INNOVATION MANAGEMENT IN THE CONSTRUCTION SUPPLY CHAIN

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The aim of the paper is to present examples and perspectives of innovation management in civil engineering projects, and to analyze innovation management tools that may be applied to road project supply chain management. The basis for observations presented in the paper are literature review, and results of a survey and interviews with project participants. This paper treats the logistic chain as a concept of product development – and in construction and civil engineering the product is a built facility. Thus, the construction supply chain management covers the whole project life-cycle, from the concept, across design and construction to commissioning and handover, and may be extended to operation and decommissioning phases. Innovations may be introduced at each phase of the project life-cycle and, potentially, by any of the project participants. Innovations relate to products, processes or organization. However, introducing new solutions into complex environment of interacting supply chains of numerous project participants is a serious challenge for a manager.

Keywords: product supply chains, supply chain management, innovation management

Introduction

Logistic management concepts are in the state of continuous transition – they evolve in line with development of IT methods and find applications in new fields of economic activity. In particular, the ideas of supply chain management and product development process, being quite common in manufacturing industries, are implemented to construction projects (O’Bien et al., 2009). Supply chain management can be defined as management of the sequence of processes that add value to the product at each consecutive stage of its development. Such chain can be also defined in construction, in particular in road building. It involves a considerable number of stakeholders and direct participants (Figure 1).

However, special character of organizing projects in construction makes it difficult to design supply chains in advance and optimize them. This arises from traditional project delivery systems and limitations of public procurement (road building). Thus, the construction supply chain may be considered, to some extent, created by random selection of participants in tendering procedures. The project organization is temporary, the cooperation is based on a number of separate contracts that regard isolated tasks, and there is no common goal for
everybody involved. What is more, composition of the project supply chain will probably never be repeated – the team members will not meet again in the same roles. This does not encourage cooperation and partnering (Sobotka, 2010).

Figure. 1. Product development supply chain involved in delivery of road infrastructure.

Modern product development process requires innovations – if the supply chain is to survive in competitive environment facing more and more demanding customers. Innovations are changes that have to be managed as they break operating (and thinking) routines, quite often not only of one member of the supply chain. Again, construction with its traditional strict division of roles is not a branch leading in innovations. The aim of the paper is to present the problem of managing innovations in road building projects with regard to innovation management tools and the possibility of their use in the project life cycle.

Innovations

The concept of innovation and its meaning for the economy has been considered for decades. One of the earliest definitions can be found e.g. in Schumpeter (1960): innovation is introducing new products and implementing new, more efficient production methods, but also creation of new markets, acquisition of new sources or raw material, or a new approach to organizing economic activities. Innovations are products of human creativity, require the ability to observe, react to changes, and use skills and knowledge in a different way, or simply applying new knowledge to operations (Begg 1997).

Innovation can be considered a process that leads to implementing something new that is efficient, beneficial, and practical. Four types of innovations are often listed in the literature on the subject (Oslo 2005; Buijs 2003):

- **Product innovation** – is introducing a new or improved products or services (“better” functionality, technical parameters, materials, components),
- **Process innovation** – is implementing more efficient production methods,
- **Marketing innovations** – introducing a more efficient marketing strategy that may be expressed in changes to e.g. the way of presenting products, packaging, promotion, price policy or business model,
• Organizational innovations – applying new method of organizing business activities, both in-house and with business partners.

It is quite common that all these innovation types come together (as e.g. offering an innovative and better product would not bring any benefit if the market stays unaware of its special feature or its sheer existence – so ways have to be found to approach the customer more efficiently). Innovations may take place by means of in-house inventions or acquisition of solutions developed by someone outside the organization.

Managing innovations has to be based on a strategy, and is a purposeful planning, motivating, controlling and supervising the processes of creating, implementing, promoting and collecting market feedback. These processes need to be leader-driven: barriers of routine have to be overcome, people convinced and motivated, knowledge shared and information forwarded to the right place and and the right time. The consecutive stages of innovation management are therefore:

• Collecting information on the business environment and customers to acquire knowledge on customer needs, expectations and behaviour; at the same time, one needs to find out what the competitors’ strategies are;
• Planning and designing based on the above knowledge and resources already at disposal;
• Acquiring new resources: knowledge, people, equipment or technology;
• Implementation
• Monitoring all the above stages to get feedback needed for control.

Focusing the analysis on road projects and their supply chains, one can conclude that there exist potential for innovation at each stage of project development and by each project participant. However, coordination of these actions is required if the aim is to improve the final product of this project: efficient, reliable transport infrastructure. The basic questions are (O’Brien et al., 2009): how to manage innovations at different cooperation levels in the construction supply chain? What tools or policies can be adopted? At what levels of cooperation do these tools stimulate innovations in construction practice? Basing on results of surveys among actors of road projects in Poland, and considering current legal and political conditions in this country, the authors claim that the most potential to innovate occurs at the design stage, and the most promising innovation types are product and process innovations (Rafalski 2012) – assuming that knowledge is effectively transferred between design and construction teams (Sobotka et al. 2012, Pilot Programme 2007).

Examples of Innovation in Road Building

The chapter presents some examples of innovative solutions in road construction. Recent highway and national road network development programmes of Polish government supported by European Union funding (NRCP 2011) are enormous opportunity to apply innovative solutions – such opportunity will not occur again for many decades. There is a field for improvement in any respect of configuring supply chains, selecting materials and technologies. Table 1 lists a selection of innovations introduced recently into Polish roadbuilding, but it is not meant to be a comprehensive review of modern materials and techniques. The examples are presented below in more detail.
Table 1. Examples of innovation in Polish road building.

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<th>Innovation type</th>
<th>Description</th>
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<td>organization</td>
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<td>Pilot project of General Directorate of National Roads and Highways</td>
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Mechanistic approach to road surface design becomes recently more and more popular. It consists in verifying assumptions of theoretic mechanical models by experiments (Figure 2).

![Mechanistic Approach Diagram](image)

They are considered much more precise than traditional out-of-the-shelf models and solutions described by standards and “best practices” based on generalised models of material behaviour, and are possible to be used due to development of testing methods (Sybilski and Bankowski 2001). Mechanistic methods allow for design with new materials (such as mineral-cement emulsions MCE), greater loads and heavier traffic, analysis of impact of new types of vehicles, and for determining causes of deterioration of existing surfaces.

As for soil conditions (mostly clays and silt), Poland is not a perfect location for roadbuilders, and soil improvement is necessary. Therefore, efficient methods of soil improvement were looked for – viable in large-scale projects. The example of implementing such methods is an A4 highway section Szarow-Korczowa, where a variety of piling techniques were used to provide reliable support for not only bridges and viaducts, but also highway embankments. Jet grouting method of soil-cement piles reinforced with steel profiles was used – with the length of piles from 3 to 20 m. The method itself is not new, and was used for a variety of construction and civil engineering projects, but the scale of A4 piling works was a challenge in itself – over 12 thousand piles had to be completed in a reasonably short time.

Another interesting example of soil stabilisation is construction of S1 expressway section – a Tensar Geocell geograte filled with aggregate was used to provide foundation for a 12 m high
This solution provided a rigid platform in the embankment base, and proved a viable option for soil replacement and piling (Kawalec et al. 2006).

Poland is not rich in high quality stone material, and quarries are located only in the southern part of the country. Road building requires enormous quantities of aggregates, and transporting them in long distances is one of the factors that make our road building expensive. At the same time, Poland’s energy production relies on coal, and we had large deposits of coal ashes. Such ashes are of proven their applicability in construction (Eskioglou and Oikonomou 2008). The highway construction programme is a great opportunity to use them and solve two problems at one time: get rid of waste and improve low-quality local materials to be adequate for embankments and subbases.

Road surface is the most expensive part of the road structure. Recent development in material science provide a variety of solutions of welcome qualities. Long-life surfaces are designed to serve for 50 years or more with replacement of top layer (20-100 mm thick) every twenty years. Porous asphalts used for wearing and bunding courses reduce the problem of aquaplaning (so improve traffic safety) and reduce traffic noise (in some cases, they eliminate the need to erect costly barriers (Nilsson et al., 2012), though require special mainatnance to keep the pores clean. Foamed asphalt is an example of product and process innovation – invented to speed up resurfacing works. This technology utilizes reclaimed asphalt and makes possible to combine milling, material preparation and placing new layer that can be used as subbase.

The above examples of innovations have not been introduced into Polish road building practice without resistance – the initiative usually comes from contractors and scientists, not the clients. Until recently, legal environment was not favourable for innovation: design teams were forced to rely on limited set of standard solutions developed a decade earlier (Gaca 2012, Rafalski 2012). There was no cohesive system of directing and financing research in the field (PKD 2009, Gaca 2012) – so innovations are not managed in a systematic way. With the traditional design-bid-build public procurement it is still extremely difficult to make any changes to specifications at construction stage – even if such change would bring economic benefits, and improvement is looked for in switching to “design build” or other procurement routes that would bring the experience of the design and construction teams together (PKD 2009, Pilot Programme 2007).

**Innovation management tools**

Developing new solutions is usually a risky and costly process. To make it possible, a system of incentives is required. A broad overview of innovation stimulating tools, with respect to construction and civil engineering environment, is proposed by O’Brien et al. (2009). The authors divided them into four groups:

- Tools that create demand – make people buy innovations
- Tools that encourage supply – make people look for better solutions,
- Tools for improving knowledge dissemination – enable knowledge transfer between organizations and within organizations,
- Tools that enable cooperation within supply chain to create innovations in team.

The first group concerns innovation-pull mechanisms – making the market willing to buy innovative solutions. In road building, this market is client-led. The tools are, first of all, legal regulations that enforce or enable implementation of new technologies. For instance,
environment protection regulations (related e.g. CO2 emissions or waste management) become stricter, which creates new “problems” that have to be solved. Other tool may be subsidies to entities that offer innovative products – so that investing in R&D becomes less risky, and benefits to be expected sooner. A very important issue is guarantee that new and creative solution finds a buyer – through the public procurement system. If such tools are applied, avoiding innovation activities becomes impossible or unbeneftitial for the enterprises within supply chain.

The second group comprises instruments that “push” innovations into the market: encouraging research and development initiatives and granting access to solutions already developed. In this group, the following tools are mentioned:

- research grants for universities – to increase number of innovative solutions available to those who do not develop them themselves, but are willing to implement,
- funding pilot implementation projects – to give grounds for assessment of new ideas,
- training programmes for potential users of innovations (innovation leaders are often most active in such actions to promote their products and technologies among designers and contractors, and through them – among clients)

Another example of innovation management tools in this group is also a legal framework of certification and approval of new solutions – some forms of control are required to protect the health and safety of consumers and the environment.

The third group of tools is used to stimulate knowledge transfer – such as initiatives to create knowledge networks or industry clusters. Within a single organization, such tool would be a communication policy that may encourage proposing and discussing even small improvements by anyone that “has an idea” (like in the Japanize kai-zen approach). A system of experience recording and dissemination also belongs to this group, especially if it can be used across the organization structure. An example can be on-site training of construction workers – they are directly involved in bringing innovative technology to practice.

The fourth group of tools tightens cooperation between the supply chain members to make them work as a team with one goal. In road building, this can take form of more cooperative procurement systems, starting with design-build, where integrating responsibility for designing and physical delivery of assets enables making better use of knowledge, to public-private partnerships or concessions, where the contractor is made responsible for maintaining his product for its lifetime. By selecting proper delivery system, adequate risk sharing in contract, and the approach to specifying the product, the public client can considerably stimulate, or completely eliminate, the possibility to innovate.

**Summary and conclusions**

Supply chains in construction as a whole do not seem innovative enough yet. In Poland, the opportunities for innovation in road building are enormous: there are many big projects underway and many to come. The number of project participants is great. Among them, there are innovation leaders with years of experience gathered worldwide. With the volume of work, even small improvement is multiplied by millions of tons of embankment material or square meters of surface, so the reward for improvement would be great.

However, if wrong solution is allowed to be implemented, the cost would be enormous (one can imagine the cost of replacing surfage on a 10 km section of a highway – if a new material
fails to conform to the requirements). Therefore, reluctance to solutions not proven by years of use is understandable. As road building stays a responsibility of public bodies, current political issues are likely to affect it. Nevertheless, progress cannot be stopped.

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