MODERN BUILDING
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May 19–21, 2010, Vilnius, Lithuania
The 10th International Conference

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THE IMPACT OF COMPUTER INTELLIGENCE ON THE MODELS OF CONSTRUCTIONS' DESIGN

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Abstract. Most building constructions made of various materials are assembled from standard items (reinforcement bars, steel profiles or wooden products). Their dimensions and shapes are known, therefore, the process can be formalized. This enables automation of many actions, as well as direct data transfer from a standard or catalogue into commands, which can be used in the process of project development and control. However, the existing standards of ferroconcrete reinforcement are presented in an unstructured form and cannot be used directly in computer science. The rational computer-aided application could be provided only on condition that the data would be structured and formalized in advance, which enables transformation of textual recommendations into digital models and commands. The paper addresses the problem of modelling of this process, which could enable the application of information technologies to using the data of the standards based on the abilities provided by computer intelligence.

Keywords: Engineering information graphics, AutoCAD, VisualLISP, Artificial intelligence, graphical management, modelling the graphical extend data.

Introduction

The application of Information Technologies (IT) to graphics enables us to use different techniques because software can be used even when the methods of pencil-aided technologies (PT) are applied. The design model presented in Fig 1 describes the main aspects of IT and PT.

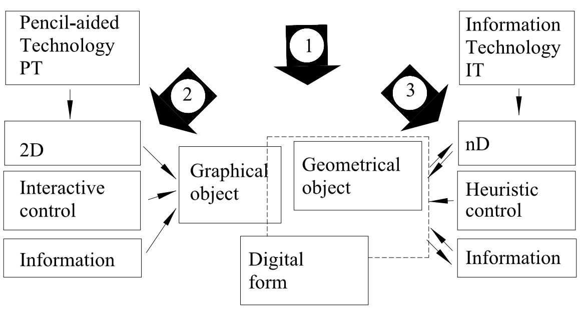


Fig 1. The specific features of design technologies

The main differences in technologies could be described by demonstrating all the potentialities of IT application, rather than making a detailed PT analysis:

1 the main difference manifests itself primarily in the object. In PT, it is just a drawing (graphical object), whereas in IT it is a digital model, which describes graphical as well as geometrical object's presentation. This extends possibilities of visualisation and makes possible computer-assisted formation of views (if required). At present, the opinion that the 3D geometrical model is superior, even when specific cases are not analyzed, prevails.

2 the measurements of drawing, determining the ways of problem solution, since, in PT only graphical methods can be applied, whereas in IT graphical as well as digital methods can be used. The effectiveness of the methods of solution depends on many conditions (e. g. object structure, the particular tasks solved, etc.) and is not always considered.

3 the process control possible in PT is only interactive, i. e., in general, only one-way control is possible, whereas various, and even heuristic possibilities can be used in IT. The links of the process in PT are only unidirectional (e. g. visualization of views), whereas in IT even unidirectional links could be supplemented with textual information and it could be controlled in an automatic or interactive way.

Thus, despite a common tendency of developing BIM technologies (Popov *et al.* 2006, 2008; Russell *et al.* 2009; Jeong *et al.* 2009; Linderoth 2010; Migilinskas *et al.* 2006), the authors think that some questions remain controversial and are worth special analysis. The tools of traditional graphics have been developed for centuries (Gieseke *et al.* 1989; Sliesoriūnas *et al.* 1998), while computers are actually used only by the current generation. This causes several problems: constant variation, the absence of traditions and intense pressure of commercial companies (Bethune 2002; Earle 2007; Kalomeja 1992, 2007).

Anyway, the users are under negative influence and stress because of quasi-backwardness and continual overtaken situation. For example, one of the most popular graphical systems *AutoCAD* used in VGTU since 1990 in *AutoCAD-9* version has about 120 commands, which could be learnt during three semesters of graphics studies and skills of modern graphics could be developed.

The currently used *AutoCAD2007* has hundreds of commands only for three-dimensional modelling; therefore, traditional studying of commands has become useless because it is impracticable. The experience shows that it could be avoided if you rely on fundamentalism and formalism in any case. In VGTU (Čiupaila 1995, 2002), the work in this direction has been already performed for some decades. As a result, the experience was gained required tools and methods were developed.

Determination of working model

In the contemporary design world, a trend of developing BIM technologies prevails, when 3D modelling is used implicitly, while their advantages are exaggerated and limitations concealed or devaluated. It stands to reason because complicated design systems could be improved infinitely, with new versions produced every year and sold profitably. However, it is difficult to realize, what unique products can be created every year and what may be the price of a product, whose efficiency goes to zero every New Year night. The question is if is it possible (and rational) to use complex methods based on PT and IT. Taking the optimal elements of these methods (Fig 1), an integrated model could be constructed (Fig 2).

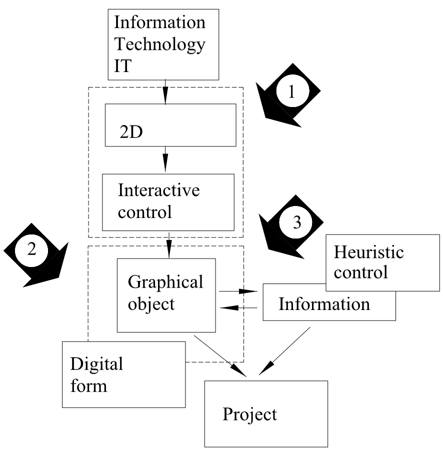


Fig 2. An integrated design model

Let us integrate the useful features of both technologies:

1 two-dimensional solution method is not only the weakness, but an optimal approach, especially, when three-dimensionality is not required. Suppose that reinforcing fabric of concrete floor slab is designed, when a three-dimensional model does not provide any extra information, while the use of digital (physical) information is more rational as extra data, whose informativeness could be absolute at minimal input. If interactivity could be supplemented with extra information it could provide comfortable operating conditions.

2 saving graphical object information in a digital form simplify the computer-aided analysis;

3 IT application for information control ensures versatile circulation of information, enabling us to extend the possibilities of automation and artificial intelligence.

The main difference between the BIM and a complex model is two-dimensional approach allowing us to minimize computer resources, which often seem immense but in the future optimality will be a valuable quality. On the hand rationality of any particular stage is also important. It concerns the technique of making the drawings of ferroconcrete elements in academical and practical sense.

This model enables modelling the data of standards which is presented in the linguistic form at a minimum cost and its direct application to a visualization process. Moreover, it is possible to prepare a rational form of drawings presentation according to standards (with different simplifications and conventionalities recommended). It allows us to prepare the IT methodology not requiring annual renewal.

The tools are required for realizing graphical object notation (in this case, reinforcement), which satisfies the requirements of a particular standard of visualization and engineering works. This information model could be described by the block-diagram presented in Fig 3.

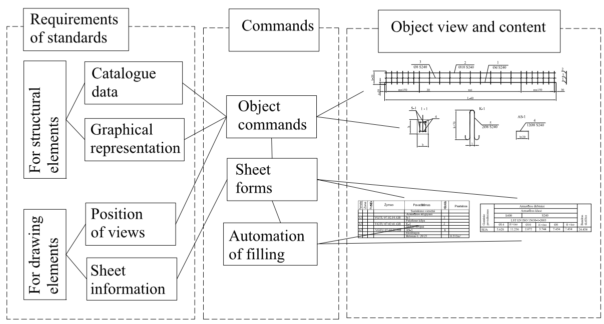


Fig 3. Information model of design process

The main feature of the model is its continuity and possibility of constant filling up. This ensures the stability of the model and consolidates the position of fundamentalism, which should predominate over novelty. This methodology does not require considerable expenditure because it can be extended and filled up constantly, avoiding saltatory renewal.

Graphical-numerical models (Čiupaila *et al.* 2004, 2005, 2007, 2008; Zemkauskas *et al.* 2007) for the notation of graphics, supplemented with intellectual properties are created, by applying the methods of information technologies. In this way, the application of computer science is maximized making it possible to avoid the methods of interactive paper-based information application (searching for extra data in books, etc.). Intellectual tools enable us to avoid casual mistakes because the requirements of standards and the data of the manuals are evaluated automatically.

Formalization of reinforcement standard

Not going into the details, the standards (STR 1.05.08:2003) could be formalized according to the following scheme (Fig 4).

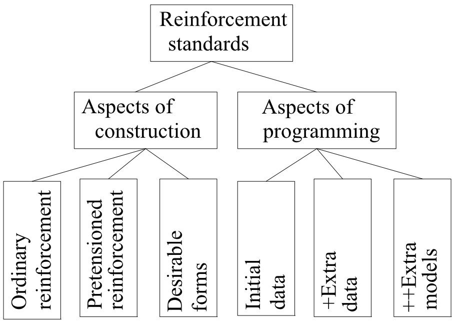
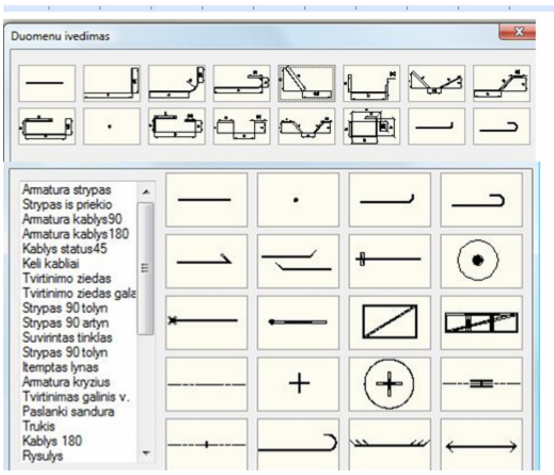


Fig 4. A model of reinforcement graphics

a)



b)

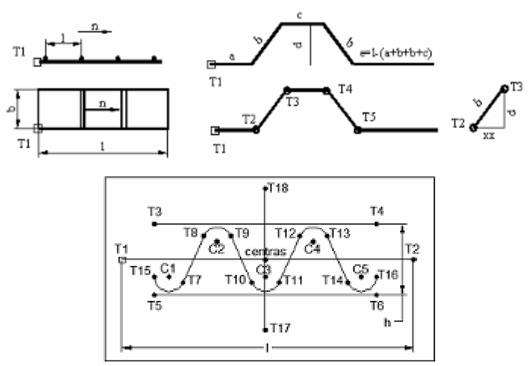


Fig 5. The process of formalization: a – for control, b – for programming

When the constructional and visualization aspects are formed in the model, a programme preparation and construction are simplified. Programming aspects are important for the creation and development of tools while the constructional aspect is directly used in design and constructional practice. At the design stage, all possible reinforcement versions are graphically controlled (Fig 5 a), using a minimal amount of information for this purpose.

The programme's implementation has become multi-stage, with the simplified preparatory actions and writing of the programme code due to the occurrence of identical fragments. In this way, the simple views are formed based on the initial data, where monotonous arithmetic actions are optimised. The major visualization effect is available for the elements of complicated forms (Fig 6), whose interactive drawing is boring as well as complicated, requiring extra calculations.

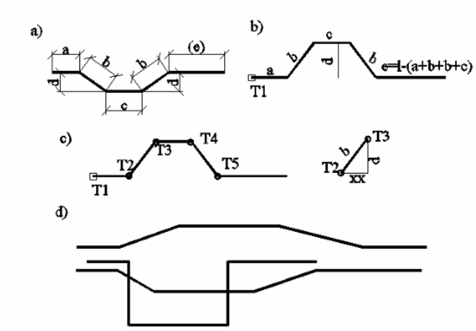


Fig 6. Visualization of the reinforcement bar form, a – standard description, b – initial data, c – programme models, d – examples of the command action

The units of special visualization (for example, the pull-on parallel threads, Fig 5 b, hammed parallel threads, etc.) require extra modelling because their programme's visualization requires the modification of plane geometry (Fig 7) (TAIGRA).

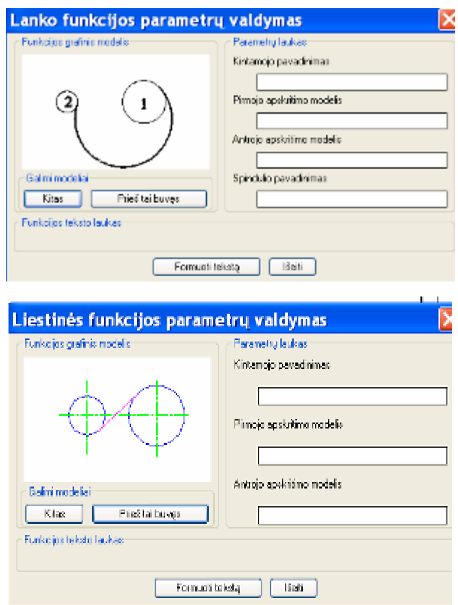


Fig 7. Plane geometry control

Due to the optimal information used, two-dimensional IT model simplifies the service of the object throughout its life cycle (Fig 8).

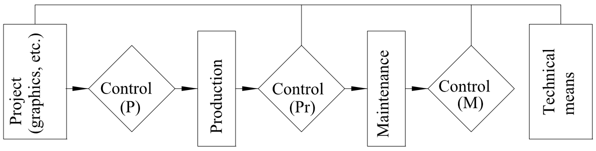


Fig 8. Intellectual model of life time cycle

The project control (Control-P) is common and necessary. However, modern technical means of communication enable us to extend information management to the stages of production and maintenance. It is a common practice to visualize the produced reinforcing fabric or other item by taking their photos by mobile telephone. Then, if it is necessary to download the view into the information network and automatically execute the control of object production based on the product's data. The obtained information could be used in a very wide range: it could be sent to supplier, contractor or other person (for example, the inspector of construction, which is very important for quality control). The expansion of the field of information beyond the limits of the design stage ensures high quality from drawing to demolishing, making unnecessary the particular checking at any stage, where mistakes could emerge. The same applies to maintenance requirements coming from the design stage. Obviously, in this case, the amount of the information saved is not a trivial detail.

The solution of practical implementation of problems

It should be noted that problem of rationality of the computer science application has not been solved yet. The standards are usually prepared with the traditional PT in mind, for which the amount of lines has importance. Accordingly, the drawing of a construction (Fig 9 a) and the real object (Fig 9 b) were apparently different.

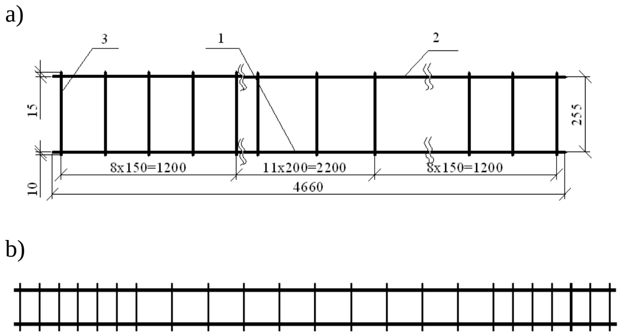


Fig 9. Differences between a real construction (b) and it drawing (a)

Another difference lies in the fact that the PT serves only graphical presentation (view). The computer drawings, though having a graphical expression, are saved in a digital form. Consequently, the possibilities of control are completely different because the automation of PT is impossible in principle. In IT it is much easier to form the objects of reality (Fig 9 b), rather than conventional views (Fig 9 a). The computer science is a powerful tool for object formation and presentation (in modelling and prototyping). Therefore, the forms of drawing presentation could remain the same as those used in PT, though this question should be considered in more detail and rational solutions should be taken. Thus, the variant presented in Fig 9 a is acceptable even in IT; however the example given in Fig 10 a could be realized in computer-aided drawing more efficiently as an example given in Fig 10 b.

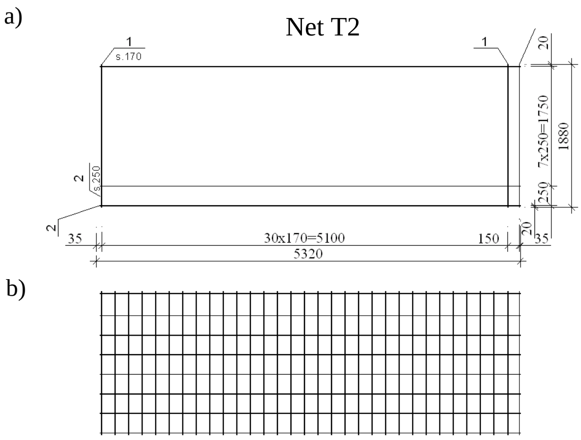


Fig 10. Differences between a real construction (b) and it drawing (a)

Thus is because it is easy to draw an extra line in IT and to analyze this element automatically, when the drawing perfectly matches the object.

Taking into account some technical limitations (a small-size screen) the automation of the process of specification table filling (Fig 11 a) is relevant because all information about the reinforcement was collected in it (the name of the item, bar mark, type of steel, size and length of each bar, the number of elements and bars in each element, the total number of elements, bar length, code of the form, dimensions of flexure). It should be noted that even digital information about the form of the bars is presented in specification table (Fig 11 b). For convenience of usage, it could be useful to provide an auxiliary graphical presentation of this form in an extra column (Fig 11 b). The graphical view of a complicated item of reinforcement could be useful for manufacture, and it is not so difficult to form it automatically by the IT means.

Thus, for practical realization scientifically grounded relationship between the application of IP and IT methods as well as methodology and computerization of centrally regulated standards are still lacking. The above discussed models and practically implemented software present one of possible solutions to this problem.

a)

Element	Bar mark	Type of steel	Size	Length of each bar	Number of elements	Number of bars in each element	Total number of elements	Total length of bar	Code of the form	Dimensions of flexure					Letter of element drawing issue
										a	b	c	d	e/R	
Bar 23	04	B	10	3 800	6	25	150	570 000	44	1 000	1 500	300	1 500		
Slabs of ground flour	01	B	12	4 000	6	50	300	120 0000	00	4 000					

b)

Code of the form	Dimensions of flexure					Letter of element drawing issue
	a	b	c	d	e/R	
44	1 000	1 500	300	1 500		
00	4 000					

c)

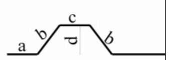
Code of the form	Dimensions of flexure					Sketch of element	Letter of element drawing issue
	a	b	c	d	e/R		
44	1 000	1 500	300	1 500			
00	4 000						

Fig 11. Reinforcement bar specification table:
a – common form, b – the requested standard forms, c – presentation of the proposed forms

Conclusions

The application of measurement ensures the effectiveness of design, production and maintenance stages. This is relevant to ensure maximal efficiency of using technical resources and the realization of elements. The 3D model version used by default in modern commercial computer-aided design systems is not the only possible.

There is the divergence of standards, causing difficulties due to the wrong use of technologies: the IT methods are represented in the PT form. The presented IIT (intellectual IT) method, combining the advantages of various methods but avoiding their weaknesses is available. However, this requires the modified standards, taking into account the IIT methods.

In computer-aided commercial design systems, the interactive formation of drawings is continually replaced with an automated process based on spatial and heuristic models however; the demand for basic knowledge and skills formation still remains. The main features of its realization at the educational stage were briefly described above.

The backwardness of standards compared to the development of computer science should be emphasized because the largest part of standard requirements is presented in the paper-printed form, which is just the basis for computer-aided automation though the situation could and should be different. The standard visualization of the elements, their geometrical data, table forms of specifications and their filling should be already automated in standards.

Accumulation of information by computer-assisted tools accelerates all design stages (i. e. construction, visualization, preparation of documentation), enables us to avoid accidental mistakes, as well as the need for searching for and using of extra catalogue. It also ensures a user-friendly interface, which is especially important at the educational stage. This creates the conditions for the formation of practical information fields.

Separation and classification of stable and dynamic information creates the fundamentalism.

The application of intellectual approaches ensures maximal automation and control of catalogue information.

The intellectual approach serves the best as the help at the educational and searching stages, reconstructing the system itself in a computer-assisted way.

Some of suggestions have been already practically realized. They are open and accessible for use, allowing modernization and further development (TAIGRA).

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