Application of information modelling technologies to avoid typical mistakes in the design of constructive solutions

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Abstract. The use of information modelling technologies is spreading more and more in the construction industry. A large number of construction projects with budget financing require state expertise. The potential for automating the verification of structural solutions for design documentation has not been fully disclosed to date. The authors of the article analyzed the comments of the expert of the constructive department of the state expertise over the past 2 years and identified a list of the most common ones. Based on this, proposals were formulated for the formation of digital information models of the structural solutions in order to automate the processes of checking design solutions and avoid similar mistakes in the future.

1 Introduction

Building information modelling is becoming more and more popular in Russia every year. The implementation of information modelling technologies is also taking part in state requirements. This leads to the fact that there are more and more three-dimensional models as a part of the information model of design documentation every year, which is undergoing state expertise. The implementation of information modeling technologies is always a complex and multi-stage process [1]. In recent times, however, 3D models have become more essential for customer service and expertise because of a tool for automating and solving the pressing problems of the construction industry. There are a sufficient number of requirements and references to information modelling in the current legislation. In [2], the concepts of an information model, a classifier of construction information are introduced, and the obligatory maintenance of an information model is established. In [3], a list of cases is indicated when maintaining an information model is mandatory. In [4], the rules for the formation and maintenance of an information model (composition) are established. In [5], a list of documents in the field of standardization is determined, as a result of which, on a voluntary basis, compliance with the requirements of the Federal Law is ensured. It includes [6], [7]. In [7], the concept of a digital information model and proposals for attributive content are introduced. In [8], the requirements for the composition of project documentation undergoing

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examination are indicated. In order to analyze the applicability of information modelling technologies, the authors identified a number of typical comments of the expert of the department of constructive solutions, which were found during the examination of design solutions over the last 2 years, and also proposed options for using information modelling technologies in order to prevent similar mistakes and situations in the future while the expertise will be conducting.

2 The main frequently repeated remarks of the expert of the department of constructive solutions of the state examination.

For the research, construction objects were selected, over the past 2 years, undergoing state examination. The most frequently repeated comments from the expert of the constructive department were selected due to selected objects. A list of typical errors identified at the stage of examination of project documentation was formed based on the data obtained.

2.1 The lack of logically linked documents and drawings.

This problem can show up as the absence of the necessary nodes in the documentation, links to non-existent nodes, discrepancies in the text and graphic parts, supporting structures are implicitly defined.

2.2 The depth of laying the soles of foundations for small structures is often taken without taking into account the depth of seasonal freezing of soils.

Measures to prevent the influence of the forces of frost heaving of soils are also not provided. Design solutions are not supported by calculations for the effect of frost heaving forces. In the presence of artificial bases (ground pads) made of coarse-grained soils, it is often forgotten about the situation when seasonal freezing of the artificial base as the most heat-conducting material should be taken into account.

2.3 The change in the bearing soil of the base due to the application of backfill.

The depth of laying the base of the foundations from the design level of the layout is taken correctly, but falls into the base soil layer, which was near-surface in its natural occurrence before the site was laid out with backfill. But during the survey, soil samples were taken from depths below seasonal freezing to determine its characteristics, and it turns out that the weakest soil layer turned out to be unexplored.

2.4 There are no technical requirements for soil materials and their characteristics for artificial. bases.

For pillows and embankments of artificial foundations, there are often no technical requirements for soil materials and their characteristics, for laying and compacting these soil materials, for controlling the design characteristics of an artificial foundation after compaction.

2.5 The resistance against ascent is not always ensured for buried underground structures.

This happens with tanks, sewage pumping stations, sewage treatment plants, etc. at the maximum forecast level of groundwater, taking into account their seasonal and technogenic rise.

2.6 For retaining walls, wall drainage, waterproofing, water passage holes, and temperature-shrink joints are often not provided.

2.7 Incorrect assignment and underestimation of loads for calculations of building structures

For partitions and non-bearing walls, the weight of plaster and facing layers is often not taken into account, which gives a rather noticeable deficit in loads. In the case of bringing loads from partitions to an equivalent uniformly distributed load, the distribution over the area is taken incorrectly and is underestimated, especially for prefabricated floor slabs; the weight of the brickwork is underestimated due to the fact that only the volumetric weight of the brick is taken into account and the weight of the mortar joints is not taken into account. Load safety factors are often underestimated for finishing and leveling layers performed at the construction site (very often the value of 1.1 or 1.2 is taken instead of the prescribed 1.3). Loads from floor structures, roofs, underground car parks, etc. often do not correspond to decisions on the section of architectural solutions in terms of the composition, quantity, materials and thicknesses of structural layers; etc. and so on. It also happens that some of the loads are simply forgotten and not taken into account at all.

2.8 The slope component of the load is not taken into account.

Often, the slope component of the load is not taken into account when calculating the steel girders of pitched roofs, while the coating of roofing sandwich panels is unreasonably taken as a hard disk, and therefore the accepted sections of the girders are in fact insufficient.

3 The application of information modelling technologies to avoid the above situations.

The authors considered how to avoid the above problems by using information modeling technologies, where they are applicable.

A well-formed employer information requirement can help to avoid any of the missing structure problems listed in 2.1. To do this, it is necessary to indicate the minimum and sufficient level of geometric elaboration and information content in accordance with the standards used in the design of the object as proposed in [9]. This includes a list of IFC classes used in the formation of a three-dimensional model of a design section, as well as a list of mandatory elements generated during design, assigned to the IFC class. The list of structures with assignment to IFC classes is given in Table 1.

Table 1. Design Section Elements and IFC Categories.

Elements	Modelling requirements and IFC categories
Foundations	Foundations are modelled by elements, reflective design type foundation (columnar, slab, tape, etc.). Foundations must be modelled according to precise dimensions and location including technological holes, niches and expansion joints. At necessary, training is simulated, replacement layer. IFC object classes: IfcFooting for column foundation, grillage, strip foundation: IfcBaseSlab for foundation slab, preparation, dressing: IfcSlab for artificial base
Piles	Piles are modelled by vertical elements. The main vertical element of the pile must be tied to the head of the pile. IFC object classes: IfcPile
Slab	Slabs are modelled taking into account their exact location, geometric dimensions, and, if available, expansion joints, openings, niches and capitals. The floor must be linked to the level of the floor on which it is located. IFC object classes: IfcSlab
Wall	The walls are modelled taking into account their exact location, geometric dimensions, if available - holes, niches and expansion joints. Adjoining walls of different heights are modelled by different elements. The wall must have a binding of the bottom and top faces to the levels. IFC object classes: IfcWall
Column	Columns are modelled by vertical elements within one floor. Columns of constant section are modelled by one element. Columns of complex section are modelled by assembly units. Columns are modelled taking into account their exact geometric size, location, if available, additional load-bearing elements (support tables, consoles, etc.). IFC object classes: IfcColumn
Beam	Beams are modelled by horizontal elements. Beams of constant section are modelled by one element. Beams with a complex section are modelled by assembly units. Beams are modelled taking into account their exact geometric size, location, if available - additional load-bearing elements (support nodes, ribs, brackets and etc.). IFC object classes: IfcBeam
Girder	Girders are modelled as assembly units consisting of rods (braces, chords, racks), and also include nodal connections, fittings and other fasteners. IFC object classes: IfcBeam, IfcMember, IfcPlate
Stair	Stairs are modelled, including flights of stairs, landings. All elements of the stairs must have exact geometric dimensions and location. Stair flights and landings must have clear points of support. IFC object classes: IfcStair, IfcSlab
Holes	Holes are modelled in accordance with the composition of the Design Documentation section. If their location is fixed and can be designed at the Design Documentation stage.

In addition to the applicable list of IFC classes, depending on the structures, it is necessary to move to a unified parametric description of requirements at all stages of the life cycle of capital construction projects. The pull of applied parameters should be dictated by the applicable regulatory documents, or serve to identify the information necessary for automation.

The list of attributes required for the automated search of the above remarks is given in Table 2.

Table 2. List of attributes to avoid typical remarks of the expert of the section of constructive solutions.

Elements	Geometric elaboration	Attribute elaboration	Solution
Foundations	Real size and position in absolute coordinates	Parameter “Depth of laying”	Comparison with the depth of seasonal freezing become possible. (Clause 2.2) Correct determination of the bearing layer of soil become possible when correlated with the results of engineering and geological surveys. (Clause 2.3)
Artificial base	Actual position and thickness, binding to the level	Parameters "Thickness", "Measures to control design characteristics", "Design characteristics"	Comparison with the depth of seasonal freezing become possible. (Clause 2.2) Obtaining missing information, as well as design characteristics is become possible.
Partitions, Self-supporting walls, finishing	The number of layers and composition is true	Parameters "Thickness", "Material", "Specific Gravity", "Load Safety Factor"	Calculation of loads and comparison with the values from the explanatory note become possible in accordance with [10]. (Clause 2.7)
Beams	Real position	Parameter "Pinch type"	Checking the calculation taking into account the considered type of pinching become possible.

4 Conclusion

In conclusion, if information modeling is treated as a forced component and not used to automate internal processes, this only wastes the work of the designer. However, we can present all regulatory documentation, such as codes of practice (for example, [10]), as a geometric and informational component (according to Table 2). This will avoid a large percentage of typical comments in future projects and develop the construction industry.

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