Features of information modeling in the design of pre-school buildings in Russia

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Abstract. In the context of modern industrial base establishment on the new technology platform, the tendencies of IT-technologies penetration into building and structure design, construction and operation and transition to Building Information Model are getting more and more emphasized. This article focuses on BIM-modeling employment in the design of pre-school educational institution. Advantages of IT-modeling for buildings complying with modern ecological and safety demands are illustrated. Integration of data on building architecture, structure, interior decoration and utilities into integrated data model effectively saves time and allows making right decisions at all stages of object life cycle. The model allows making optimal decision accounting for such factors as weather conditions analysis, building shape, amount of people to be hold, periodicity of their stay, materials to be used, natural light level, utilities design etc.

1 Introduction

IT-technologies make up the basis of new social digital infrastructure. The new industrial base on new technology platform is mostly established by means of technology diffusion. It is by means of diffusion that digital technologies penetrate into the area of building and structure design, construction and their operation and the fact destined the birth of the new trend – Building Information Modeling.

The new technology, BIM (Building Information Modeling), allows creating construction object multivariate model containing full information on the object [1]. Object information model consists of virtual items that exist or will exist in reality and also contains data on their specific geometric and physical properties.

The new technology has very powerful capabilities [2]. With information modeling, even before actual construction beginning (with sufficient model detailed elaboration) all processes at all life cycle stages can be determined and fully estimated in advance. Thus, a brand new approach to building construction and managing is expected. Full-fledged building information model allows business process improvement at all stages: facility design, planning of required resources volumes and delivery schedule, planning of construction operations, facility operation process, its demolition after its service life depletion or in case of other necessity [3–5]. As advantages of using BIM-technology, they

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are – the decrease of project cost and design development period, improvement of coordination and communication between design engineers of different departments, project quality improvement and decrease of collisions/errors at the ready made model output [4].

BIM-technologies are in sufficient detail described in special literature [6–7]. At present modern methods of information modeling are actively introduced into Russian construction practices [8]. BIM-technologies are used for the design of office and industrial buildings as well as medical, educational ones and in the sphere of transportation [9–12], surrounding amenities [13], apartment buildings [14]; they are widely used not only in construction but also for reconstruction of existing buildings [15, 16]: historical [17] and industrial [18] ones, schools [19] and etc. One of the information modeling new trends is Green BIM [20]. It is used to design environmentally friendly buildings when such factors as temperature conditions, power supply, materials, utilities etc are to be accounted for, and the fact makes BIM employment for pre-school buildings design particularly topical.

Since 2011 in Russia the work has been carried out to select economically efficient projects for their reusing, among them one can mention pre-school buildings which are built with the involvement of budgetary funds. At the end of 2016 Ministry of Housing and Building of Russia resolved to create a register of economically efficient design documentation to be reused. Project selection criteria were approved: project cost estimate shall not exceed construction expected (limit) value and the facility energy efficiency class shall be at least class "C". As of December 2017 the register included 17 kindergarten projects. BIM-technology employment in the design is just the factor that allows approximating construction ultimate cost to initial budget value due to exact calculation of materials assortment and quantity.

2 BIM-Modeling in Pre-School Building Design

Information model of "Pre-School Educational Institution for 180 Inhabitants" facility was made with the use of Autodesk Revit software. The appearance of a 3-storey building with a basement is shown in Fig.1.

Fig. 1. Information Model of Pre-School Educational Institution.

From the model all the necessary information on the architecture, design, interior decoration and engineering systems of the kindergarten can be obtained.

The color solution of the facades of the kindergarten matches surrounding accommodation buildings has the same outside finish and makes up unified composition. Bright accents on the facades give the building an individual look.

The information model shows that the facade is decorated with white lining ceramic bricks; bright accents are accomplished by façade plastering on top of mineral wool board. The color solution emphasizes the volumetric composition of the building and is based on combination of green, green-yellow, yellow, turquoise and light-blue colors. The facade is visually divided into spaces and every space has its own color accent. The base is decorated with grey facing block with relief surface. There are visors and canopies over the porches of the building entrances, which are a continuation of the floor slabs. For all materials and elements there are volume indicators.

The facility is to accommodate 12 groups (each comprising 15 kids) of children of different age. The kindergarten model consists of five functional groups of compartments: entrance group; group compartments; additional compartments for lessons (halls for musical and physical training lessons, club rooms, logopedist room, study room); related compartments (medical, kitchen and laundry); service rooms. Compartment specification with area and space indicated as well as finishing material list is available.

The model comprises data on the specific type of materials to be used for finishing of any particular compartment. For wall internal finishing, plastering, vitreous tile, water paint and polyvinyl acetate paint are used. Flooring material is linoleum (its warm-keeping type is used on the ground floor) and ceramic tile with nonskid surface. Floors in the game rooms, located on the ground floor, are equipped with a "warm floor" device. Ceilings are decorated with liming, water-proof emulsion paint or hung ceiling is used.

Data on structural system is also integrated into building information model. The model of the load carrying structure system (Fig. 2) if necessary can be extracted from unified information model.

Load carrying structure system of a monolithic reinforced concrete building of a kindergarten consists of a foundation supported by vertical bearing elements (columns and walls) and integrating them into a single spatial system of horizontal elements (slabs and cover plates). Building structural system is of a column type, structural diagram of the building is of a cross-over design. Building transverse and longitudinal strength as well as its buckling resistance are ensured by a system of transverse and longitudinal reinforced concrete walls of stairways enclosures 200 mm thick joined with horizontal monolithic intermediate floor discs 220 mm thick. The building is designed monolithic: walls are 200 mm and columns are 400x400 mm. Monolithic reinforced concrete flooring 220 mm thick serves as horizontal stiffening diaphragm.

Foundation is in the form of monolithic reinforced concrete slab 600 mm thick made of grade B25W10F150 concrete. Basement wall material is grade B25W10F150 concrete; wall material for 1 to 3 floors is grade B25W4F75 concrete; ceiling material is grade B25W6F150 concrete above basement, grade B25W6F75 concrete above 1 to 3 floors. All flights of steps and window wells are made of class B25W10F150 monolithic reinforced concrete; link beams are monolithic of B25 concrete. Partition walls are of tongue-and-groove gypsum-cardboard sheet 160 mm thick. Information model comprises data on concrete quantities and reinforcement consumption specified item-wise, by diameter and length for all monolithic structures.

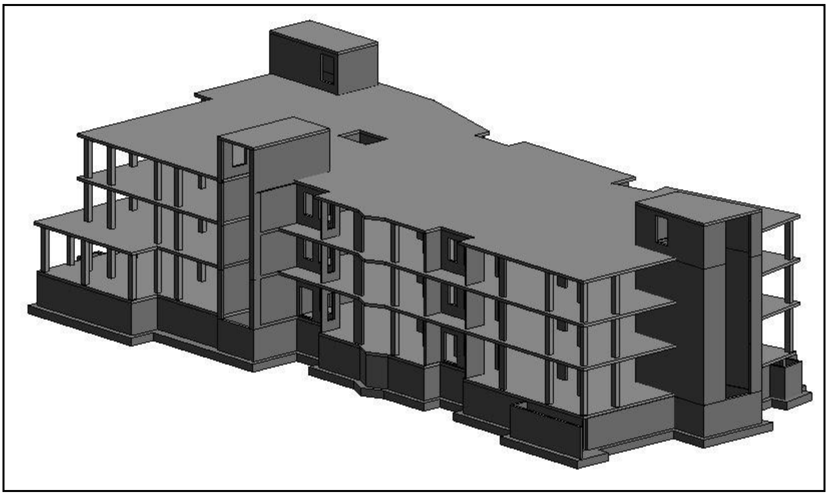

Fig. 2. Load Carrying Structure Model of Pre-School Educational Institution.

Undeniable advantage of correct building information model is the possibility of extracting models of load-carrying structures with their prompt export to design computer complex.

Autodesk Revit software is provided with an export file (with R2S extension) and load-carrying structure model was exported to SCAD Office computer complex, then loads and constraints were set and all required design calculations were made. Kindergarten computer model is given in Fig.3.

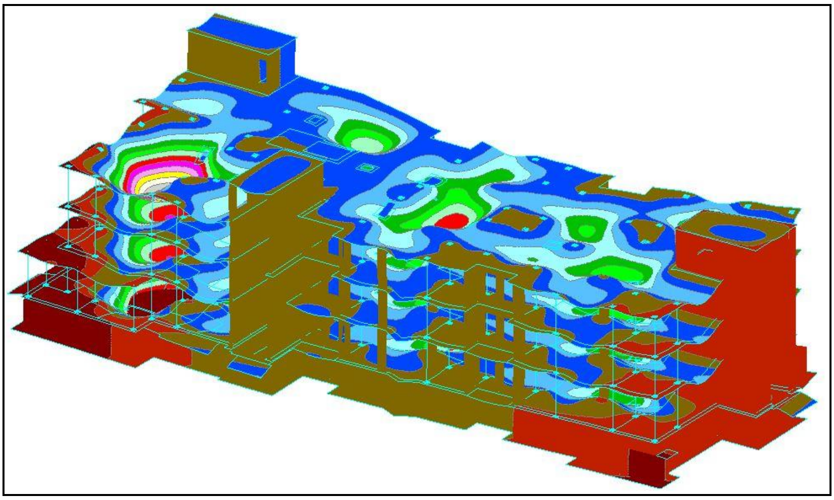

Fig. 3. Computer model of Pre-School Educational Institution.

Data on building technical equipment and the design compliance with sanitary norms are also included into integrated information model and can be easily extracted with all technical specifications.

For vertical connection of the building floors and for the purpose of evacuation, the design provides for three stair enclosures for people including those with limited mobility and also a passenger lift. Kindergarten main compartments have natural light. Natural light level complies with demands which is achieved by means of group and study compartments optimal orientation, location and dimensions of window areas filled with reinforced-plastic double-pane insulated window for protection against outdoor noise.

For protection against internal noise sources, the design provides for lift and winder without machine rooms; spaces enclosing lift hall and lift shaft are separated from adjacent compartments by monolithic reinforced concrete walls 200 mm thick. Lift and winder compartments do not border on permanent human presence compartments. Heat supply station, boiler and pump rooms in the basement are also arranged under compartments with temporary stay.

For noise protection, design measures have been taken: all technical compartments with noise generation are provided with acoustic joints between the floor and adjacent wall structures; engineering equipment with the lowest noise and vibration levels is installed; floating floors with acoustic joint are provided for noise-producing equipment; sound-insulated walls, floorings and partition walls are adopted by acoustic computation.

3 Conclusion

Employment of BIM-technologies opens a wide range of opportunities. Information model rapid development and design options allow online presenting the Investor/Client with technical-economic values and selecting optimal solution of a variety of options. Full conversion of the project into digital form with interactively changing indicators and application of interactive visualization of the project speeds up the consideration of options and allows substantiating the technical literacy of the adopted project solutions. Operation and technical department automatically receives all data online with respect of quantities of materials and resources required for facility construction, resource models curves for all construction stages. Construction subdivisions receive soft copy of complete set of design documentation supported in updated mode without collisions.

Brand new approach to building design and management in the form of an integrated and full-fledged information model helps to effectively save time and allows making right design and managerial decisions improving business processes at all stages of object life cycle.

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