APPLICATION OF LEAN PRODUCTION METHODS TO CONSTRUCTION INDUSTRY

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ABSTRACT

Current challenge is information exchange between stakeholders in construction in BIM (building information modeling) environment. BIM provides platform for all aspects of construction products and process, that allows simulate and optimize not only a design, but also processes in lifetime cycle of building. BIM platform create appropriate environment for application of principles of lean construction in construction industry environment. For lean construction are not characteristic only a principles and methods, but in first place mentality, but not only a managers, but all who participate on the construction process. Lean production and lean construction represents two view on optimize construction production. In this article are presented selected methods of lean production, which appropriate application into BIM environment creates conditions for lean construction.

Key words: *BIM (Building Information Modelling) lean production, lean construction, information flow*

1 INTRODUCTION

BIM technologies are related with wide spectrum of construction professions. They are usable in position of client (investor, state administrators, developer, property manager, etc.), designer (architect, manager of project teams, technologist, technician, etc.) or contractor of construction works (general contractor, subcontractor, site manager, manager of construction works, manager of quality, manager of safety etc.). For all this areas represents BIM uniform platform, which allows better cooperation and sharing of information through virtual model of building. This virtual building model is connected with tools of information technology.

Benefits of BIM:

- Ability to create and evaluate variants of design;
- Support the integrated analyses for better design and managers decisions before construction begins;
- Coordination of several team members and professions working together on project within schedule and budget;
- Reduction of mistakes and inaccuracies in project documentations;
- Increase production thanks to simple information flow in project;
- More effective communication between construction team and designer;
- Increase speed of documentation delivery;
- Construction simulation with possibility of error detection before construction begins;
- Use of 3D model, which carry needed information for facility management;
- Verification of various factors that affect a building;
- Automation of construction process (GPS navigation of construction vehicles).

Lean production got several different definitions. Lean production is process of elimination of waste with goal to create value for every stakeholders in production. (Murman et al., 2002). By authors (Hines a Taylor, 2000) lean production is discipline, which working on every aspect of value creating flow, through elimination of waste. This elimination helps with costs reducing, generation value, increasing sales and company can keep up with competition in increasing global market.

Lean production extends to all value generation company processes:

- Research and development;
- Supply system;
- Production;
- Testing;
- Marketing;
- Post-production services.

Each methods of lean production find their use generally in engineering industry. BIM technologies provides tools for use of principles of lean production in whole building lifecycle. Lean construction do not takes every stakeholders in the same way. Client got special place and only what matter is what generate value for client and everything for client unimportant, what consumes resources, is eliminated or minimalized. In terms of capital construction is client a state and state should, through specification of requirements, reflects the needs of all society.

2 METHODS OF LEAN PRODUCTION AND THEIR APLICATION IN CONSTRUCTION

Into task of construction belongs production and sale of construction products, organizing, managing and preparation of construction process. There are differences between construction and production, but application of principles and methods that was developed mostly for assembly line for production of products of manufacturing industry is possible in construction environment. Construction process can be separated from different view (information flow in planning and managing construction process, lifetime cycle of building process, resource of construction process, working area, etc.) and after that applicate each principles and methods of lean production into these parts of construction process.

Issue of lean production from view of typical methods, which find wide application mainly in engineering industry, is covered by many authors in literature (Womack et all, 1991; Diekmann et all, 2004). In following part of this article are presented and characterized some selected method of lean production, which can be applied in construction industry. In engineering industry are these methods know under names:

- Jodika;
- Just in Time;
- Poka – Yoke;
- Visual management;
- Method 5S;
- Eight kinds of waste;
- Total productive maintenance;
- Kanban;
- Muda, Muri, Mura.

Same as lean production lean construction too have in foreign literature wide information platform. By authors (Diekmann et al, 2004) is lean construction never ending process focused on elimination of waste, achieve and overcome client requirements, focus on whole value adding flow and monitoring perfection in construction process.

2.1 Jodika

Fundaments of Jodika (Automatization with human intelligence) is allowing machine autonomus detection of abnormal condition and with help of alert signal warn machine operator on emergence of disorder and interrupt work on product. It means that mistake is detect and announced and that allow operator to operate more machines in same time. Work is stopped right after mistake is detected after that can be attention focused on source of problem and operator can undertake corrective action. Production process can be, thanks to corrective actions, modified to reduce repeating mistakes in future. With help of Jodika costs, caused by fails in production process, can be significantly reduced.

Use of Jodika in construction industry: Automatization of assembly line, with tools to detection of mistakes, for production of construction products, higher cost caused by less quality of construction products can be lowered. Costs can be lowered by using building information modelling and information – communication technologies (IKT) for immediate control of just constructed part of building and their comparison with project documentation.

2.2 Just in Time

Just in Time method was developed in 70s of 20 century by Japanese company Toyota. Just in time is concept, which main goals is create supply chain that is able to deliver required material just in time when it is needed. That mean there in no need to create stocks of material. This material is used immediately in production. Production is adapted to client requirements and nothing is produced that cannot be immediately sold. This state can be achieved by precision planning, where material is delivered into production process just in time when it is needed. Final product is delivered to client with no delays. Focus is on minimalize warehouse supply. Thanks to that requirement for warehouse space is lowered, requirement to warehouse workers and machines are lowered and time save is maximized because product don't have to be transported to warehouse then to client, but product is transported directly to client.

Use in construction industry: Lowering stock of material in site warehouses to the smallest possible required quantity, thanks to using of precise planning of supply requirements. Lowering costs for warehouse, lowering costs on warehouse workers and mechanism. Lowering time need to transport material between warehouse and site warehouse and between site warehouse and workplace. Creating of supply chain that is able to fulfil requirement that results from application of just in time method.

2.3 Poka - Yoke

Poka -Yoke methods deals with prevention of human errors in production process. Human errors results in the most of errors and delays in production. Main goal of Poka-Yoke is that is not allowed to produce waster, which is caused by human error. This goal is achieved by installation of mechanical and electrical equipment, which don't allow produce waster.

Use in construction industry: Possibility of installation mechanical and electrical equipment for instant detection error in production of construction products or construction process. Preventive actions for increasing technological discipline of employees.

2.4 Visual management

The idea of Visual management is to show information about construction process to every employee that participate on process. Thanks to sharing this information among employees can be response to errors quicker and employees can work as one team. For this visualization are used information

boards, which easily and regularly inform employees about construction process in form of charts and schedule. Application of different colors or shapes helps visualize state of construction process.

Use in construction industry: Usage of information boards for better delivering information to employees about status of construction process. Usage of information boards that tells employees, which construction and where is actually in construction process.

2.5 Method 5S

Method 5S (five Japanese words that starts with letter S) is about five steps, which are needed to keep system and order at workplace:

- Seiri – workplace is organized so there will be no materials, tools or mechanism that are not really needed to performing work operations. Other materials, tools and mechanism are stored in warehouses and unneeded items are removed;
- Seiton – is about assigning place for every resource according to intensity of their use
    - Daily use – stored directly at workplace in arm range,
    - Weekly use – stored in warehouse at workplace,
    - Monthly use – Stored near workplace,
    - Yearly use – Stored in central warehouse;
- Seiso – Cleaning of workplace according to prepared standards, if its needed change shape of workplace;
- Seiketsu – Workplace is standardized. Main question in creating of standard are: Who? What? How often? How? Where? When?
- Shitsuke – Self-discipline in respecting these four steps, 5S audits and workshops.

Use in construction industry: Standardization shape of workplace with focus on construction process for purpose of lowering time needed to move workers and materials on site. Standardization of workspace form view of place of tools, mechanism and materials. This can lower time required for construction process.

2.6 Eight form of waste

Eight form of waste is focused on elimination of waste from this eight view:

- Transport – Transport, longer or more complicated that is needed, is waste. Transport of information, longer or more complicated that is needed, is waste;
- Supply - Too many of everything is waste, supply of all unnecessary things is waste;
- Movement – Unnecessary movement is form of waste, only actions, which must be done to generating value are not waste;
- Waiting – Waiting for anything (humans, material, mechanism or information) is waste;
- Overproduction – Production too many or too early is waste;
- Errors – reworking, correction and repair is waste;
- Not used potential of employees – Human resources and their potential are not in many companies fully used and this is form of waste;
- Time of generating of value – Value can be generated for less time, this form of waste can be eliminated by managers.

Use in construction industry: Use of information technologies for faster and better communication between stakeholders in construction. Creation of conditions for stakeholders in construction so they can meet requirements that is demanded by intention of elimination of waste in area of transport, material requirements, information flow, supply, waiting.

2.7 Total productive maintenance

Total productive maintenance deals with planning and organizing of every activity related to mechanism maintenance, so as to ensure operation with no trouble. This contributes to decreasing time needed for mechanism repair. There is goal go from repairing machine after failure to preventive maintenance. Responsibility for mechanism maintenance is transferred to operator. In production is better shutdown machine for planned maintenance, like when machine stop by itself cause of failure.

Use in construction industry: Introduction of maintenance plan of company mechanisms. Basic maintenance transfer to operator of mechanisms.

2.8 Kanban

Kanban can be translated as board. This concept talking about need of existence of board or signal system, where will be indicated state of given task (work in progress). This system got several column. Every column represents one state of given task: unassigned tasks, approved, working, finished. Tasks go from left side to right side of board. By using this method can be decreased time needed to finish task there is better understanding what need to be done and what is actually finished.

Use in construction industry: Introduction of board for employees, where will be tasks shown, which need to be done and in what state they are right now. Usage of IKT technologies to identification of tasks and their monitoring their realization by employees on every level of management.

2.9 Muda, mura, muri

Muda – is every action, which consumes resources but do not generate value:

- Muda type I – actions that do not generate value for client but they need to be done;
- Muda type II – actions that do not generate value for client and they do not need to be done. These actions can be eliminated from construction process.

Mura – This word mean non-uniformity in resource usage (this can be eliminated by just in time principles). Muri – This mean that whole process is too complicated to be done without errors, this can be eliminated by splitting process into standardized parts.

Use in construction industry: Elimination of processes that consumes resources but do not generate value of construction product. Time schedule of construction, where is resources evenly distributed between processes.

3 IMPROVING OF CONSTRUCTION PROCESS BY USING BIM TECHNOLOGY

Digital technologies brings to construction industry new possibilities of using main goals of lean construction. By author (Funtík, 2015) in time, when construction industry got problems with low quality and high error rate, which cause weak information flow, BIM is appropriate solution how keep project under control.

Building information modelling is new discipline so there is lot of definition. Acronym BIM itself is used only from year 2002. Many literature tells definition of BIM differently. By (www.wikipedia.org) “building information modelling is process of creating and managing data about building through whole lifetime cycle.” By (Černý, 2013) “BIM is organized collection and using of information about project. Center of this effort is digital model, which contains graphical a descriptive information about design, construction and facility management.” Greg Bentley, CEO of company Bentley Systems, starts conference his own definition: “B mean better decision by use of simulation and visualization, IM explain as information mobility for lesser energetic usage of project.”

This means that users can achieve better cooperation by using mobile platform and application. Goal of BIM is not create only 3D model of construction, but to get complete, reliable, available and easy exchangeable information about construction for everyone, who need this information, in building lifetime cycle. Many studies show that by using BIM there can be saves up to 10% from costs of whole building. BIM technologies offer these benefits:

- Allow coordinated access to information;
- Provides environment to creating virtual model, to show what need to be build and what is already build;
- Allow work with models on 3D, 4D, 5D level and that helps to better understanding of building environment;
- Allow testing of risks that can come with construction process;
- Allow faster obtaining and analysing of information.

It is obvious that between lean construction philosophy and the possibilities offered by BIM technology, it is possible to find several parallels.

4 CONCLUSION

Manufacturing companies working on lean production principles since World War II and they create lots of methods, which deals with increasing of effectivity of production. There are differences between construction and production, but methods that is used in lean production can be used in construction industry. Thanks to implementation of principles of lean production into construction industry, there can be less errors in construction process, improve supply chain, improve thinking of employees and thanks to that decrease costs and time needed to construction process. Principles of lean construction and lean production allow provide to client better building, which will meet no only client needs, but requirement of society as sustainable construction. Application of BIM technologies is actual challenge in Slovakia construction industry. To maximize the benefits of using BIM technology would be no stakeholder in the construction process did not refuse to use multi-dimensional virtual model of the building.

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