FAILURES AND CATASTROPHES

CLASSIFICATION OF CAUSES OF FAILURE OF BASES AND FOUNDATIONS

É. I. Mulyukov

A register of deformed buildings (96 units), investigated over the period 1969-1991, is described. A classification of causes of failures of bases and foundations is proposed, which contains a formulation of the possible adverse actions, unified into two classes. By statistical analysis of a posteriori material quantitative evaluations are formalized, and the role of different factors in the behavior of the building is established.

The problem of failures of bases and foundations of buildings and structures is a cause of concern for reconnaissance engineers, designers, constructors, and operation engineers, since the cost of restoration of deformed structures is substantial and their number is continually increasing. Back in the thirties, damages of buildings were associated with "structure pathology due to incorrect construction of bases and foundations" [1]. The causes were attributed to "incompetent explorations, insufficiently studied projects, and deficient organization of construction of bases and foundations" [2]. The engineering-geologic causes of deformation of buildings are discussed by N. N. Maslov [3] and F. V. Kotlov [4]. At the present time, four groups of causes of emergency settlements and tilts have been singled out, which are established as deficiencies in exploration, design, construction, and operation [5, 6, 7]. The different aspects of the problem of failure of bases and foundations are considered in the works of Russian and foreign scientists and specialists.

However, at the present time there is not a systematization or a posteriori evaluation of the causes of failures, and studies have not been carried out to determine the role and significance of different types of negligence, errors, and simple misuse leading to above-normative settlements and tilts of different structures.

Over the period from 1969 to 1991, the writer investigated in several cities of the nation 96 deformed buildings and structures, including 69 in Ufa. All of them are included in chronological order in a register of deformed projects (NIIpromstroi Institute), which contains the necessary information: name, state, age of structure, nature of damage, type of foundation, location, observation date, cause of failure, and its cipher in accordance with the classification, as well as the measures for stabilization of the structure settlements. The register was worked out on the "Iskra-1030.11" personal computer, using the writer's program "Cadastre.PRQ," which makes it possible to input, operatively and in a dialogue form, information about the projects, to expand the data base, and to obtain the statistical parameters described above.

Availability of representative data about the causes of failures of bases and foundations of the buildings included in the register, as well as of the investigations of the above-mentioned authors, made it possible to single out, in accordance with the terminology of the theory of reliability, the so-called design, construction and operation causes of errors. Table 1 presents their systematization in the form of a classification including the following taxonomic categories: class, group, type, and cipher. The class covers the design, construction, or operation cause of failure of bases and foundations. The group (subclass) unifies the deficiencies occurring in design—reconnaissance work and in construction of bases and foundations, or points out the anthropogenic actions which adversely affect the soil base properties during the building operation period. The type discloses the causes of failure of the base and foundation of the building. The cipher consists of a three-digit number in which the first digit indicates the class; the second, the group; and the third, the type.

The proposed classification, drawn up on temporary principles, contains formulations of the possible adverse events from the start of the explorations to the expiration of the normative period of operation of the projects, unified into two classes of causes of failure of an anthropogenic nature, which is a distinctive characteristic in comparison with similar classifications.
of other investigators. The fullness of the possible actions on the base, which is practically exhaustive, characterizes the causes of emergency settlements and tilts of existing buildings with different degrees of construction readiness or in operation.

The classification is used for filling the above register by indicating, in accordance with the table, the ciphers of the causes of failure of the bases and foundations of each project. The cipher number is identified with the cause number, which made it possible to count up the cause content, sum, frequency, and details.

A statistical analysis was made for buildings investigated during the period 1969-1989, which were grouped in the following way [8]:

1) a total of 79 buildings in different cities of the nation, including 18 under construction and 61 in operation;
2) a total of 55 buildings in Ufa (9 under construction and 46 in operation);

It was found that failures of bases and foundations were due to the action of 1-5 causes in accordance with a hyperbolic relation (Fig. 1). The maximum number of buildings (46%) were deformed as a result of a cause that was characteristic in each specific case. Failure of the bases and foundations of 18 building (23%) occurred as a result of two causes. One-third of the buildings were damaged owing to 3-5 different causes.

The makeup of the causes of failure of the bases and foundations of the buildings and structures was established. Among the basic causes (112 units) leading to damage of 55 buildings under construction and in operation in Ufa, the following must be noted (Fig. 2a):

1) design—construction, 37%, which includes the following groups: exploration deficiencies, 6%; design errors, 19%; low-quality construction of bases and foundations, 12%;
2) operation, 63%, which includes the following groups: adverse effects exerted on the bases of the buildings, 34%; evolution of the engineering-geologic conditions of the area, 29%.

As regards the makeup of the causes of failure of the bases and foundations of 79 buildings in Ufa and other cities of the nation, shown in Fig. 2b, it fully agrees with the makeup described above, adopted as the basic one, as a result of analysis of the most representative sampling of the buildings in Ufa.

The causes of failure of the bases and foundations of the 18 buildings under construction (40 units) were of only the first class: exploration deficiencies, 25%; design errors, 15%; low-quality construction of the bases and foundations (gross, manifest errors), 60% (Fig. 3a).

The 61 buildings in operation had 123 causes of failure of the bases and foundations (Fig. 3b):

1) design—construction, 29%, which includes the following groups: exploration deficiencies, 7%; design errors, 19%; low-quality construction of bases and foundations (concealed errors), 3%.