The need of BIM technologies implementation in design companies

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ABSTRACT
The aim of this article is to analyze the need BIM technologies application in design companies. Increased effectiveness of design companies using BIM was assessed. Article discusses BIM design challenges, barriers, problems and solutions. In order to assess the need of BIM technologies for design companies 10 designers using BIM software were interviewed. Factors influencing design firms to implement BIM programs were also identified. According to the respondents easier and faster calculations of 3D construction was the biggest benefit of BIM software installation in their companies. Furthermore, the change in the effectiveness of the design services using BIM was assessed. Demand for BIM technologies in a micro company which carries out design work in Lithuania was estimated. It was concluded that if the demand for projects is moderate, a company is not willing to expand and the economic situation in the country does not change, it is not profitable to implement BIM in a micro enterprise unless it carries out complex projects.

KEY WORDS
BIM, BIM technologies implementation, design companies, faktors affecting BIM implementation

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Introduction

Nowadays construction industry is very demanding, specialist must have knowledge about different construction areas, be able to work with multifunctional complex computer programs. BIM design has many advantages which make the traditional design model gradually lose its value. Many design firms gradually switch to BIM design. Editing of the project with graphical objects such as spaces, walls and structural elements becomes easier with BIM programs, whereas. When information about chosen structures' physical and functional characteristics is collected a comprehensive project is generated. Increase in the design company effectiveness is evident when a complex project with many elements and stages is considered.

The result of BIM design methodology is not just a manifestation of architect's intentions and the presentation of spatial relationships in three dimensions., BIM is a repository of digital information and data generated by the design process and simulations; it is the design, fabrication information, erection instructions, specifications, materials palette, schedule, and project management logistics in one database (Schinnerer, 2006). Data models will exist for the life of a building and can be used to manage the client's asset. BIM models will exist as the „As-

Built" documents for future additions, renovations, and upgrades (Kuehmeier, 2008). The question remains when does the need to implement BIM technologies in design companies arise?

1. BIM technologies need to design companies

Despite the fact that the development of the ArchiCAD software in 1982 in Hungary is viewed as the real beginning of BIM, for over two decades the implementation of BIM in the construction industry has been relatively slow as compared to industries such as manufacturing and engineering. There was a significant shift in momentum over the past five years as technology and implementation issues improved and the industry realised the advantages offered by BIM technologies (Smith, 2014). McGraw Hill (2014) has been tracking the evolution and implementation of BIM in the global construction industry since 2007 through extensive global surveys. They have found significant change over that period and quite dramatic implementation increases over the past few years in particular. In North America their survey results showed that BIM adoption by contractors escalated from 28% in 2007 to 71% in 2012. The United States have long been a global leader in BIM development and implementation in the construction industry. The Scandinavian region is also a global leader in BIM adoption and implementation. BIM technology is ideally suited for prefabrication construction methodology that is popular in the region. A survey undertaken by the China Construction Industry Association in 2012 found that less than 15% of 388 surveyed Chinese construction companies used BIM (McGraw Hill, 2014). McGraw Hill found that the Chinese industry had structural barriers such as difficulties with changing traditional methods and that in many projects the Chinese law requires the design and construction stages to be separated with contractors not involved in the design stages. Therefore, it is not possible to use one of the main advantages of BIM collaboration in the work process.

BIM programs for complex design are rarely used by small design companies because they usually engage in the small objects design. Therefore it is not possible for them to quickly realise benefits, changes and payback for their companies. In addition, most of the companies are specialized – they design certain types of buildings or structures.

Building information model technologies are more popular among large design companies, manufacturing enterprises, design centers, and so on. The use of BIM creates an opportunity for construction companies to create workplaces in the design companies subdivisions: buy BIM programs, train staff. The most important benefit is received in the construction management area because BIM helps to prevent errors occurring during construction stage.

BIM technology is suitable for all construction objects but it has become popular after using BIM for the design of complex buildings and construction: multi-storey buildings and skyscrapers, bridges and flyovers, roads, highways, etc. Nowadays construction productivity lags behind other industries. Research analyzingd 100 tallest skyscrapers in the world has been conducted (Reizgevičiūtė et al., 2013). The study analyzed construction times when BIM was not yet in use. Productivity of the construction of skyscrapers built before 1990 and after 1990 was compared. According to the research results the construction speed in the last years incresed by more than 36%.

According to some authors, once BIM technology is widely used by small and medium enterprises, it would be worthwhile to investigate the difference between the perceptions of architects in large organizations and architects in small and medium sized organizations (Son et al., 2015).

Despite many advantages of BIM design many companies delay buying expensive BIM programs. There are several reasons which influence designers' hesitation to use BIM:

- companies accomplish small objects and errors during different construction stages occur rarely,
- it is not possible to carry out the project without the 2D CAD drawings (detailed drawings, site plans and etc. are required),
- designer of a project is chosen by the lowest price and designer's work is not valued considering wasted time or quality, so return of investment is doubtful,
- lack of information about the copyrights (when project is made in BIM environment question is who ownscopyright when client owns the model),
- when client owns the model and builds similar or typical project he might choose a cheaper designer.

It is important to assess designers' priorities when thinking about the need of BIM technologies. It is important for a designer:

- to design a building which complies with the essential requirements and regulations,
- to provide a list of materials, quantities, provide

technical specifications, base constructional solutions,
- to provide major non-standard detailed drawings,
- to work with project as long as it is profitable.

It is not important for the designer:

1. How long construction of a building will take?
2. What the delay in building erection would be?

Factors, affecting BIM design implementation in the building industry:

- builders can see that a lot of time is spent in downtime (meanwhile employees receive hourly wage),
- errors in calculating materials and quantities estimates for large objects may ocurr (diference of 10-30%),
- it is hard to control the work of employees,
- it is hard to plan work for several months ahead,
- it is important to ensure workers' safety and health.

Right plot exploitation in urban areas (storage places) is a very important factor. Therefore it is very important that the materials and equipment arrive to the object at the time when they are needed. When using BIM design and planning platforms it is possible to exploit the construction site effectively. Delays occurring on the construction site significantly raise the construction cost. Different factors may influence the increase of downtime. The main reason for the difficulties on construction site is inadequate planning. Without BIM it is difficult to control the delivery of materials in time and correct mistakes. Delays may also occur because of the lack of cooperation between the contractor and the designer. Without BIM technologies these parties do not communicate, the work is not coordinated and must often be repeated, additional time for adjusting the project is needed.

2. Challenges, barriers, problems and solutions of building information modelling

In order to assess the need of Building Information Modelling for a company it is necessary to consider BIM barriers and challenges that should be solved. Before starting to use BIM the follwomg issues are usually considered: software cost, staff training, training time, downtime. However, when company starts to use BIM many more barriers arise which are different for each individual company and are depending on its size, number of employees, status in the construction sector.

During BIM implementation to design companies three types of barriers may be identified: legal, technical and commercial. One of the biggest legal threats are unclear terms of collaboration between project stakeholders. Furthermore, it is important to indicate responsibilities of different project parties, assess the risks of model ownership. Technical barriers are: interoperability, the lack of standards (national). Commercial barriers are: inertia (stagnation), needed investments, asymmetric risks and rewards, no standard business models, no standard contract models (Ashcraft et al., 2015).

There are three critical BIM installation issues in the design company:

- selecting software,
- addressing IT issues,
- training up and rolling out.

It is noted that many BIM programs are similar and have the following characteristics: 3D modelling environment, ,,domain" toolkits, cutting drawings, possibility to import and export. However, a professional user sees the differences between various BIM programs: some are easier to use, some are more advanced and require ,,traditional practice in 3D", some handle more complex geometries, some handle larger scale.

The question is how to choose the right software which would fulfill all the requirements for the quality and planned financial resources. When commercial software proposals are received price, opportunities of a program and adaptation for specific design company should be evaluated. In order to choose properly it is advised to try at least a couple of programs (trial versions). This would create an opportunity to compare strengths and weaknesses of different programs (Ashcraft et al., 2015).

Figure 1 illustrates connection between the owner (builder), a building contractor and a designer (design company/architect). This model describes standard cooperation model. When design is completed a contractor is sought. It is noted that the owner transfers the instructions directly to contractor who coordinates the construction issues with subcontractors, suppliers and other participants in the construction. In this case the designer is left behind and cooperates only with the owner implementing his instructions and tasks. This model refers to a hierarchical management system; individual construction project participants do not

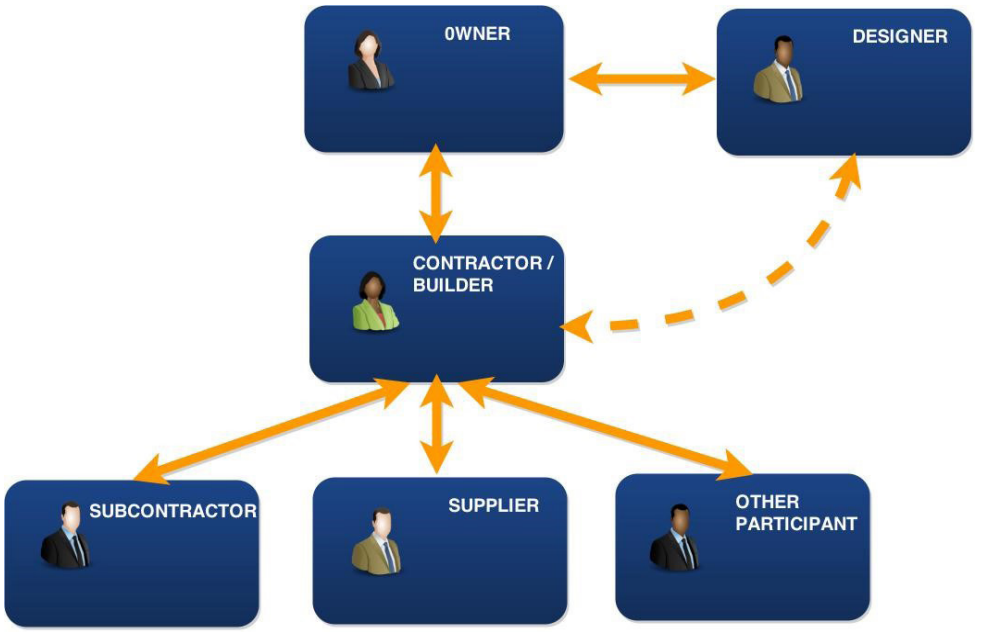

Fig. 1. Standard cooperation model between construction parties
Source: author's elaboration on the basis of (Ashcraft, Shelden, 2015).

communicate; there is no cooperation between the different parties.

Using a Construction Management (CM) company early in the design process will result in more accurate preconstruction estimates that will keep the owner more informed for bankroll and cost purposes. Fully integrated BIM design process links the CM to the architect at the beginning of the design phase. Each of them will have input to the design of the building, and the end result will be a more cost effective building due to the increased productivity from this type of relationship. They enable the exploration and improvement of the project execution strategy, facilitate improvements in constructability with corresponding gains in on-site productivity, and allow for the rapid identification and resolution of time-space conflicts (Fischer et al., 2004). Although this model is based on a much more complex design process, it creates an opportunity to create the most effective construction project „script". Figure 2 illustrates the relations during construction process when building information model is used. Model changes from hierarchical, which is common in today's construction industry, to a collaborative one. One of the biggest advantages is the feedback between the participants of the construction process.

The biggest disadvantage of BIM model are the equal rights to the common project. Everyone can express their opinions in the design phase so the design process may significantly slow down. Contractor cares to erect building as fast as it is possible. Meanwhile, engineer cares about constructional simplicity, so it would be easy to calculate constructions and building statics. Architect seeks that his/hers designed building would be interesting and impressive. Furthermore, architect cares about comfortable building usage. Often some exterior-interior details cost a lot and are difficult to build. The owner usually seeks to profitably sell or rent the premises as fast as it is possible. Different participants of the project see design work through a different angle, so this model brings new perspectives and is very complex with regard to fast design and different opinions.

Important difficulty when deciding to start using BIM is uncertainty whether the investment pays off. Technology is envolving fast and a lot of time and money might be spent on software and training with unceratin outcomes. The „pioneering" path can be high risk as firms become „test pilots" for certain technologies whilst their competitors wait in the wings to see if the „testing" results in commercial value and competetive advantage. But this „wait and see" approach is no longer viable for firms that want to be key players in the construction market particularly at the top end (Smith, 2014).

Because the true benefit of a BIM is for the project owner, the push to use a BIM will most likely be a client-driven development. Many owners see the single point of responsibility in integrated practice as

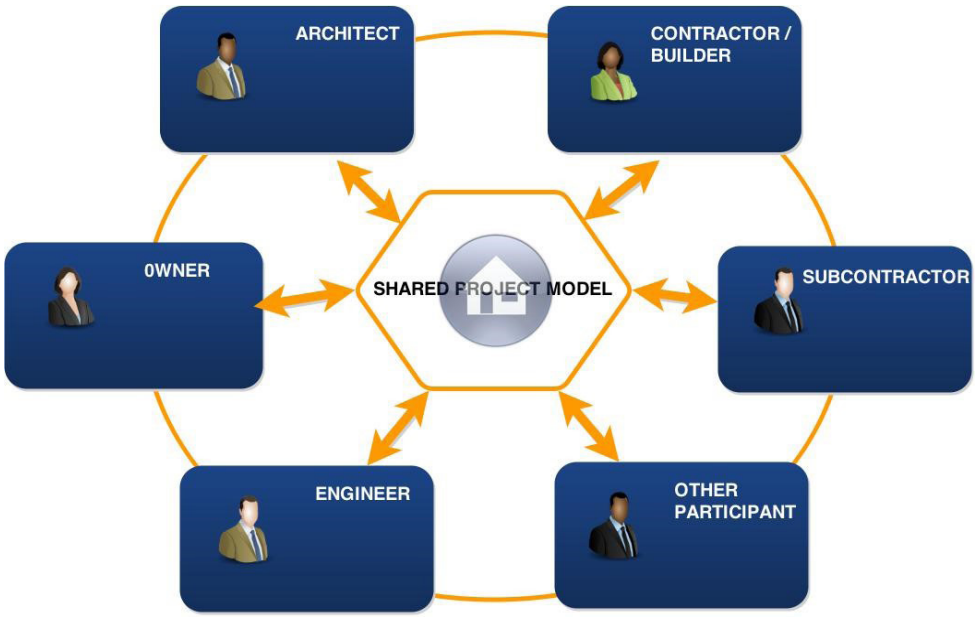

Fig. 2. Reciprocal relationships between various parties involved in the design process and the BIM project
Source: author's elaboration on the basis of (Ashcraft & Shelden, 2015).

an attractive alternative to the „over-the-wall method" of design and construction in which an architect completes a design and hands it over to a contractor for construction. Speed, accessibility, communality, and adaptability are achieved by the use of a common database, early information user input, knowledge representation and information technology, team collocation, and information exchange in small batches (Elvin, 2007). Based on expert studies, other benefits of BIM include reduced risks, improved productivity, streamlined production, maintenance of design intent, and facilitation of quality control through clear communication and sophisticated analytical tools (Guidelines for Improving Practice, 2007).

Figure 3 presents different needs of participants in a project. BIM helps to fulfill these needs. In addition, the figure shows issues which are of no interest for particular project participants. Architects and engineers do not care about the construction time delay. When considering the need of BIM implementation, architect does not care how long

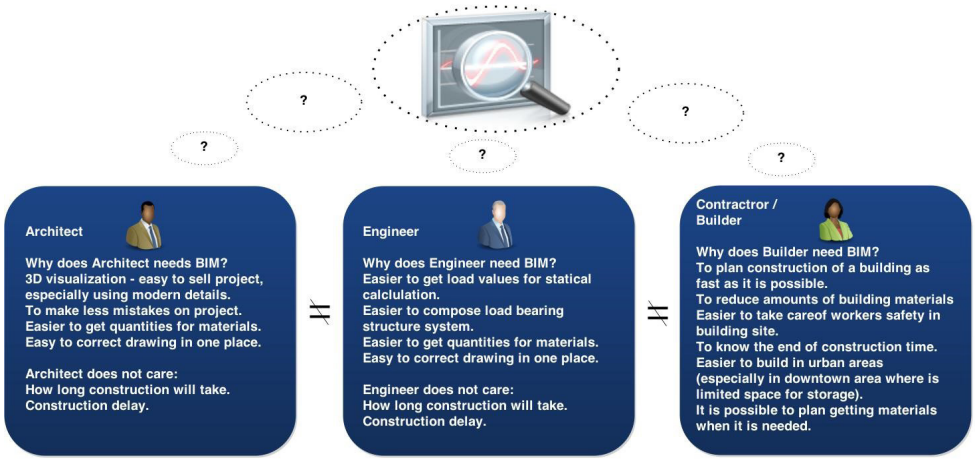

Fig. 3. Different needs of participants in the project
Source: own.

construction of a building will take or about project delays. According to the provided information the contractor/builder feels the biggest benefit from using BIM. BIM model helps to shorten the construction time, reduce the quantities of materials, accurately plan the ending of construction. It also helps to ensure workers' health and safety. Building Information Model makes it easier to build in urban areas, plan the arrival of materials on construction site at the right time.

3. Identification of factors, which affect BIM implementation

In order to assess the need of BIM implementation correctly and identify factors which make design companies invest in expensive technologies 10 designers whose companies are using BIM were interviewed. 12 factors which generally encourage design companies to start using new design software were randomly presented to the respondents. The respondents evaluated the factors affecting BIM installation in their company in 10-point system: 10 points for factors which had the greatest influence; 1 –the weakest influence. Figure 4 shows the results of the survey.

According to the respondents the greatest influence of BIM software installation for their company had calculations of 3D construction. This factor unanimously got 10 scores from all respondents. It may be assumed that the studied companies carry out complete complex projects so it is convenient to use a single BIM program because constructions are calculated in the same model that holds all building information in the central file. Therefore, information is always updated and there is no need to change formats or convert files.

According to the respondents the second place of the most affecting factors was occupied by easy drawing correction (it is enough to change something in one drawing and it automatically changes in the whole model). This factor got high rating because it helps to save time – during initial project stage the primary project proposals are changed a lot depending on the client's needs.

Places 3 and 4 were taken by the list of materials generated by one click and the higher accuracy of the automatically generated material list. The high importance of this factor reflects the need to accurately calculate material needs. Less labor cost because of the automatic data is generation is an additional advantage.

Demand for complex objects design got 8 points on average and was placed in the fifth place by importance. In the respondents' opinion it may be assumed that the object size is not an essential factor when choosing BIM programs since surveyed companies do not have many of large scale projects. In addition, it may be assumed that despite the risk of re-working when using 2D programs, professional designers implement large projects as successfully and smoothly as smaller ones.

Sixth and seventh place were shared by the the following factors: multiple model usage and visualization opportunity that helps to sell a project. Repeated model usage does not have a decisive influence since projects are rarely similar. In this

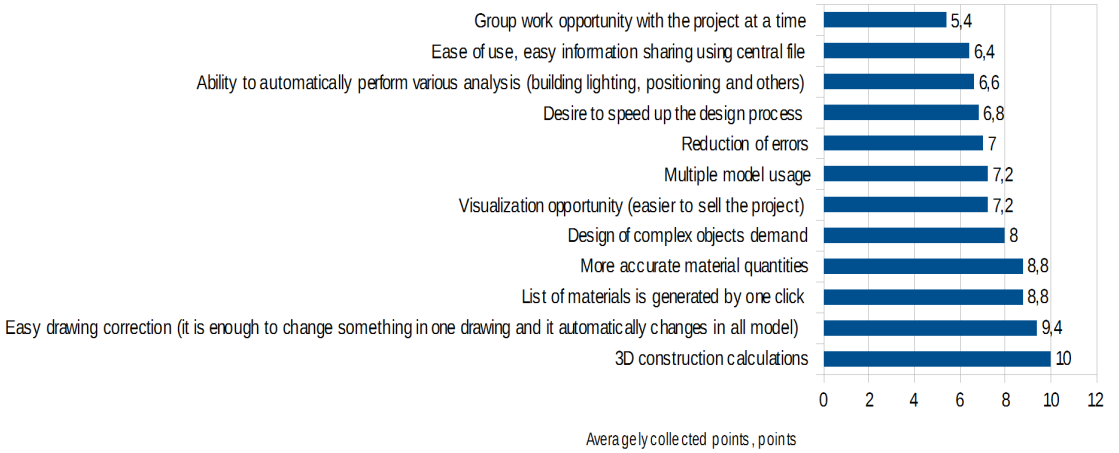

Fig. 4. Factors affecting BIM implementation
Source: own.

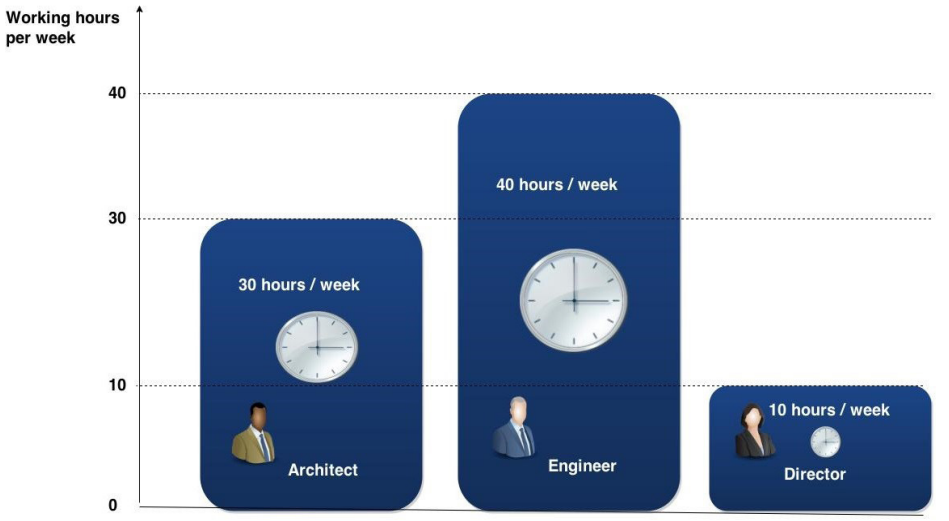

Fig. 5. Distribution of employees in the company by working hours
Source: own.

context the value of one central file model is mostly beneficial to the builder who posseses the purchased project for the whole duration of the construction process. Design companies do not get obvious benefits from visualization because 3D view is often unnecessary for the customer, especially when building is residential, constructed for own use and not for sale.

Factor named „reduction of errors which occur in the project" collected 7 points on average. It may be concluded that professional users working in the surveyed design companies make few mistakes so this factor occupies the eighth place.

The desire to speed up the design process collected 6,8 points on average. It is believed that users' 2D skills were excellent before starting using building information model programs. Therefore, a decision whether or not to install expensive BIM software did not stem from the need to speed up the design process since employees work optimally.

According to the respondents' opinion the ability to automatically perform various analyses (building lighting, positioning and others) is not of high interest to them. This factor collected 6,4 points on average. It was noted that demand for such analyses from customers is not high so the factor has no significant influence when choosing to use BIM programs. Ease of use and easy information sharing using central file got 6,4 points on average.

Factor described as the opportunity of simultaneous group work on a project took place 12 and collected 5,4 points on average. In today's society professionals often seek to be leaders – to show their knowledge, take leadership, make everything perfect to the last detail. Therefore, several professionals are not willing to work together in one project and share their knowledge, ideas and information. The survey revealed the common opinion of the companies that have implemented BIM technologies on the factors that influenced their decision and on the most improved working areas.

In order to assess the importance of BIM technologies and design services need, the activities of a design company „N" were analysed. The company is a private limited company which has operated for more than 2 years. Company „N" is a micro enterprise which employs 4 employees (2,5 full-time posts). Since the company belongs to the group of young companies it employs several staff members on a part-time basis (it is not their main job). By doing this the company has adapted to the changing market and if it is necessary it can do larger projects because it has necessary certificates and available professionals. The company carries out different kinds of design work. Various authors have proven BIM benefits for large companies theoretically and practically. The aim of the research was to find out whether it is beneficial to implement BIM software and spend money on designers training in a ‚micro enterprise doing business in Lithuania. Figure 5 shows the staff time distribution in a micro enterprise by profession.

The company prepares detailed plans and site formation plans, single family house projects, construction design projects, simple structures and other building projects, renovation and refurbishment projects, building energy certification. The company

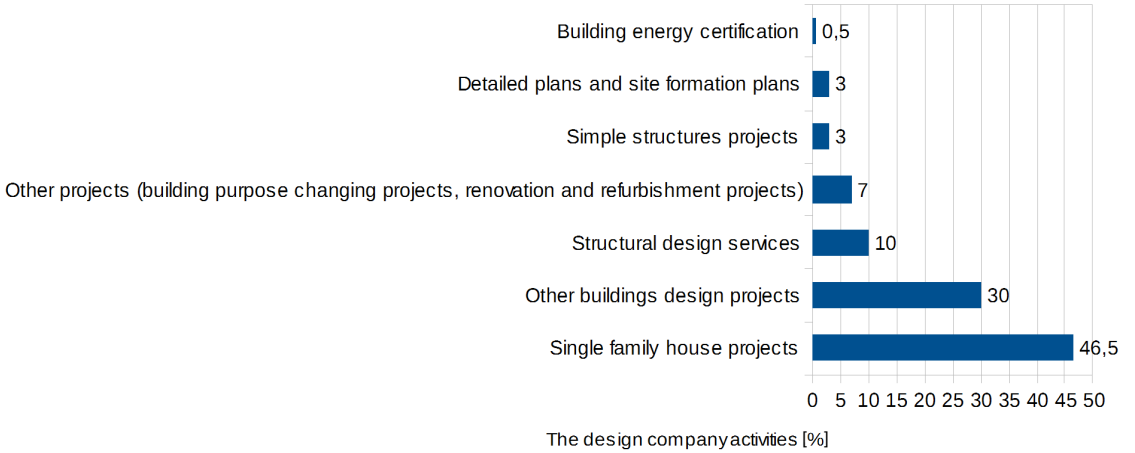

Fig. 6. The design company activities
Source: own.

performs a wide range of activities. It was noted that not all activities require complex project designs. From among the activites mentioned above, complex project may be necessary only in the case of single family hous design when architectural and structural parts are required.

Calculations regarding company's economic performance and different activities have been carried out . The cost of different projects has been evaluated after company's activities were grouped into different areas. Figure 6 shows the part of different project types in the total vaule of all conducted projects. The biggest part of the company's project portfolio consists of single family house projects – 46.5%. Other buildings design – 30%, 10% – structural design services. Other activities take only 13%. Despite the fact that single family house design takes the largest part of the company's activities (when full complex project with architectural and structural parts is needed), this activity receives less than half of the company's income.

Not all company's projects are complex. Full complex project with architectural and structural parts is needed only for single family houses. However, the company does not offer heating and ventilation, air conditioning, plumbing and other project parts. It is concluded that it is not worth to install BIM programs and train staff in a ‚micro company which operates in many different areas. Payback time is long because the expenses for programs and training are needed. In addition, the company receives less than 50% of income from complex projects. When demand for projects is moderate, the company in not willing to expand and the economical situation in the country is stagnant, it is not profitable to implement BIM in a micro company.

Conclusions

Implementation of BIM in design companies is a complex process that affects three areas in a company: technology, processes and people (their skills, qualification). Thanks to BIM design process is faster and more efficient, cost estimation accuracy increases, unplanned expenses decrease. According to the survey, the need of faster and more convenient 3D design calculations has the greatest impact on the decision to implement BIM technologies in a design company. It is convenient for a company that runs a complex project to use a single BIM design program because constructions are calculated in a modelwith all building information stored in one central file.

Building information model technology is more often used by large production companies and design centers. The most common reasons why designers refuse to work with BIM are: the design of small objects, demand for 2D drawings (detail drawings, site plans), doubtful return on investment, copyright issues. Designers‘ priorities when they assess the need for BIM technologies are following: to design a building fulfilling all essential structural requirements, to provide the basic material quantities, to justify the choice of construction solutions, to provide technical specifications, to provide major non standard detail drawings, to shorten design time.

Designers often do not care how long the construction of a building may take or what are the possible project delay factors. That is another reason for implementing BIM. Building companies feel the maximum benefit of using BIM thanks to the possibility of downtime reduction as well as precise project planning. Moreover, the list of materials is more accurate, the work is more easily controlled and scheduled, workers' safety and health is better assuredbetter storage places are chosen and finally plot exploitation in urban areas is more efficient.

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