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Improvement of the Method of Comparing the Drainage of Structural Grades by Using F - Fisher's Criterion and the Foster-Stuart Method

A.S. Suyunov, Sh.A. Suyunov, M.B. Aminjanova, SH.R. Samankulov, A.B. Axmedov

Doctor of Technical Sciences, prof, Samarkand State Institute of Architecture and Civil Engineering, Uzbekistan
Doctor (PhD) in technique , Samarkand State Institute of Architecture and Civil Engineering, Uzbekistan
Applicant, Samarkand State Institute of Architecture and Civil Engineering, Uzbekistan
Applicant, Samarkand State Institute of Architecture and Civil Engineering, Uzbekistan
Student, Samarkand State Institute of Architecture and Civil Engineering, Uzbekistan
Samarkand State Institute of Architecture and Civil Engineering, Uzbekistan

ABSTRACT: The article improves the method of comparing the sediment grades of a structure in the K cycle with each other using the Fisher F-test and the Foster — Stewart method, where the choice of time between measurement cycles depends on the type of structure, the period of its operation, the rate of deformation change, and other factors.

KEY WORDS : deformation processes, dispersion, Cochran's criterion, the Foster - Stewart method, industrial and civil objects, comparison of the settlement of structural marks, cycle, F-Fisher's criterion.

I.INTRODUCTION

The spatial position of industrial and civil objects under construction or already built is determined mainly by geodetic methods, which include most of the observation of deformations. The determining factors of this process are natural and climatic conditions, design features of buildings and structures, human economic activity, design errors and defects during construction.

Currently, construction organizations are faced with the problem of monitoring the deformation processes of buildings and structures, because their stability and the normal mode of the technological process depend on the magnitude of the deformations that occur. But at the same time, the complexity and volume of observations, the requirements for the accuracy of their production, are increasing every year. The main task of the observations is to assess the stability of the structure and, if necessary, apply various measures to ensure its normal operation.

In this article, we will compare the settlement of construction grades in a cycle to each other, using the Fisher F-criterion and the Foster-Stewart method, where the choice of time between measurement cycles depends on the type of structure, the period of its operation, the rate of deformation change and other factors.

II. MAIN PART

On average, during the construction period, systematic observations are performed once or twice a quarter, during the operation period - once or twice a year. In case of urgent observations, they are performed before and after the appearance of a factor that dramatically changes the usual course of deformation [1].

To determine a sufficient condition for the stability of a structure using Fisher's F-criterion, it is necessary to determine the standard deviation of the differences Δi(k) from the average unevenness

$$m^2_\Delta = \sum_{i=1}^{n-1} (\Delta^{(k)}_i - \Delta^{(k)})^2 / (n-2) \quad (1)$$

and compare it with the general variance estimate

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$$\acute{m}^2 = \sum_{i=1}^{n} m^2_{Si} / n \qquad (2)$$

according to Fisher's criterion [3]. The uneven settlement of the structure in this case is recognized as identified if at the level of significance p the inequality is fulfilled [2]

$$(m^2_{\Delta} / \acute{m}^2) > F_{1-p}, \qquad (3)$$

where F - distribution is considered with f1 = n-1 and f2 = n degrees of freedom.

Expression (3) - one-way analysis of variance - is valid only when the general variance of reproducibility σ2 is the same at all levels n. To test this assumption, it is necessary to consider the ratio of the maximum variance to the sum of all the others (Cochran's test) [4]

$$g = m^2_{Si} / \sum_{k=1}^{n} m^2_{S\kappa} - m^2_{Si} \qquad (4)$$

The distribution of g depends on n and r (the number of degrees of freedom - redundant measurements in the leveling network). In the case of a significant change in the estimates of the variances m^2_{Sk} $(1 \leq \kappa \leq n)$,т.е. $g > g_{tabl}$, it is necessary to select the appropriate transforming function [4].

Another useful criterion for identifying patterns in the differences in elevation or settlement of adjacent structural marks is the Foster-Stewart method [6]. A distinctive feature of this method is that it allows you to simultaneously identify significant changes in variance estimates and determine possible trends on average. The method is based of two characteristics

$$[c] = \sum_{i=1}^{n} c_i, \qquad (5)$$

$$[d] = \sum_{i=1}^{n} d_i \qquad (6)$$

in which the values of c_i and d_i are calculated by the formulas

$$c_i = u_i + l_i, \qquad (7)$$

$$d_i = u_i - l_i \qquad (8)$$

The u_i and l_i values are determined by sequentially comparing the marks or slump marks on structures, and

$$u_i = \begin{cases} 1 \text{ for } H_i > H_{i-1}, H_{i-2}, \dots H_1, \\ 0\text{- in other cases,} \end{cases}$$

$$l_i = \begin{cases} 1 \text{ for } H_i > H_{i-1}, H_{i-2}, \dots H_1, \\ 0 \text{ - in other cases.} \end{cases}$$

Whence $c_i \in (0,1)$, and $c_i = 0$ if Hi is not an extremum among all previous values, in the opposite case $c_i = 1$ [5], i.e.

$$0 \leq [c] \leq n - 1 \qquad (9)$$

Remark 1. If the elevations (precipitation) of all points are equal

$(H_1 = H_2 = \dots H_{n-1} = H_n$ or $S_1 = S_2 = \dots = S_{n-1} = S_n)$,

then [c] = 0, if they change monotonically or their oscillations alternate, systematically increasing or decreasing, then

$$[c] = n - 1. \qquad (10)$$

In turn, the quantity $d_i \in (0, 1, -1)$, whence

$$-(n - 1) \leq [d] \leq n - 1. \qquad (11)$$

Remark 2. The lower limit corresponds to a monotonically decreasing, and the upper one - to a monotonically increasing series of elevation values (precipitation).

Cases are interesting for practice if the value d = 0:

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1) $H_1 = H_2 = \ldots = H_n$ $(S_1 = S_2 = \ldots = S_{n-1})$,

2)

$$\text{то} \quad \sum_{i=1}^{n} ui = 0, \quad \sum_{i=1}^{n} li = 0$$

(which indicates the complete absence of uneven settlement of structures);

2) $\sum_{i=1}^{n} u_i = \sum_{i=1}^{n} l_i$ - two periods in the behavior of structures of this structure with opposite deformation tendencies;

3) d = 0, when the rises and falls of the Hi (Si) levels alternate [8].

It should be noted that the indices [c] and [d] are asymptotically normal and have distributions independent of each other (it is obvious that their distributions depend only on the order of arrangement of sedimentary marks on the structures) [7]. The indicator [c] is used in this case to statistically detect changes in variance, [d] - to determine possible trends in a trend. Testing the hypothesis about whether the differences (d - 0) and (c - M) can be considered random (M is the mathematical expectation of the value c for a random distribution of marks on structures) is carried out using the Student's *t*-criterion

$$t^{(1)}_{1-p} = \frac{[d] - 0}{\sigma_2}, \qquad (12)$$

$$t^{(2)}_{1-p} = \frac{[c] - M}{\sigma_1}, \qquad (13)$$

where the values σ_i (i= 1, 2) are determined from the expressions

$$\sigma_1 \approx \sqrt{2 \ln n - 3{,}4253}\ , \qquad (14)$$

$$\sigma_2 \approx \sqrt{2 \ln n - 0{,}8456}. \qquad (15)$$

The values of M, σ1 and σ2 are given in table 1.

Table 1

Initial values of research at this stage

h	M	σ_1	σ_2		H	M	σ_1	σ_2
10	3,858	1,288	1,964		26	5,672	1,800	2,379
12	4,125	1 ,243	2,027		28	5,831	1,841	2,413
14	4,392	1,361	2,105		30	5,990	1,882	2,447
16	4,659	1,456	2,153		35	6,294	1,956	2,509
18	4,927	1,535	2,216		40	6,557	2,019	2,561
20	5,195	1,602	2,279		45	6,790	2,072	2,606
22	5,354	1,660	2,313		50	6,998	2,121	2.645
24	5,513	1,712	2,346		60	7,360	2,201	2,713

From the above, it follows that modern and systematic monitoring of deformations of buildings and structures increases the level of safety of construction sites, reduces the risk of emergencies. The results of observations of

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precipitation and displacements of engineering structures by geodetic methods must meet the requirements for their completeness, timeliness and accuracy.

III. CONCLUSION

The development of effective methods for detecting deformations of engineering structures and its successful solution, as well as subsequent development, make an important contribution to ensuring the reliability, durability and safety of operation of critical structures. The solution to this problem creates conditions for increasing the efficiency of using capital investments in construction, helps to rationally plan various construction works, including geodetic observations of the deformation of structures, and also brings a certain social effect.

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