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Impact of Installation Quality on Engineering Systems' Operational Behavior

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Abstract: *This article discusses the role of quality in the installation of utility networks and reduces operating costs. The author has developed a list of single indicators of the quality of installation inside house engineering systems during their operation. The frequency of occurrence of defects within the building engineering networks was revealed in terms of the quality of installation.*

Keywords: *engineering and communication networks, installation, quality assessment, unit indicators.*

1. Introduction. Engineering systems exhibit the characteristics of complex systems, which incorporate functionally distinct sets of components. The system can be in two or more operational states, each of which is characterized by its efficiency. Individual component failures do not result in the failure of the entire system, but they may cause a fall in its efficiency.

The system's emergency modes are probabilistic in nature and susceptible to the law of random processes. This holds true for both the failure's actual expression and the specific instant it took place.

2. Methodology. The requirement to list a significant number of states in complicated systems makes this task particularly challenging. The decomposition approach, which essentially involves breaking down the system under investigation into reasonably independent subsystems, is one of the techniques for streamlining and systematizing estimations. In the construction of intra-house systems (IHS) of residential multi-story structures, it is practical to identify five subsystems: inputs, distribution lines, risers, eyeliners, heating, and sanitary appliances [1,2,3,4,5].

Each of these subsystems has components connected to devices with various functionalities. The article discusses heating, sewage, and cold and hot water delivery systems. Additionally, the performance of the IHS in multi-story structures is influenced by the pressure drop at the home's entrances. Two sets of devices may be recognized from these positions: one contains IHS in 4-5-story buildings, and the other - 7- to 9-story structures.

The caliber of their installation has a significant impact on how well IHSs work, particularly during the initial phase of operation. Although the existence of such correlations is clear, they have not previously undergone quantitative research. We now give the findings from the effort done to identify these dependencies. Due to the article's constrained length, we will simply focus on the essential principles, a few instances, and conclusions.

Furthermore, the pressure drop at the home's entrances affects the IHS's performance in multi-story structures. These sites allow for the separation of two groups of devices: one group contains IHS in 4-5-story buildings, and the other group comprises 7- to 9-story structures.

The caliber of the IHS's installation has a huge impact on how well they work, particularly during the first several months of operation. Such linkages are undoubtedly there, but up until recently, they were not statistically investigated. The findings of the work on these dependencies' identification are presented. We will just focus on the core ideas, a few instances, and conclusions given the article's constrained length.

The sample includes 28 Samarkand structures constructed in 2016–2017 that had failed. The study's sole objective was to identify the time period with the greatest number of failures. At this point, failures' physical sizes, underlying causes, and mathematical properties were not taken into account.

Years of operation with more than 25% of failures documented in the first year of operation were included in the period with the highest number of failures. Monthly failure reports were kept at this time.

The data on the operation of the Samarkand housing stock in the objects of observation were used to determine the rules of the density distribution of the probability of failures. The aim was to research data on structures constructed in various organizational and technological conditions of production and also different operational services. Objects with well-established failure accounting and system operational maintenance were chosen. This made it feasible to prove that failures during the initial years of operation, when the working life of the devices has not yet been used, depend on the quality of the equipment supplied and its installation rather than on operational maintenance.

The minimum permissible number of buildings was established, in accordance with which a sample of failed IHS elements should be constructed, in order to account for the whole range of circumstances and events that can occur during construction and influence the likelihood of failures in operation. Using the formula, the necessary sample size, n^1, was found. (1)

$$n^1 = \frac{Nt^2pq}{N\varepsilon^2 + t^2pq}$$

here N – population size (number of buildings); ε - marginal sampling error; t - guarantee factor; p - total proportion of buildings in which failures of IHS elements can occur; q - total proportion of buildings where IHS elements will not fail. The limiting sampling error was taken into account in the calculations ε =0,05; guarantee factor $t =$ 1,96 with a confidence level β =0,95; pq =0,25 (the product is taken equal to its maximum value, since the value of the sample fraction is not known in advance).

The latter can be classified into two types in terms of what causes failures to appear: 1) as a result of inadequate system installation; 2) as a result of substandard fittings and plumbing supplies made available to installers.

3. Results. According to a study of histograms over time, the failure distribution in these two groups follows several rules.

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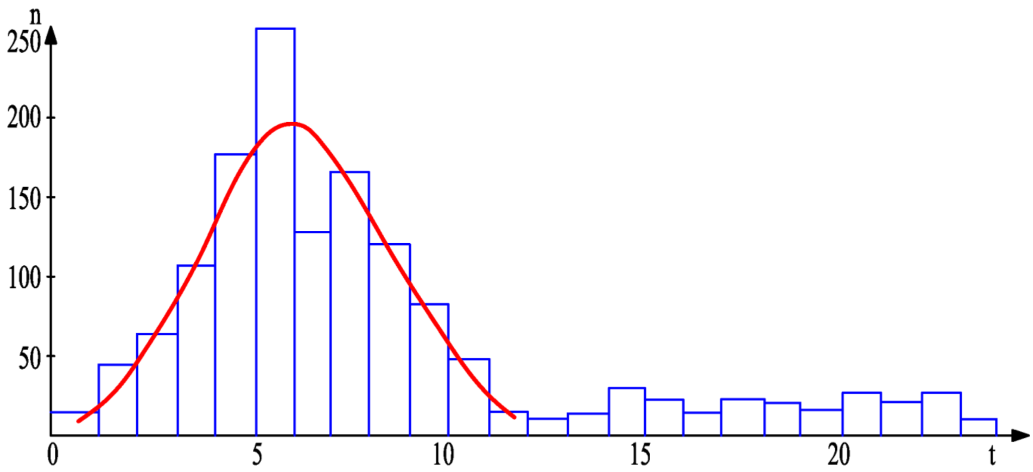
Depending on the installation quality, the distribution of failures in the first group follows the typical distribution rule. On the basis of sewer system leaks, the features of the density distribution of the likelihood of failures for this group are depicted (figure).



Frequency histogram of integral series and theoretical distribution density curve.

t- months of operation; n- number of failures per month

Because of the poor quality of the fittings and plumbing fixtures, the failure time distribution does not follow the typical rule (leaks from valves, mixers, flush tanks, etc.). In this instance, just one characteristic—the arithmetic mean expectation of the time of failure—was identified.

It is possible to determine the values of the average duration of the preservation of consumer properties of IHS elements and determine the likelihood of failure during the running-in period as a result of flaws made during the construction or supply of low-quality fixtures and appliances based on the nature of the distribution of failures over time. [4,5].

The duration of the preservation of an element's consumer properties) has a normal distribution, and the absolute value of its deviation from the mathematical expectation does not exceed three times the standard deviation, so the periods of running-in of IHS elements are determined in the distribution of failures based on the data and the previously determined root-mean-square deviation. The failure of every component linked to a violation of the requirements of the standards for which the construction organization is accountable will most likely occur during this time. It may be regarded as a guarantee period for the eradication of operational flaws by building construction companies.

One can observe that the already recognized warranty term for the rectification of faults is not always adequate and must be expanded by the greatest of the discovered values using the example of the IHS elements under consideration. When evaluating the standard of the devices and fittings supplied by manufactures, similar findings were obtained.

The investigations that have been done enable us to approach the resolution of problems of major practical significance.

A. Based on a well documented record of their behavior during operation, evaluate the caliber of the system installation and the caliber of the prefabricated IHS components given to the installers. A system of moral and financial rewards for performers should be developed using such a quantitative evaluation, which will help to raise the caliber of the final goods.

B. Based on the formalization of the laws of distribution of failures, it is possible to predict the total number of failures from observations during the first few months and obtain early estimates of the performance of systems prior to the expiration of the warranty period, giving rise to the possibility of timely evaluation of the caliber of work produced by performers and suppliers.

C. It is possible to select the priority steps to eliminate the factors contributing to the most significant failures by ranking failures according to their frequency of occurrence and relevance for each business.

4. Conclusion. In conclusion, it should be mentioned that one of the most important variables affecting a residential building's quality is the IHS. The challenge of creating trouble-free IHS is presented by the rising standards for the quality of house development. The history of foreign construction demonstrates this potential. It is best to address this issue gradually. An instrument for a quantitative, unbiased evaluation of the caliber of system installation will be needed for this. Such estimations may be obtained using the approach outlined in the article and the unique calculating criteria created on its foundation.

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