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Some causes of reinforced concrete silos failure

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Abstract

This paper presents some problems connected with causes of reinforced concrete silos failure. Reinforced concrete silos and other shells were built for decades. Vitality i.e. durability of cracked silo walls are one of the most important parameters during designing process, constructional and exploitation time of these shells. Some reasons of appearance of horizontal and vertical cracks as temperature, pressure of stored material, live loads e.g. wind, dynamic character of wind, moisture, influence of construction joints, thermal insulation, chemistry active environmental etc. reduce the carrying capacity of the walls of the silos and causes lower the state of reliability. Horizontal and vertical cracks can cause corrosion of concrete and steel bars, decreasing stiffness of contraction, bigger deflection, increasing of carbonation of concrete cover and dank of concrete wall. Horizontal and vertical cracks allow condensate water infiltrates into wall. Local and global imperfactions of concrete shells are increasing according to greater number of cracks. Taking into account these facts, reducing of strength parameters reduce the service life of the whole reinforced concrete structure causing failure status. The technology of repairing cracked walls must take into consideration the model of failure, simple one parameter or complex as series or parallel system models.

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Keywords: durability, silo, concrete, reliability.

1. Introduction

In recent years many engineers objects, as reinforced concrete silos, tanks are renovated. In particular they are not only renovated but also strengthened. Most of them lost their designed durability life, another failed with frequency which is much higher than almost any other industrial equipment. The basic reason of this state is

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carbonation of concrete, reinforcement corrosion, chemical activity on objects, loss of concrete cover, too many cracks with wide-width, too large deformations and deflections, etc. Another reasons are changes of kind of exploitation of objects and changes in technology of production in which the object is the part. Some of these failure cases are invisible, some of them involves complete collapse of the structure. Recently, more and more often investigates the impact of silos on the environment. Other causes for the demolition of the silos and tanks may be noise, pollution, impossibilities of recycling, insolation of objects surrounding etc. But also due to the increasing standard requirements do not meet the requirements for reliable use. Another reason for renovated is change of kind of use of buildings i.e. changes of live loads, changes of constructions static schemas. New objects built in close proximity to cause increased wind loads and additional impacts on ground foundations. During designing of buildings there is not expected regeneration or renovation of parts or of the whole object. Reduced resistance due to many years of buildings exploitation is included in partial safety coefficient. Durability is stochastic process and structures lose their reliability before the termination of operation of the facility.

2. The causes of silo structure failures

There are another many mistakes which were made during designing; building and maintenance of concrete reinforced silo walls. We can distinguishes them as follows: too small distance between vertical and horizontal steel bars in concrete wall; insufficient concrete care during building; too rapid drying wall; using adjustable formwork in building shells; using joints in shell during building; non-proper joint design; too long pause between subsequent concrete filling; using vibrators inappropriate for steel bars diameter and for distances between them; touching by vibrator steel bars; too small or destroyed thermal insulation; destroyed moisture; chemical; thermal protecting coating; too few steel bars calculated shrinkage for shells wall; temperature field on the silo wall caused by storage grain; insolation and daily temperature variation; big temperature gradient across the wall; additional unexpected horizontal pressure caused by wind and grain pressure; concentrated loads (patch loadings); large and non-symmetric pressure caused by inserts; bending of circular walls caused by eccentric withdrawal; parameters connected with wall strength as changes in wall stiffness (thickness); differentials in diameter and area and strength of bars and in strength of concrete; differentials in concrete cover of bars; buckling of unsupported wall; imperfections in steel bars localization; imperfections of wall; cracks; height of compressed concrete area; quantity of reinforced horizontal and vertical bars; adhesion of bars to concrete; low quality of lap splices; type and quality of wall strengthening; steel corrosion; low quality of technical condition of concrete; i.e. concrete carbonization; etc.; ignoring flow patterns and material properties; failure due to construction errors; incorrect material; uneven foundation settlement; designing changes during construction; failure due to usage; changing of stored material; dynamic loads; self-induced vibrations; explosions; changes of flow patterns; failure due to improper maintenance; improper reaction to signs of distress.

3. Durability as a random value

According to [1], the durability of the material we mean its ability to maintain declared by the manufacturer the mechanical, functional and aesthetic material properties during design lifetime of the object. The measure of durability is the time T from the start of use for the first failure and is a measure i.a. of reliability of systems. Durability of construction materials depends on the operation time of the facility, the stress number of cycles N of structures subjected to cyclic interactions and the number of exceedances of the limit states. Lowering the durability of materials reduces the computational resistance parameters and narrows the area of reliability of the whole structure. The basic equation of reliability of each of construction element and the whole construction can by described in following equation (1) [2]

$$S \leq R \tag{1}$$

where R – construction resistance, strength, limit deflections, limit value of crack width, fire durability, acoustic insulation etc, S – loadings acting on construction, movements of supports, acoustic, chemical, thermal influences, etc. This equation is used by engineers in stresses quantities, inner forces etc. Inner forces N and M are directly