Project Estimation of Thermal-Humidity Actions upon Foundation Beams, Grillages and Foundations for Cold Regions

See the figure on the site:
1. The thermal-humidity displacements $\Delta(T, W)$ are not considered
2. The thermal-humidity displacements $\Delta(T, W)$ are considered
3. The same as 2., but technological and constructional methods are applied

Profit:
1. The instructions on theoretical and project estimation of the design values of thermal-humidity actions upon foundation beams, grillages and foundations of heated and non-heated buildings and constructions on the permafrost.
2. Prevention of destruction of foundation beams, grillages and the upper part of foundations (particularly those made of reinforced concrete) in cold regions when applying the offered foundation-designing recommendations.

The Objective of the Research

The objective of the present research is to develop the proposals on determination of design values of thermal-humidity actions on foundation constructions in the northern regions while erecting the foundation beams and grillages above the ground surface, and an original technique for foundations designing taking into account those actions.

The working hypotheses:
- when determining the thermal-humidity actions, it is expedient to consider the stage of construction and stage of maintenance of the building separately;
- it is necessary to consider working of the foundation constructions as two stages (1st stage $\rightarrow$ summer-autumn, when foundations are jammed in the permafrost, and 2nd stage $\rightarrow$ winter-spring, when foundations are jammed in the layer of the seasonal thawing);
- the design values of thermal-humidity actions and the efforts in the foundation constructions are greatly affected by the moments of their closing into a single static system and the change of stages;
• temperature changing in the foundation constructions is to a considerable
degree determined by the alterations in the outside air temperature and
the building’s cold cellar air temperature, solar radiation and thermal
action of the building.

Approaches

Determination of the design moments of the change of stages is made through
theoretical studying the temperature zones in the layer of the seasonal thawing
and the efforts in the foundations when effected by horizontal loads and bending
moments. The investigations are carried out for non-heated buildings and
constructions, as well as for heated buildings having cold cellars.

The analytic schemes of working of the foundations in the presence of thermal-
humidity actions upon the foundation beams and grillages are developed and
efforts in these constructions are analyzed for different cases (precast and mono-
lithic beams and grillages, concreting the grillages with and without electric
heating, availability of two calculating stages, etc.). According to such analysis,
the probable terms of closing the foundation constructions into a single static
system are determined, as well as the optimum periods of time during which
the efforts reach their minimum values.

The design values of thermal-humidity actions are determined based on the
periodic fluctuations of the air temperature with consideration for the regional
features reflecting the climatic conditions, cold cellar ventilation regime, physi-
omechanical properties of soils and other factors. The calculations are carried
out using the literature sources and climate reference books taking into account
the investigations conducted previously.

A building thermal action coefficient is applied to the design values of tem-
perature climatic actions. The values of this coefficient are determined according
to the data of computer modeling the temperature zones in the above-ground
constructions fulfilled with various constructive solutions of the above-ground
part of the building.

The analysis of efforts in the foundation constructions is made based on the
condition of interaction between piles and soil. The rigidity of the reinforced
concrete elements is determined with consideration for cracks in the concrete.
Soil, both frozen and unfrozen, is accepted linearly deformed, subject to Winkler
hypothesis, with the bed factor increasing as the depth increases (except for
the frozen soil situated above the design place for the pile jamming, where
its plastic deformations are taken into account, and the soil below the place
of such jamming, where the model of a linear-strain half-space is additionally
considered as an alternative). Possible combinations of loads and actions as
well as different conditions of supporting the beams and grillages on piles and
columnar foundations are considered.

The theoretical investigations are supplemented with the analysis of the
observed data on the state and deformation of foundation constructions.
The main results of the present work are as follows:

- the design values of thermal-humidity actions upon foundation constructions of buildings designed for the northern regions;
- an original technique to design foundations on the permafrost under vertical and horizontal loads, including thermal-humidity actions, offered as simple instructions and dependencies applicable for manual calculation;
- a decrease in the efforts in foundation constructions (up to 3 times) vs. thermal-humidity actions and an increase in thermal compartments of the buildings are due to altering the conditions of supporting the foundation beams and grillages, pile constructions, cellar ventilation regime and technology of concreting beams and grillages; this eventually allows to avoid destruction of the upper pile tops, posts of columnar foundations, beams and grillages.

Findings of investigation

a. Inclusion in Manuals on structural design of foundations on permafrost, taking into account thermal-humidity actions;

b. Transfer of the technique obtained to universities, institutes, firms and organizations for its application in building design;

c. Development of the system of computer-aided design (CAD) for foundations in cold regions, with consideration for the recommendations given.