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INFORMATION TECHNOLOGY IN THE DEVELOPMENT OF THE POLISH CONSTRUCTION INDUSTRY

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Abstract. The utilization of Construction Management (CM) tools and Information Technology (IT) is the object of the paper. A review of the problems of usefulness of IT solutions on offer in Polish construction sector is presented. Generally, changes in approach to information technology, diversification and variety of its software, prosperity in construction industry and its solutions are the main motif of this paper. A significant discrepancy in the assessment of attractiveness and usefulness of those methods by businessmen and academics has been pointed out. Relationships between prosperity in construction market and usage of new planning methods, decision making, and IT systems are discussed. Results of studies are negative. The reasons for such a state of things have been presented. The research was based on questionnaires and interviews. Regression and correlation were used for the analysis. Besides, an attempt to describe the phenomenon of saturation of Polish construction sector with IT tools has been indicated. The discussion of those problems may be addressed to potential IT suppliers and can be implemented in different construction sectors.

Keywords: construction industry, Poland, construction management tools, evolution of IT, usage of IT tools, saturation in the IT tools

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1. Introduction

The IT market (not only in construction sector) changes faster than we can notice. The situation in this market is easy to become familiar with through websites. What is clear is the lack of synthetic analyses whose results more form the dynamics in the IT market and changing challenges.

In Poland, it is the ITB (Building Research Institute), which had begun the integration of research on saturation of measurement processes with IT, and on broadly understood

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quality management in the construction sector. Characteristic results of the said integration have been presented in the following reports: Witakowski, 2005, 2007, 2008. The examples of papers prepared at the department steered by the Author are following: Gajzler 2008; Karłowski 2008; Karłowski and Pasławski 2008; Pasławski 2008a; Thiel 2008. The preliminary results of these research are presented by Kapliński and Miłosz 1996; Kapliński and Meszek 1992; Kapliński and Thiel 1995; Kapliński and Janusz 2006; Janusz and Kapliński 2006, 2007; Kapliński 2007.

Polish construction sector is, in principle, influenced by four factors. They are indicated as *N*, *S*, *E*, *W* and presented in Fig. 1. Factor *S* is a general tendency towards knowledge based economy. Factor *W* is IT equipment development, development of methods, including decision making methods; a new way of functioning of a business. Factor *E* encapsulates technical and economic conditions; good economic climate in construction sector; fast growth of profitability of the sector; and even the philosophy underlying company management. Factor *N*, the REALITY, is situated on the borderline of all conditions, equipment capabilities, as well as psychological barriers (i.e., in new IT methods implementation).

A review of the basic factors, *E* and *W*, in the context of IT development and implementation is the subject of this paper. Construction Management is the context of the discussion.

2. Changes in approach towards information technology

Deeper and quite sudden interest in IT has resulted from changes in a manner of decision making and production planning. Fig. 2 presents those changes: what is clear is the tendency to replace intuition with research (Kapliński 1994). This was undoubtedly fostered by the development of IT tools. The universal trend is marked as (d). The situation in EU before 1990, and in 2005 is presented in two ovals (a), whereas the situation in Poland before 1999 and in 2005 is marked as (b) and (c). The results of the Author's research covering the 1990s and 2005 have been published in a variety of form – see: Kapliński 1994, 1997, 2008a, b, c.

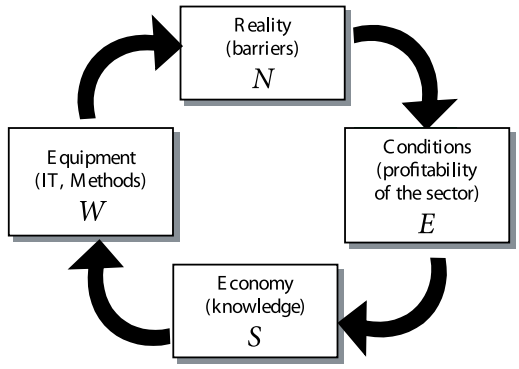


Fig. 1. Technical and economic conditions of development and utilization of IT in the construction sector

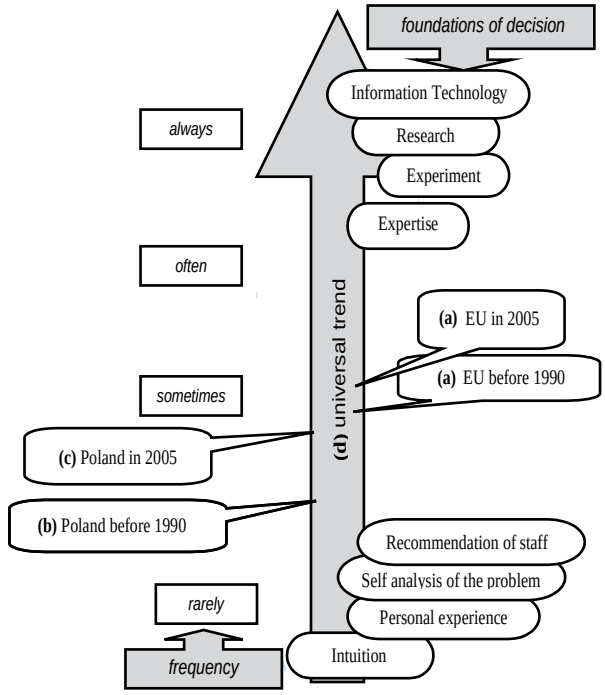


Fig. 2. Trends in changes in approach towards decision techniques and IT

The evolution of IT tools in construction project management (Fig. 3) is very characteristic. The dominating identification covers the area from identification of promotion state to object identification. The right side of the graph presents respective techniques: from statistical analysis to radio frequency identification (RFID). Constant and dynamic development of those techniques can be observed (Kapliński 2008b, c). Numerous examples of the development of these techniques are published, for example: Jurkevičius and Laukaitis 2007; Kapliński and Zavadskas 1997; Krylovas and Kosareva 2008; Mickaityte *et al.* 2007; Nassar and Casavant 2008; Lee and Egbu 2007; Turskis *et al.* 2006; Turskis 2008; Popov *et al.* 2006; Schafer and Sędziwy 2001; Scheer *et al.* 2007. Various other aspects was analysed by: Khamkanya and Sloan 2008; Mitkus and Trinkuniene 2008; Rutkauskas 2008; Rutkauskas *et al.* 2008; Samuelson 2008; Šelih 2007; Skorupka 2005; Zavadskas *et al.* 2008a.

Other considerations in the context of economy are presented by: Ginevičius and Podvezko 2008; Kaganova *et al.* 2008; Kaklauskas *et al.* 2007; Kapliński 1985, 1993, 2001; Kapliński *et al.* 2002; Mickaityte *et al.* 2008; Mitkus and Sostak 2008. The synthesis of these comparisons and analysis have been presented by Kapliński and Zavadskas 2002.

RFID finishes left part of the Fig. 3. This aspect will be very significant in the development of IT in the construction. Effects of this approach are already visible, for example: Cheng, M.-Y. and Chen, J. C. 2002; Cheng *et al.* 2008; Karłowski 2008; Turskis *et al.* 2006; Witakowski 2007; Yagi *et al.* 2005.

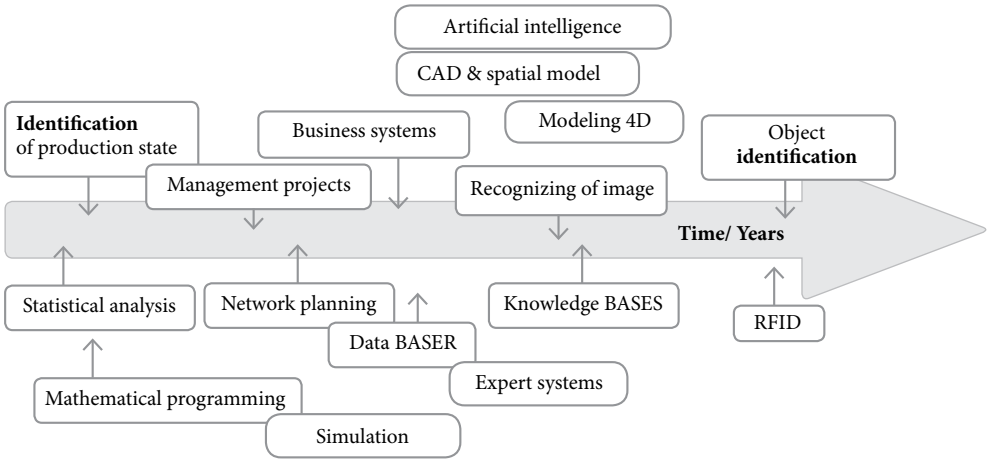


Fig. 3. Dynamic development of IT tools in construction project management

3. Diversification and variety of IT software. The Polish experience

Due to a specific situation (growth in profitability) and relatively low level of investment in the area of management systems, Polish construction companies may be an ideal market for IT companies. The character of activity (construction services) makes project management a dominating issue. Companies generally look for such project management systems which would be integrated with financial management, human resources, stock management and machinery maintenance. All companies create timetables but, unfortunately, they use different systems. What dominates here is the package called *MS Project*. Source data on materials, availability of workforce and machinery is introduced using a variety of applications (for example, *Oracle*, *Lotus Notes/Domino*), by hand, or with considerable delay.

ERP (Enterprise Resource Planning) has recently been the best known IT offer for construction industry (Brzozowski 2007; Inwestycje 2007; IDC 2007; Piotrowski 2007). Unfortunately, it is usually a standard package which does not take specific character of construction industry into consideration. This is why there are more and more IT companies in Poland that have been making modifications focused on construction industry. Some of them create modules supporting solely building companies. The following tendencies can be observed: management of the building site on-line which makes it possible to acquire information form the Internet (for example, tender announcements, supplier price lists) and WORKFLOW, supposedly based on processes. It is known from experience that an *ERP* package must be equipped with cost estimation tools.

It is the manner of organisation in a construction company that is decisive in a success of implementation of *ERP*. Polish companies notoriously switch to the so-called process management. Regardless of the size, or organisational structure, all building companies are

similar from the standpoint of function of the processes. Therefore, it is possible to present a "normalised" process management model. The most popular model in this field is the model presented by *Athena Soft*, a company geared exclusively towards construction industry (Capital 2005). The model embraces finding customers, presentation of offers, signing an agreement, and etc., the whole series of events connected to production preparation through to final accounting of the investment. Such activities (according to the pattern) are also expected to: accelerate and ensure the reliability of information flow within the company; swiftly detect departures from plan; counteract wasting resources and lead to avoiding penalties for delays.

Creating a model of a learning company is an important background to such a discussion, so that the knowledge was available to entire company, and not become a residue in the heads of only some of the employees.

The experience of construction companies suggests that in order to operate well, they need to integrate their management system with the surroundings. This goal is usually achieved by the means of:

- integrating the system with cost estimation programmes and work scheduling programmes;
- co-operation with suppliers, sub-contractors, and with the investor;
- communications with banking systems and official institutions.

For example, integration means that labour, materials and equipment information, gathered in the cost estimate, and processed in the work schedule, are downloaded to the computerised management system (*ERP*).

Therefore, future users trust those programmes which are made up from modules. An additional condition for successful *ERP* implementation is a division into three levels and, what is most important, correct data flow between system modules and the surroundings. Building site and construction management is the main level (*MRP*, Manufacturing Resource Planning). What is also important is the integration with cost estimating and work scheduling. At level two, the PROCESSES module is one of the most important ones. It supports the process management model in the company. Level three, containing modules used to manage relationships with customers and accounting, is called communications with the surroundings (*ERP II*).

Departing from reasonable data flow between system modules and the surroundings will generally waste the effort of implementing IT. One can say, Microsoft creates the Polish construction market at present. *MS Office System 2007* (with *MS Project* and *EPM* – Enterprise Project Management family – project management elements, *Unified Communications* solutions for communication) is a modified proposal (Infosystem 2008). Additional internal *Windows Sharepoint Services* website makes building site status reporting more precise. This is foreign software, nonetheless, capable of supporting an order portfolio. Some Microsoft Office mutations have also appeared. The best graphic solutions are offered by *Microsoft Office Enterprise 2007* package which is based on the following applications:

- *Microsoft Office Professional Plus 2007*,
- *Microsoft Office Groove 2007*,
- *Microsoft Office OneNote 2007*.

The package offers to users the availability of information regardless of the fact that they may be using their computers on-line or off-line. Notably, industrial companies are major clients for such applications.

There exists software assisting communications, namely *Microsoft Office Communication 2007*. On the other hand, *Microsoft Unified Communications* enables effective communication between an individual and an organisation.

Some interesting Polish solutions of integrated management have already appeared, for example: *ERP-Impuls 5* (written by BPSC), and *Microsoft Dynamics AX* (formerly *Axapta*), (Infovision 2008). The latter is an *ERP II* class IT system, i.e., a merger of *ERP* and *e-Biznes*.

Software for construction companies is individually written and tailored. This is how *Xpertis Deweloper* (created by Macrologic) was created, including a number of modules, also a communications management module (Piotrowski 2007). This software is addressed to real estate developers and general contractors.

An example of efficient adjustment of an integrated *SAP* type (SAP Global Hosting Partner) IT system to the construction sector is an offer of a company called *intelligence*. This software, called *it.construction*, is addressed to the industrial construction sector (see: Capital 2005). It is particularly useful at the offer presentation stage. It takes into account the following: changes, for example in material and service prices, currencies; sub-contractor cost valuations. The companies which took interest in the *it.construction* use this software to search for new offers, and to compare them to historical data.

Valuation and cost-quotation software is another major group of applications. They use a wide range of interactive price databases. Traditional spreadsheets are replaced with interactive applications which facilitate simultaneous work of team members on the same spreadsheet. Users indicate that such applications make sense if they help in timetabling and monitoring the process of erecting a building. Athenasoft proposes to integrate *Norma Pro* cost quotation development software with *Capital*, a construction company management system (see: Opoń 2006). *Capital* system uses the *XML* standard, and co-operates with *MS Project* network planning packages, as well as *Planista*, a Polish application. The integration is based on uploading information on resources (labour costs, materials, equipment) gathered in the estimate to the *Capital* system, and processed in the timetable. A four stage model of implementation of a construction work contract embraces the following: procuring an offer, preparing production, construction work as such, accounting stage.

There is an abundance of software used to make cost estimates. Apart from *Norma Pro* mentioned above, there are other software packages: *Edbud*, *Expert*, *Forte*, *Kobra*, *Leonardo*, *Norma 3*, *Norma Standard*, *Rodos*, *Seko*, *Skobud*, *Strix*, *Sykal Winbud*, *Zuzia*. They use the following pricing databases: *Sekocenbud*, *Orgbud-Serwis*, *Bistyp*, *PZU*, and *Intercenbud* databases (on CDs and on-line) (Paradowski 2007). Apart from those mentioned above, there are software packages which will write cost estimates in *ath* and *XML* (*ath2*) formats, which is especially important when cost estimates are transferred to investors – public investors in particular – who often do not have any cost estimate software at all. It also fosters data exchange between building companies (basing their work on different software) in electronic form. The *XML* format facilitates storage, publishing, and exchange of data between users. This format is supported by major software producers. Moreover, the software which pro-

duces cost estimates in keeping with foreign documentation, for example in the *FIDIC* or *PRINCE2* standards (Ministry … 2008), or based on German standards, is more competitive, for instance: *DBD-Bauteile*, *STBL-Bau*, *DBD-Baupreise* (Paradowski 2007).

It is worth mentioning that 20% of construction companies use their own databases of labour consumption and prices. The remaining 80% use averaged databases (for instance, *KNR*).

As it is clear from own experience, IT products in the Polish market satisfy 80% of needs in electrical and machinery sector; barely 2% of the construction sector; while the remaining 18% can be allocated to other sectors.

The best software saturated branch of the construction sector is the branch of building materials production and distribution (Bielewicz 2005; Brzozowski 2007; Mitura 2006). It has surpassed the bridge branch, i.e., generally speaking, the area of bridge management (Bień 2002). Further down the line there are industrial construction and real estate companies.

The building material branch is slowly turning away from *SCM* (Supply Chain Management). For instance, Polskie Składy Budowlane (Polish Construction Warehouses) have based the recent version of their system (distribution network) on *Microsoft SQL Server* (Bielewicz 2005). This step was caused by growing competition from international networks, such as Castorama and Leroy Merlin. Mostostal implemented *Business Intelligence* (Mitura 2006). A number of companies have set up their own *EDI* (Electronic Data Interchange). This branch will probably be first to introduce an *RFID* system.

In construction sector, following a number of experiences, there is a belief that:

- there is a irrevocable demand for a thorough analysis before IT software is bought,
- a supplier who can offer a tailored application package, not a ready made system ought to be chosen; the system that meets the needs of the company should be created. It must analyse crucial data, for example, cost of labour, cost of materials, etc., and be able to compare them with the scheduled budget,
- the system to be implemented must have open architecture, as in the future it is supposed to enable extension and guarantee openness to co-operation with application packages from other IT suppliers,
- complete hardware and network infrastructure should be secured.

4. Prosperity in construction industry and IT solutions

The profitability trend in construction sector has been evident since 2002. In the years of stagnation, building companies rarely invested in IT systems. A specific paradox can be observed, namely that favourable market conditions in the sector and rapid development of construction companies make IT solutions implementation more difficult, especially *ERP* class systems. It can be explained by the fact that the choice between distant benefits (which an IT system may bring in the future) and a short term profit resulting from a number of projects which are worked on is difficult. In Poland, at the moment, it is the builder who dictates conditions in the market (see: Brzozowski 2007; IDC 2007; Kapliński 2008a; Inwestycje 2007; Mitura 2006; Wierzbicki 2007).

The degree of utilisation of techniques and methods (mentioned in Fig. 2 and 3) under discussion in Polish enterprises is insufficient. Their usage before 1990 has been compared to 2005 (Kapliński 2008b). The interest in mathematical programming decreased. Similarly to digital simulation. The said degree, regarding expert systems stayed at its level. There has been an increase of: scheduling 4D (modelling space + time), WEB-based project management systems and *RFID*.

The research on the degree of software utilisation (mainly: planning methods, decision making techniques are illustrated in Fig. 2 and 3) has been made basing on two surveys (in 2000 and in 2005), interviews in the Wielkopolska Building Chamber, and data obtained at BUDMA, an annual construction fair (International Trade Fair in Poznań). In January 2008, an "IT island" has been created at the fair, with IT systems proposals (Infosystem 2008).

With such results in mind, the author has checked the relationship between the degree of usage of the above mentioned methods and techniques and their type, size (see Table 1), and properties of a building enterprise. Regression and correlation calculation methods have been used. Unfortunately, determination coefficient (Table 1) was nearly equal to zero in all cases. The lack of such a relationship proves scarce utilisation of construction management (CM) tools. It may be the result of limited usage of research results, and excessively refined questions, as well as a result of companies' reluctance or aversion to such confessions which may violate secrecy, obligatory in a competitive market.

Further research has made it clear that there is a discrepancy in the assessment of "attractiveness" of recommended or used methods between academics and businessmen.

Indications regarding attractiveness of recommended or used methods between academics and businessmen in 2005 have been presented in Fig. 4. The differences in indications are quite significant.

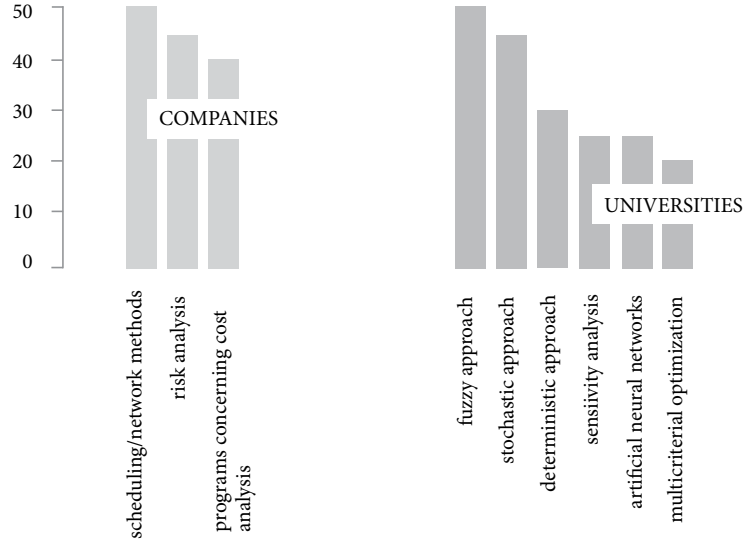
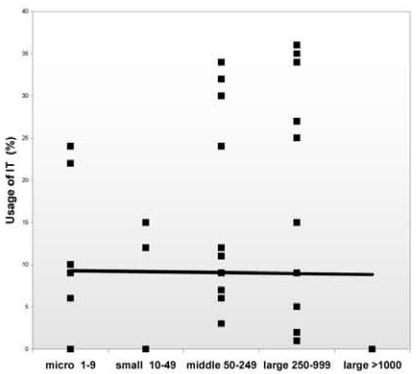
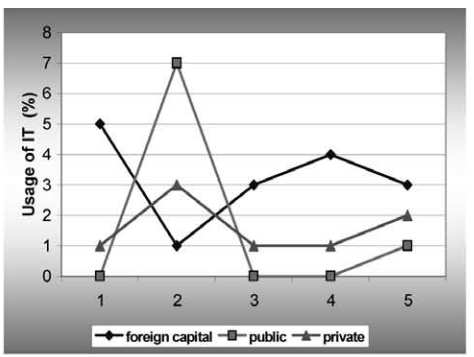
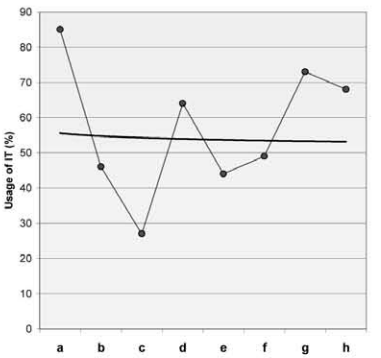


Fig. 4. Recommendations by Polish building companies and academic teachers and research institutes (2005)

Table 1. Relationships between the usage of IT techniques and the characteristics of a building company

Relationship	Size of building company	Property of company	Type (specialization)
Usage of IT			
Number of data	5 classes; data: 31 plus 25 (zero)	3 classes; 15 data (in this 3 zero)	8 x 4 data; after reduction to average: 8 data
Equation	$y = -0.11x + 9.41$	$y = -0.1x + 3.5$	$y = 55.573x^{-0.0216}$
Determination coefficient R^2	0.0005	0.0114	0.0017

Similar research, but dated January 2008, have been illustrated in Fig. 5. This data added to earlier results presented in Fig. 4.

The academics found fuzzy and stochastic approaches most attractive. After 2005, such issues as flexible management, advisory systems appeared, as well as a range of problems with *GIS*, *GPS*, and *GSM*.

Building managers have high hopes not only about *RFID*, but also about *GIS* working together with *GPS* navigation system supported by *GSM*. This merger can bring about an interesting effect regarding monitoring and controlling production in construction industry, for example with respect to sequencing deliveries, site of construction, and precision of assembly.

On the other hand, planning departments find the following most attractive: scheduling & network methods; risk analysis; cost analysis programmes. After 2005, there has been more demand for *ERP*, communication, as well as information and documentation transfer (see Fig. 5).

The following are currently experienced problems: human resources management (including head hunting for professionals and skilled craftsmen); Public Private Partnership (PPP); cash flow. It means that there is a greater demand for software packages focusing on budgeting, risk management, time and cost contingency, ways of financing investment.

5. The phenomenon of saturation with IT solutions

Various methods flourish in various periods of time, followed by periods of stabilisation or stagnation. The major criterion of their assessment is usefulness. The following course of events can be observed: it happens that some methods become extinct. It confirms author's

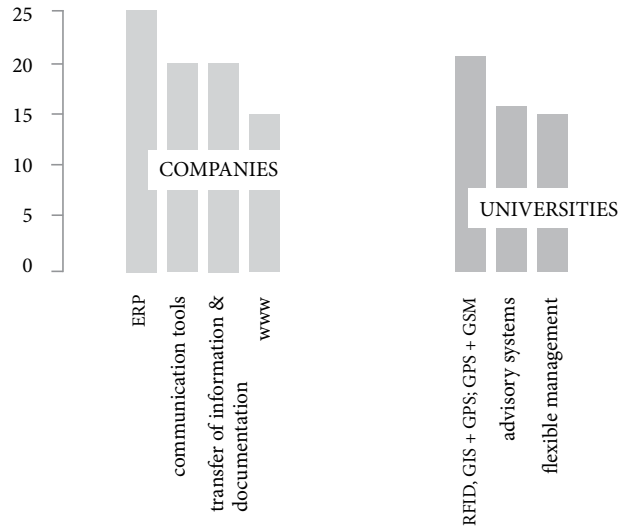


Fig. 5. Present requirements on IT tools by Polish building companies and academics (2008)

earlier thesis that "pure" methods – for practical reasons – lose their position to combined and hybrid methods. DSS (Decision Support System) – c.f. Fig. 3 – is a good example of such an evolution. DSS methods initiated other methods, such as: WEB-management systems, advisory systems, as well as agent technology (see Kapliński 2008c). The statements presented above are confirmed in the research work by Brauers *et al.* 2008; Hoła 2006; Hoła and Schabowicz 2007; Konior 2007; Marcinkowska and Rejment 2007; Zavadskas *et al.* 2008b; Zavadskas and Turskis 2008.

Parallel to the development or extinction of IT methods and techniques, a phenomenon of saturation with IT solutions can be observed. Those methods and software will not be available to all potential users. It means that there will never be a full (i.e., 100 per cent) saturation with a given product, for example with a specific software package, and so on. This situation is presented in Fig. 6. There is, hypothetically, a saturation limit. The point is that it would be better to "move" those lines more to the right in order to "take over" the area in the middle. The existence of the area towards the far right also results from inertia (in acquiring new tools); the barriers mentioned above (resulting from the possibility of achieving profitability without investing in IT); as well as the time threshold (new methods appear, old solutions have to go). IT suppliers should investigate this phenomenon in depth.

6. Conclusions

A number of detailed conclusions were presented in the text. The conclusions below have a more general character.

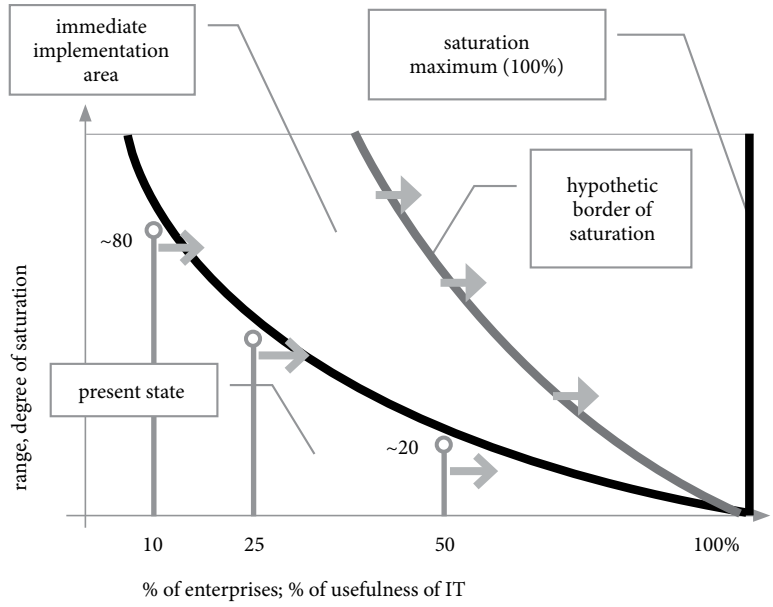


Fig. 6. Hypothetical saturation with IT tools

1. What follows from the review of IT methods and software in Polish construction sector is that the development of those tools is dynamic, though not all solutions account for specific character of the construction industry. This is particularly visible in applications of *ERP*.

2. Expenditure and investment in IT tools in construction sector is insufficient.

3. The market for IT suppliers is huge. Nonetheless, IT suppliers (and designers), in order to satisfy their ambitions, should take into account the phenomenon of saturation with IT products.

4. The study of the construction market in Poland indicates the discrepancy in the assessment of attractiveness and usefulness of IT by decision-makers from companies and universities. The Polish companies at present still manage to be highly profitable and do not need to invest in IT tools.

5. The period of prosperity for building companies who chose not to use IT on the regular basis is coming to an end – because of financial crisis disclosed in 2008.

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INFORMACINĖS TECHNOLOGIJOS IR LENKIJOS STATYBOS PRAMONĖS PLĖTRA

O. Kapliński

Santrauka

Straipsnio objektas – statybos valdymo priemonių ir informacinių technologijų (IT) naudojimas. Iškeliamos Lenkijos statybos sektoriui siūlomų informacinių technologijų sprendimų naudingumo problemos. Pagrindinis straipsnio atsiradimo motyvas – kintantis požiūris į informacines technologijas, programinės įrangos įvairovė ir diversifikacija bei statybos pramonės klestėjimas. Verslininkų ir mokslininkų vertinimai minėtų technologijų patrauklumo ir naudingumo požiūriu labai skiriasi. Aptariama, ar suklestėjimas statybos rinkoje priklauso nuo naujų planavimo ir sprendimų priėmimo metodų bei informacinių technologijų naudojimo. Tyrimai pateikia neigiamą atsakymą ir paaiškina to priežastis. Tyrimas paremtas anketavimu ir interviu ėmimu. Tyrimams pritaikytos regresinė ir koreliacinė analizės. Be to, pabandyta atskleisti, kiek statybos sektorius yra prisotintas informacinėmis technologijomis. Šių problemų aptarimas gali būti naudingas informacinių technologijų teikėjams ir pritaikytas įvairiose statybos srityse.

Reikšminiai žodžiai: statybos pramonė, Lenkija, statybos valdymo priemonės, IT evoliucija, IT priemonių naudojimas, prisotinimas IT priemonėmis.

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