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Causes and Consequences of Losses in the Water Supply System of Cement Manufacturing Enterprises

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Abstract: *The article mainly cites the example of the water supply system in cement plants and the main water consumers Sherabad Cement Plant. Information is provided on losses that occur during the water supply process at the enterprise and are not taken into account. The formation of small cracks in the trench of the primary water supply route, the seasonal nature of the faults observed during the year, the amount of water losses not taken into account, the timing of the emergency response. In the analysis of the results, accidents in the waterway trench from well №5 to the main pumping station occur mainly during the rainy months, the main cause of failure is the sand layer, which should protect the pipeline from external influences. It is concluded that due to the nature of moisture is absorbed into the soil. It was also reported that it would take some time to detect water leaks from small cracks in the pipeline as a result of the accident, and that the company was incurring significant costs for annual repairs. At the end of the article, scientific recommendations are given as a solution to this problem.*

Keywords: *Cement plants, water supply system, water well, small cracks, water losses, water pipes, pumping station.*

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Introduction. The main water consumption is used for cooling equipment at cement plants, filling the consumer and fire safety systems with water. Losses in the water supply system occur mainly in the process of transmission, preparation and delivery of water to consumers. The energy consumption of industrial enterprises producing construction materials is high, while the energy efficiency of the industry can reach up to 40% [1]. One of the most pressing issues in the cement industry is the conservation of water resources and reduction of excess losses. In order to reduce losses in water use, industrial enterprises should regularly check the water balance in accordance with their normative and technical documents [2]. A small leak in the pipeline can lead to water loss and a significant increase in repair costs. It is important to offer solutions based on the company's water supply system, study, analysis of water sources and scientific analysis of water loss points. The first International Energy Congress in Australia unanimously approved the need to restructure the water industry of industrial enterprises to a closed circulating water supply system [3]. Although a closed water supply system is considered to be a non-wastewater system, it also generates wastewater at certain stages. On the example of Sherabad cement plant, recommendations are given for possible water losses in the water supply system and their elimination.

Main body. In the context of global climate change, the Central Asian region in particular has been facing water shortages in recent years. Along with the use of energy-saving and water-saving equipment and technologies in the use of water by industrial enterprises, there is a need to eliminate the detection of excess water losses. We will focus on water losses in the water supply system of industrial enterprises and scientific recommendations for their elimination. Sherabad Cement Plant is located in the Surkhandarya region of the Republic of Uzbekistan. The climate of Surkhandarya region is hot and dry, the main source of water for existing industrial enterprises is groundwater [4]. Water consumption varies depending on the climate of the area where the enterprise is located. Sherabad Cement Plant is a modern enterprise with a production capacity of 1.5 million tons of Portland cement per year. Although the dry method of cement production uses water, the company has a high demand for water because it has a small thermal power plant. The "waste heat" is simply transferred to a generator that produces 8 MW of electricity without being released into the atmosphere. In the Sherabad Cement Plant closed circulation water supply system, 30% of the water is used for cooling the main equipment and 70% for the needs of a small thermal power plant [5]. Natural “soft” water resources can be used to reduce costs in the water preparation process; rain and snow water is sufficiently “soft”, calcium and magnesium ions are less than 1 eq / l. [6]. Scientific research on the use of annual rainwater is nowadays carried out. The main water sources of the Sherabad cement plant are groundwater. In order to supply the company with water, 5 wells were put into operation on its territory and out of territory. The fact that the deepest well is №1 (203 meters) and the smallest is №5 (70 meters) indicates that the groundwater intake itself consumes a lot of electricity. Water flow in wells is seasonal (№2 and №5) and constant (№1, №3, №4). The company's water consumption is also seasonally variable (total water consumption in July 2020 averaged 35 m^3 per 25593.6 m^3 per hour, and in January averaged 27 m^3 per 19811.4 m^3 per hour) [7]. Given that wells can operate on a combination basis, all water wells will supply water in working condition. The water flow rate of the water wells is shown in Table 1.

Water supply wells in Sherabad Cement Plant	Depth of wells	Average hourly debit of the well during July	Average hourly debit of the well during January
№1	203 meters	25 m^3/hour	25 m^3/ hour
№2	100 meters	25 m^3/ hour	10 m^3/ hour
№3	200 meters	10 m^3/ hour	10 m^3/ hour
№4	160 meters	25 m^3/ hour	25 m^3/ hour
№5	70 meters	10 m^3/ hour	5 m^3/ hour

Each water well and Phase I pumps operate simultaneously. For this purpose, each water well is equipped with a 5-ton water tank and Phase I pumps, which vary in size and distance of water supply. Water in wells is determined not by measuring instruments, but using a direct method of calculation (pump operating time and the amount of electricity consumed). The design of water flow meters measures the flow of water in the pipeline for a certain period of time, and does not provide for an instantaneous increase in water consumption [8]. Initial losses occur during the water metering process and then during the delivery of water from the Phase I pump to the main pumping station. The main pipes are laid at the base of the trench. Unaccounted water losses depend primarily on the condition of water pipes and the accuracy of water metering equipment reaching consumers [9]. Water is brought from the farthest well №5 to the main pumping station through a 3790 meters long DN89x3.5 mm polyethylene pipe. The tightness of the main catchments not only prevents water loss, but also ensures the sanitary safety of drinking water [10]. Violation of tightness in the catchment area and pipelines leads to excessive water loss and the addition of various biologically harmful substances to the water. For 2020 and 2021, we consider the study of the time and periodicity of forced shutdown of №5 wells due to a fault in the pipeline (Table 2).

Quarters	Monthly	Observations for 2020			Observations for 2021		
		Number of outages	Average repair time (per hour)	Total repair time (per hour)	Number of outages	Average repair time (per hour)	Total repair time (per hour)
I- quarter	January	1	4	4	2	4	8
	February	2	4	8	2	4	8
	March	5	4	20	6	4	24
II- quarter	April	5	4	20	6	4	24
	May	5	3	12	5	4	20
	June	1	3	6	0	0	0
III- quarter	July	1	3	3	1	3	3
	August	1	3	3	1	3	3
	September	1	3,5	3,5	2	4	8
IV-quater	October	3	3,5	7	4	4	16
	November	5	4	20	6	4	24
	December	1	4	12	4	4	16
Total:		32		118,5	39		154

Major accidents in the pipeline can be detected quickly (as a result of a drop in water pressure). However, a small number of accidents are detected using visual observation. The Sherabad Cement Plant operates in the II-shift order, and monitoring time on this pipeline section is carried out before each shift change. This means that the maximum time for the appearance of a small crack in the pipe (less than 10x2 mm) and the detection of water loss in it is 11 hours, and the minimum time is 1 hour. As a result of a small crack in the pipe, we can assume that the duration of water loss will last an average of 5 hours. The operation of the Phase I transmission pumps was not stopped to determine the amount of water flowing from a small hole in the pipe. As a result of observations (in the process of troubleshooting the pipeline, which occurred on 17.03.2020, 03.05.2020, 23.11.2020, 14.02.2021, 07.04.2021, 28.10.2021) the average water losses are given in the following table (Table 3).

(Table 3)

№	Dates	Picket in the area of the accident (in meters)	The size of the crack (in millimeters)	The amount of water flowing out of the hole (liter / second)
1	17.03.2020	PK24+52	9x2	≈0,14
2	03.05.2020	PK10+11	10x2	≈0,15
3	23.11.2020	PK11+52	7x2	≈0,12
4	14.02.2021	PK15+89	8x2	≈0,13
5	07.04.2021	PK17+49	9x2	≈0,14
6	28.10.2021	PK25+63	9x2	≈0,15

According to the project, the pipe was buried in a trench 1.4-1.6 meters above the ground using a protective layer of sand. Causes of cracks can be: hydraulic shock, poor quality or poor installation of pipes, active movement of the earth's crust. The geological features of the earth's surface are mainly composed of a layer of sand-gravel sediments and a mixture of gravel-clay. As a result of active rains in the area where the pipeline is laid, many small streams appear, and later these streams merge into the Vandobsoy, which collects flood water. In the process of laying the pipe, despite the presence of a protective layer of sand, there were cases of landslides around the side of the trench. As a result, the pipe was deformed on the outside (Fig. 2).

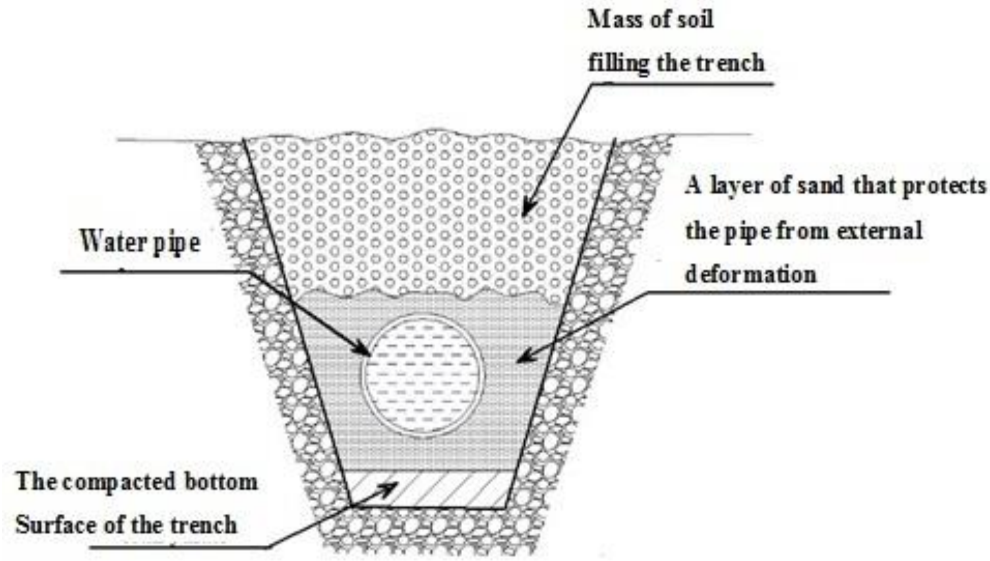


Figure 2. Longitudinal section of the initial position of the trench where the water pipeline connecting the main pumping station of Sherabad cement plant with the water well №5.

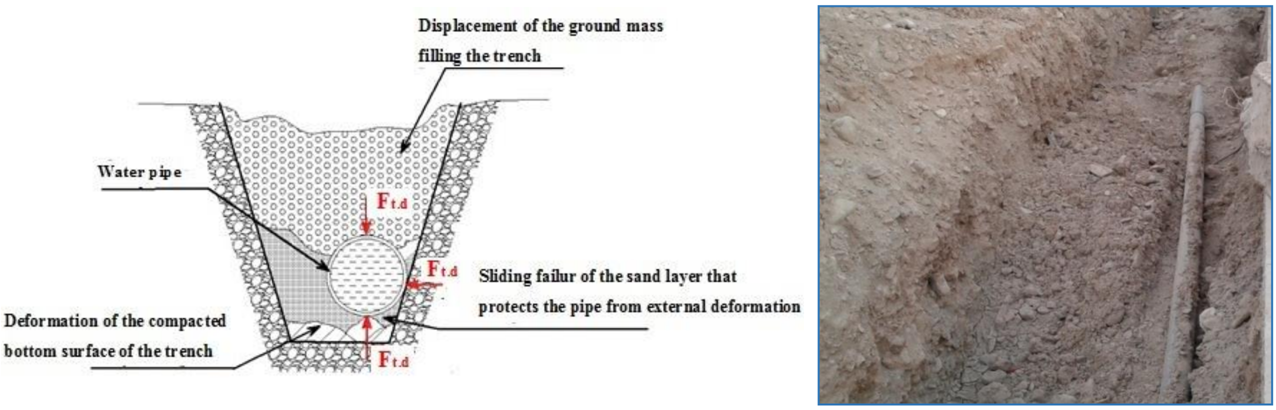
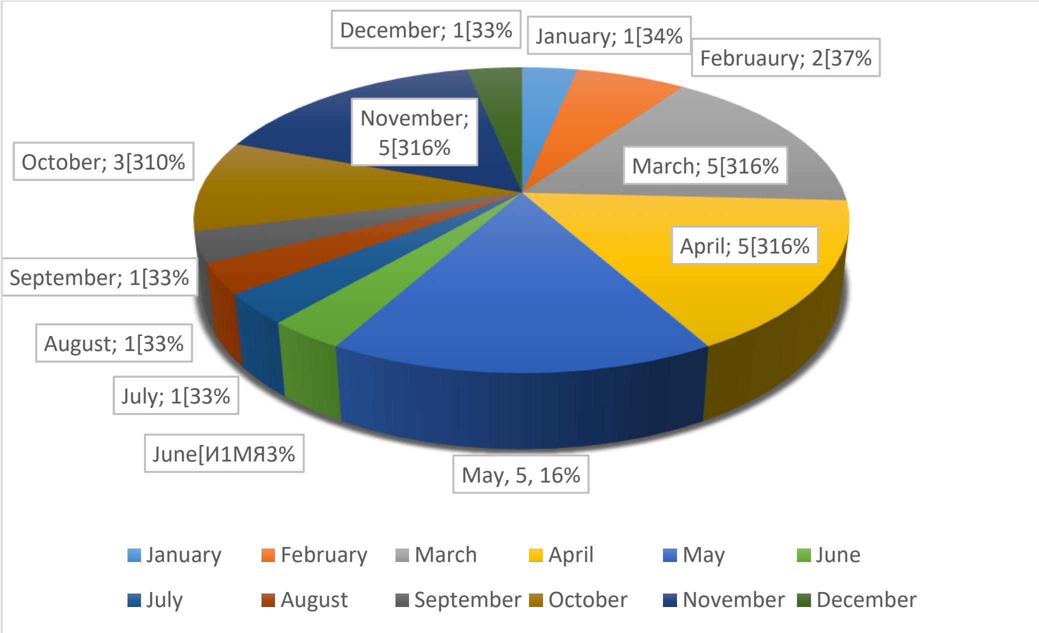
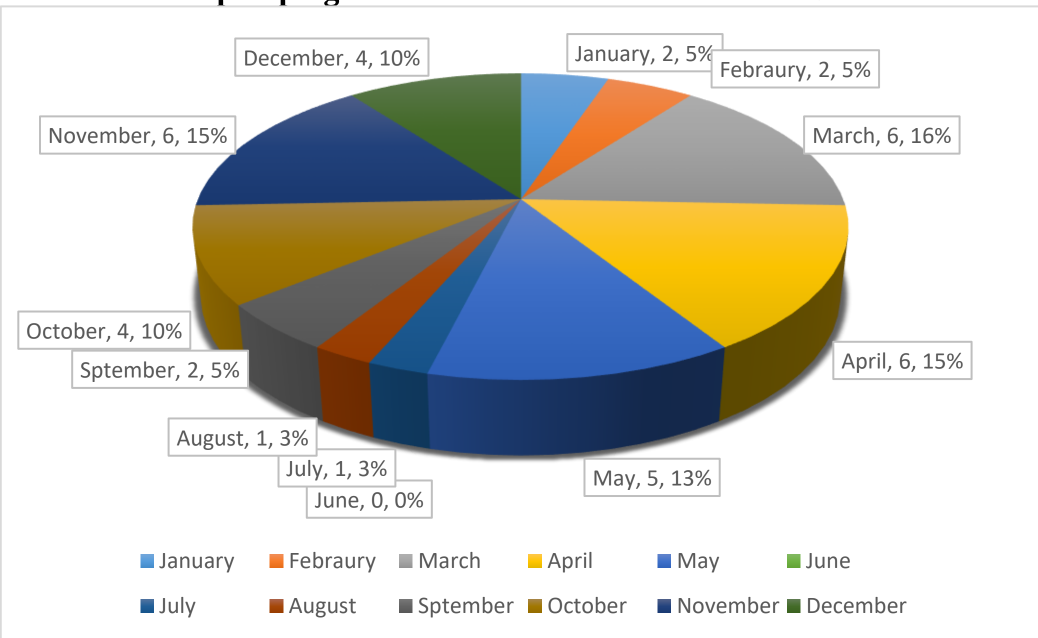


Figure 3. The state of failure of the trench connecting the main pumping station of the Sherabad cement plant with the water well №5 due to landslides. $F_{t.d}$- Possible external deformation forces.

Results. Theoretical analysis of the results revealed that the average water loss from the cracks is 0.138 liters / second. As mentioned above, it takes an average of 5 hours for cracks to form in a pipe, during which time 2,484 m^3 of water is lost from a crack in the pipe. It should be noted that in rainy weather reduces the possibility of visual detection of water leakage from the pipe to the surface. This means that the amount of water lost in small cracks may be greater. During 2020, there were a total of 32 accidents on the №5 pipeline, and in 2021 there were 39 accidents, with a relative increase. The average annual water loss of the enterprise in this direction was 79.68 m^3 in 2020 and 97.11 m^3 in 2021, respectively. Accidents that occur over the years are represented in the form of diagrams.



1- diagram. Sherabad Cement Plant №5 Accidents in the pipeline connecting the main pumping station with the water well in 2020.



2- diagram. Sherabad cement plant №5 accidents in the pipeline connecting the main pumping station with the water well in 2021.

If we analyze diagrams 1 and 2, the highest number of accidents is in the spring (in 2020 March 16%, April 16%, May 16%, and in 2021 March, 16%, April 16%, May 13%) and late autumn. (in 2020 October 10%, November 16%, and in 2021, October 10%, November 15%,) we can see that precipitation has occurred. This means that the main cause of small faults in the pipeline is the displacement of the pipe and filler soil as a result of precipitation of the sand layer in the trench. Because this process is very slow, excessive deformation forces ($F_{t.d}$) fall on the pipe walls. As a result, small cracks are formed in the pipe. It is a bit difficult to determine because the volume of water flowing from the well is very small relative to the total water volume. As a result of these failures, we can calculate the damage to the enterprise. It should be noted that in none of these failures did the company cease operations. However, if the scale of the failure in the pipes is large, it can lead to disruption or failure of cement production technology. According to the internal regulations of the Sherabad cement plant, the cost of each hour allocated for repairs is 2.18 million soums. Expenditures include excavator rental hours for excavation work, repair equipment and operating hours for a small internal combustion engine generator (up to 75% of the total cost). In 2020, the number of repairs was 118.5 hours, and in 2021 - 154 hours. Allocated funds in 2020 will be 2.18 (million soums / hour) x118.5 (hours) = 258.33 million soums, and in 2021 - 2.18 (million soums / hour) x154 (hours) = 335.72 million soums. In 2020 and 2021, the fee for the use of groundwater by industrial enterprises was 1,200 soums per 1 m3. The damage from the total loss of water is 1200 (soums / m3) x (118.5 + 154) (hours) x 0.568 (m3 / hour) = 185736 soums. During 2020-2021, the total damage caused by accidents in the pipeline between №5 and the main pumping station amounted to 25833000 + 33572000 + 185736 = 594235736 soums.

Recommendations. As a result of small cracks in the pipe, the company suffers more material damage for its repair than water loss. This leads to waste of groundwater and inefficient operation of the water supply system. Taking into account the geological condition of the pipeline route, the impact of climate change, the company's proximity to the main raw material quarry, we recommend the following:

- Cast beams made of reinforced concrete or modern polymer products can be used to protect the pipe from external forces.
- In the event of an accident, the pipe should be replaced with a pipe made of a material that can withstand external forces.
- Use of modern sensitive manometers for immediate detection of accidents.
- Equipping this water pipeline route with emergency sensors and automated software and hardware.

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