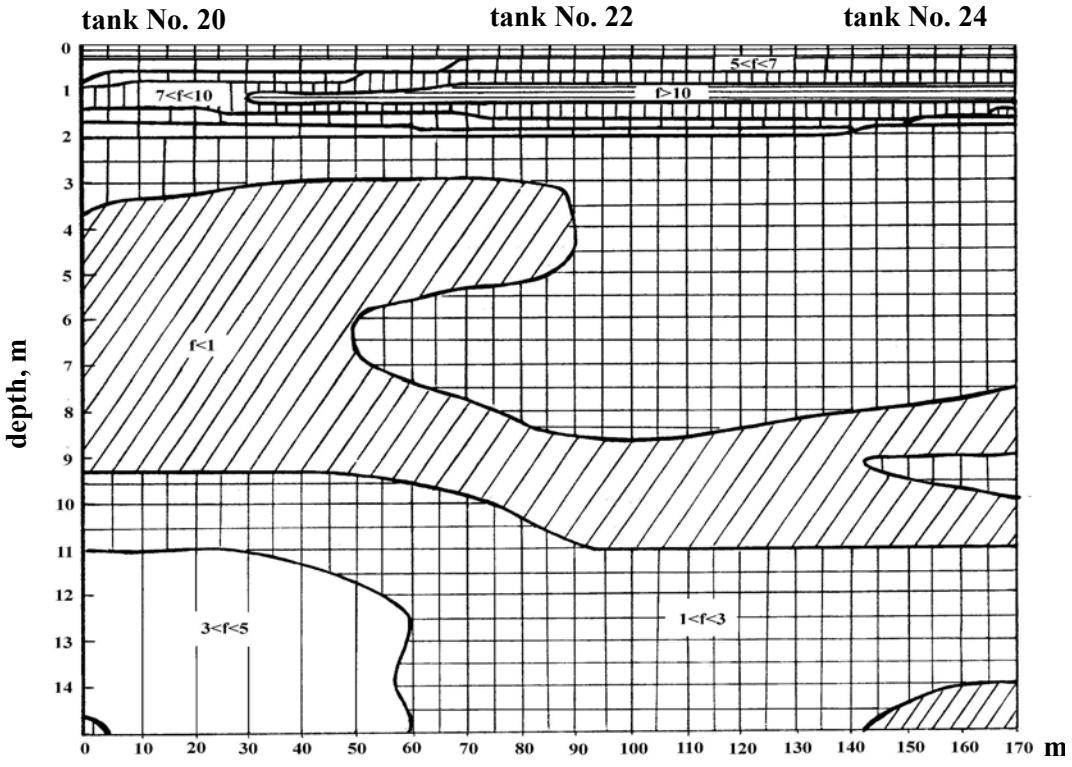

Figure 2 : Soil section in plane of tanks No. 20

In this condition the speed of a probe travel is near to zero or equal to zero and the so-called stabilized values of soil resistance along the frontal and lateral probe surfaces are recorded. The results obtained give the better characteristics of the statically loaded soil. The values of soil resistance are recorded each meter of the probe penetration. The distance between a tank wall and the point of CPT is 1.5 - 2.0 m. CPT in vicinity of a tank is done with a small inclination (about 5^0) in the direction under a tank pad.

Soil CPT around a tank allows to evaluate the strength and deformational characteristics of a soil base, its heterogeneity, to construct the digital soil sections, to define the limit resistances of pads and piles.

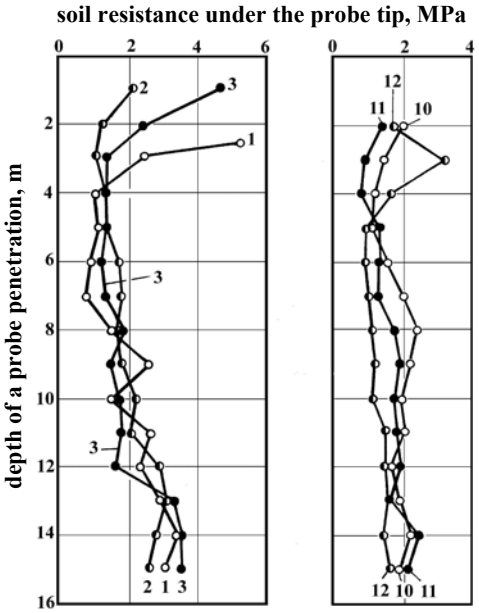

Figure 3 : Dependences of soil resistance under the probe tip on the probe penetration depth in vicinity of the tank No.22 (left) and the tank No.25 (right).
1-3, 10-12 – points of CPT

INSPECTION OF THE TECHNICAL STATE OF STEEL TANKS BASES AND PADS

The inspection of tanks bases and pads removed from service by the method of digging a hole helps to evaluate their technical state, find out the deformation reasons, define the correspondence of the existing pads and their bases to the design decision and, if necessary, to work out the method of bases and pads strengthening.

The tanks are positioned on the foundation consisting of soil fill, sandy pad and a waterproofing layer. The bedrock under the soil fill should be compacted with rock debris or gravel by 10 t rollers.

The comparison of results of bases and pads survey in one tank battery consisting of 6 tanks with the design data shows the following.

When the type of a tank pad chosing, the errors were committed: instead of a solid reinforced concrete ring precast slabs are applied. The application of the latter as a pad of a tank with the volume capacity 20 thousand m^3 and more is prohibited by Codes.

The slab width is decreased by 12%, the slab length inwards the tank is decreased by 36%, the waterproofing layer is almost absent or less than the design depth by 3 - 10 times, the sand bed under the slabs is either absent, or its depth is decreased by 2 -6 times.

Table 1

Investigation results of bases and pad of tanks Nos. 20, 21, 22, 23

Source of information	Tank number	Exploring shaft number	Depth of a foundation slab, mm	Width of a slab bottom, mm	Length of a stab outside the tank, mm	Availability and depth of the moisture barrler, mm	Depth of the concrete bed, mm
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
According to survey results	20	1	220	1000	550	-	100
		4	220	1000	400	15	80
	21	2	220	1000	550	30	90
		3	220	1000	460	20	50
	22	5	220	1000	500	35	100
		6	220	1000	540	-	100
	23	7	220	1000	500	10	100
		8	220	1000	350	15	400
According to project *	20-23	-	250	1000	300	100	100

*No. 704-1-60 album III

1	2	3	4	5	6	7	8
Source of information	Tank number	Exploring shaft number	Sandy pad availability and its depth, mm	Width and depth of the pitched work, mm	Sandy pad availability and depth under the pitched work, mm	Availability of native soil compacted with rock debris or gravel, mm	Slab length, m
According to survey results	20	1	130	1650/140	300	-	1.7
		4	50	1900/100	350	-	1.7
	21	2	-	1600/130	180	-	1.7
		3	40	1460/100	-	-	1.7
	22	5	250	1900/120	440	-	1.7
		6	250	2000/140	370	-	1.7
	23	7	100	2000/80	200	-	1.7
		8	400	1900/500	500	-	1.7
According to project *	20-23	-	250	1000/120	350	-	1.4

TECHNICAL DECISIONS ON THE RECONSTRUCTION OF A TANK BASE

One of the ways of a tank base and pad strengthening is the change of the existing precast reinforced concrete slabs onto the solid reinforced concrete foundation ring, the additional reinforced concrete wall-column is erected over the tank perimeter (version No.1).

The other way of a tank base strengthening is the arrangement of a solid reinforced concrete foundation ring over the existing slabs (version No.2). The construction of a tank pad by the given version differs from the previous one in that the existing reinforced concrete slabs are not disassembled, but a concrete bed is placed over the slabs and then the solid reinforced concrete ring is assembled.

The next version of a base strengthening forsees the penetration of bored piles over the tank perimeter with the construction of a solid ring reinforced concrete raft under the tank wall (version No.3).

THE USE OF SOIL THERMAL STABILIZATION FOR A TANK BASE STRENGTHENING

One of the methods of a tank foundation soil stabilization is the thermal strengthening with the electromagnetic radiation of microwave frequencies (microwave energy). The thermally stabilized soil piles, manufactured with the help of a mobile unit are recommended as the main constructive element of the foundations and tanks pads.

For sites composed of highly compressible clayey soil, the tank base is suggested which forsees the bearing of a tank wall onto the ring reinforced concrete raft, which combines the thermally strengthened soil piles. In loess subsident soils a sand bed is recommended under the tank bottom and for subsidence exclusion piles are manufactured of the thermally stabilized soil. The thermal stabilization of soil excludes the

danger of subsidence when soil flooding. The tank pad, including the thermally strengthened soil piles, reinforced concrete caps, ring grillages and slabs can be used for differential settlements prevention in conditions of highly compressible clayey soils.

CONCLUSIONS

Soil CPT allows to evaluate the soil strength characteristics and heterogeneity at site of the tank battery, to define base characteristics for a tank pad design, to define strength and deformational soil charateristics within the active zone of a tank pad.

Three versions of constructive decisions of a tank pad strengthening are suggested:

version No.1 - with the change of the existing slabs onto a solid reinforced concrete foundation ring;

version No.2 - with the arrangement of a solid reinforced concrete foundation ring on the existing slabs;

version No.3 - with the help of the bored piles.

The estimated cost of strengthening and reconstruction of a tank battery base including 6 tanks with the volume capacity 20 thousand m^3 is:

according to version No.1 - 714 thousand US $

according to version No.2 - 718 thousand US $

according to version No.3 - 1 million 82 thousand US $.

The soil thermal stabilization with the microwave energy provides significant improvement of chemical-and-physical properties of soil bases. In fact, the compressive strength is 2.5 - 12.0 Mpa, cohesion is 10 - 150 kPa depending on soil type. The load capacity of thermally strengthened soil piles with the diameter 0.45 - 0.8 m and length 5 m is 35 - 60 kH for loess soil, 180 - 420 kH for loam, 380 - 800 kN for clay. Thus, the given method can be recommended for a tank base reconstruction and strengthening.

REFERENCES

1. Spector, Y.I., Babin, L.A., Denisov, O.L. Elimination of foundation base termination criterion by means of soil thermal strengthening with the microwave energy //Proceedings 7th International Conference and Exhibition on Piling and Deep Foundation. Vienna, Austria, 15-17 June, London: Westrade Group Ltd. 1998. - P.511-515.
2. Spektor, Y.I., Shchepetov, A.E. and Absalov, K.A. Experimental investigations of interaction of soil and geosynthetics used for reinforcing tank bases and pipelines embankments //Proceedings 8th International Congress International Association for Engineering Geology and the Environment. Vancouver, Canada, 21-25 September, Rotterdam: A.A.Balkema Publishers, 1998 - P.3379-3382.
3. Spektor, Y.I., Denisov, O.L., Abdullin, I.B., Lyubushkin, V.V., Absalov, K.A. New methods of computation the reinforced and thermally strengthened soil bases of pipeline transport objects //Proceedings 12th European Conference on Soil Mechanics and Geotechnical Engineering. Amsterdam, The Netherlands, 7-10 June, Rotterdam: A.A.Balkema Publishers, 1999. - Vol.2. - P.941-948.