THE DETERIORATION OF REINFORCED CONCRETE WATER–SUPPLY TOWERS IN LITHUANIA

RAIMONDAS ŠADZEVIČIUS

Aleksandras Stulginskis University
Water and Land Management Faculty
Institute of Hydraulic Construction Engineering
Universiteto str. 10, LT–53361, Akademija, Kaunas distr.
raimondas.sadzevicius@asu.lt

ABSTRACT
The period of 1950 – 1980 was most intensive for water – supply towers construction in Lithuania. The purpose of water – supply towers – to increase the water pressure and to supply with water consumers residing far away from central stations. Under the influence of loads and negative environmental impacts water – supply towers constructions are wear out, and deteriorations are formed. The technical state of water – supply towers should be evaluated before planning repairs or reconstruction. Special research or studies of technical state evaluation of reinforced concrete water – supply towers were not performed in Lithuania.
The aim – to establish the main deteriorations and to evaluate the technical state of reinforced concrete water – supply towers.
The most commonly occurring water – supply towers deteriorations are cracks in the concrete surface by 0.2 to 0.3 mm wide, surface delamination. One of the most dangerous deteriorations is corrosion of reinforcement and concrete.

Keywords: water – supply tower, deteriorations, technical state.

INTRODUCTION

Water – supply towers – the structures with tanks (one or more) constructed above the ground. Water – supply towers are designed for storage of water supplies and maintain the pressure in the water network. These structures smoothes the water supply and the inequality of water consumption (VADLŪGA, 2003).
Most of the water – supply towers were built in 1950 – 1990. The towers were built mostly of two materials: concrete and metal. In rare cases, towers constructed of brick masonry (http://lt.wikipedia.org).
In most cases water – supply towers were built with cast–in–place, sometimes – with precast reinforced concrete tanks. The tanks consists of several cylindrical, cone–shaped or complex rotation shells, rings and plates. Tank walls are usually made from cast–in–place concrete (KUSTA ET AL, 2006).
The object of investigation: concrete water – supply towers investigated in 2009 – 2011 years.
Under the influence on different loads, climatic factors, quality of used materials, poor maintenance, the defects in water – supply towers during exploitation may develop to structural deteriorations (VAIŠVILA, 2008). In case of big deterioration – structure must be repaired, reconstructed or demolished.
Analysis of the literature about the agricultural building defects, deterioration, shows, that is lack information about detailed reinforced concrete water–supply towers defects, deteriorations evaluation in Lithuania, so this work is actual and necessary.
Foreign scientists have studied these tower buildings constructions: silos (CARSON, 2000), water – supply towers (POUKHONTO, 2003) and found that the most dangerous cast–in–

place and precast construction defects are: inadequate or defective reinforcement, too low concrete class or grade, low quality or too thin concrete layer for reinforcement protection. The state of structures and constructions is evaluated according to the main indices of defects and deterioration and is expressed by the method of grades (points, sorts, categories). The technical state of reinforced concrete water – supply towers structures is not clear, because detail field investigations in Lithuania were not performed

The main purpose– to investigate the main deteriorations and evaluate the technical state of reinforced concrete water – supply towers.

MATERIAL AND METHOD

10 reinforced concrete water – supply towers were investigated in 2009 – 2011.

These methods were used for reinforced concrete water – supply towers defects, deteriorations and technical state evaluation:

1) analysis of literature, a review of design and construction documents, engineering data;
2) visual observations and field investigations (instrumental methods) performing the measurements of defects and deteriorations;
3) technical state was determined according to quantitative indices – scale of defectiveness.

Sources of engineering data which can yield useful information – include project design memoranda, plans and specifications, construction history reports.

The structures were *visually examined* on location and their most deteriorated places were established, typical defects and deteriorations were measured. The visual method enables to evaluate such surface defects of structures as broken corners, edges, deteriorated concrete covering layer, stratified concrete, cracks, bad concrete pouring and steel corrosion. *Technical states* of water–supply towers were assessed considering to noticed defects and deteriorations and according to the criteria specified in *Table 1*.

Table 1. The criteria for evaluation of technical state of reinforced concrete hydraulic structures (LINDIŠAS, 1997)

State category	The size of defects and deteriorations	Points
I good condition	There are not irregularities of standards and normative documents.	0
II moderate condition	Minor defects of structure	1–2
III satisfactory condition	Significant defects of structures, that does not have important influence to strength.	3–4
	Deterioration of the element does not have important influence to strength, reliability and the actual service life of the element. The actual load–bearing capacity of structure from 1.2 to 1.0 of the estimated during design.	5–6
	Defects significantly weakening structure. The actual load–bearing capacity of structure from 1.0 to 0.8 of the estimated during design.	7–8
IV unsatisfactory condition	Remarkable structural defects greatly reduces the strength and reliability of element. The actual load–bearing capacity of structure from 0.8 to 0.7 of the estimated during design.	9
V critical condition	Risk of collapse. The actual load–bearing capacity of structure less than 0.7 of the estimated during design.	10

RESULTS AND DISCUSSION

Field investigations of reinforced concrete water–supply towers technical state carried out in 2009–2011. For investigations were selected the typical 25–50 meter high reinforced concrete water–supply towers. Study objects were selected for their convenient geographical position in 5 districts of Lithuania: Kaunas, Šakiai, Šilalė, Šilutė, Jurbarkas. Summarized data of investigations of water–supply towers deteriorations and technical state are presented in *Table 2*.

Table 2. The results of investigations of technical state of reinforced concrete water–supply towers

District with a water–supply tower, construction year	Cracks in concrete	Corrosion of reinforcement	The deterioration of concrete surface layer	Corrosion of concrete	Technical state in points
Kaunas (1986–1987)	+	+	+	–	**5.0**
Kaunas distr. Pagynė (1989)	+	–	+	–	**3.5**
Kaunas distr. Mastaičiai (1990.)	–	–	+	–	**3.5**
Kaunas distr. Garliava (1990)	+	+	–	+	**6.0**
Kaunas distr. Ringaudai (1988)	+	+	+	–	**7.0**
Jurbarkas (1989–1990)	+	+	+	+	**7.0**
Šakiai (1991)	+	+	+	+	**6.5**
Šilalė (1984–1985)	+	+	+	+	**3.0**
Pagryniai (1990)	+	+	–	–	**5.0**
Šilutė (1986–1987)	+	–	+	+	**5.0**

The results presented in *Table 2* shows, that the oldest of investigated water–supply towers – in Šilalė distr. (built in 1984–1985), and the latest – in Šakiai distr. (built in 1991).

The results of field investigations of 10 reinforced concrete water–supply towers (*Table 2*) shows that the mostly occurred defects and deteriorations of constructions were: cracks – up to 0.2 to 0.3 mm in width (9 from 10 objects), and deterioration of cover layer (delamination) (8 from 10 objects). These deteriorations are observed in almost the all investigated water–supply towers – at 90% and 80% of the researched objects, respectively. Deterioration processes mostly break the badly made covering layer (small concrete strength and frost resistance) which, being under the influence of frost cycles, crumbles. Its physical–mechanical properties change, form deteriorations, pitting.

Concrete and steel corrosion is one of the factor, mostly reducing load–bearing capacity and durability of concrete structures (JOKŪBAITIS AND ŠAUČIUVĖNAS, 2012). During expeditions the main attention was focused for these deteriorations. The corrosion of reinforcement – founded at the 7 from 10 investigated objects, at 70% of the researched objects, respectively. The maximum length of the segment, with corroded reinforcement, is 38 cm. The signs of concrete corrosion – white spots with leaching calcium hydroxide were noticed at the 5 water – supply towers, at 50% of the researched objects, respectively.

At present time the technical state of reinforced concrete structures of water–supply towers in Lithuania is not the same. There are a number of water–supply towers structures being in almost good condition, others are less or more deteriorated.

After summarizing the results of field investigations of reinforced concrete water–supply

towers, is it found, that detected deteriorations do not satisfy aesthetic requirements, but directly do not reduce load–bearing capacity. According to the criteria specified and technical state categories shown in *Table 1*, it can be said, that most of water–supply towers are in the third technical state category.
Only in structures of water–supply towers in Jurbarkas, Ringaudai, Šakiai distr. deteriorations are significantly weakening structure (flaky rust on the reinforcement decreased cross–sectional area more than 15%). These deteriorations are reducing the load–bearing capacity of water–supply tower, so the total technical state assessment – 7 points.

CONCLUSIONS

The results of field investigations of 10 water–supply towers show, that the mostly occurring deteriorations of water – supply towers are: cracks in the concrete surface by 0.2 to 0.3 mm wide and surface delamination, founded at 90% and 80% of the researched objects, respectively.
One of the most dangerous deteriorations is corrosion of reinforcement and concrete, founded at 70% and 50% of the researched objects, respectively.
Most of detected deteriorations at reinforced concrete water–supply towers are not reducing load–bearing capacity of structures and investigated water–supply towers are in the third technical state category.
All the investigated water–supply towers are relatively safe to use for this day, except water–supply towers in Jurbarkas, Ringaudai, Šakiai distr.

REFERENCES

CARSON J. W. (2000): Silo failures: case histories and lessons learned. Proc., 3rd Israeli Conf. for Conveying and Handling of Particulate Solids, Dead Sea, Israel, Vol. 1, 4.1–4.11., 14 p.
JOKŪBAITIS V., ŠAUČIUVĖNAS G. (2012): Statinių konstrukcijų techninės būklės vertinimas: mokomoji knyga. Vilnius, Technika, 200 p. (in Lithuanian).
KUSTA A., RADZEVIČIUS A., ŽIBIENĖ G. (2006): Žemės ūkio ir gyvenamųjų vietovių vandentieka. Vilnius, Margi raštai, 323 p. (in Lithuanian).
LINDIŠAS L. (1997): Gelžbetoninių hidrotechninių statinių techninės būklės įvertinimo metodikos sukūrimas, jų naudojimo darbų sudėties ir periodiškumo nustatymas pagal įrenginių būklės klasifikavimą. Mokslinio tiriamojo darbo atlikto pagal autorinę sutartį nr.AT9.3 ataskaita Kaunas–Akademija, 64p. (in Lithuanian).
POUKHONTO L. M. (2003): Durability of Concrete Structures and Constructions. Silos, Bunkers, Reservoirs, Water–supply towers, Retaining Walls. Tokyo, A. A. Balkema Publishers, 405 p.
VAIŠVILA K. A. (2008): Statinių būklės vertinimas ir rekonstrukcija. Mokomoji knyga. Kaunas, Ardiva, 100 p. (in Lithuanian).
VALDŪGA V. (2003): Gelžbetoniniai bokštiniai statiniai. Mokomoji knyga. Vilnius, Technika, 67 p. (in Lithuanian).
http://www.wikipedija.lt, accessed on 2013.01.05