Environmental Management in Project Oriented Companies Within Construction Sector

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Construction sector activities are predominantly project-oriented, and production processes are being executed on a temporary production (construction) site. Contemporary view of the sector includes, in addition to achievement of traditional goals, requirements related to environment, such as resource efficiency, emission control and preservation of biodiversity. For this purpose, the paper proposes an extended concept of quality and its comprehensive management in construction to the field of sustainability. Next, the existing body of knowledge is examined in order to identify specific measures to be used in the implementation of an Environmental Management System (EMS) into the contracting organisation as well as into the construction project. Challenges associated with project oriented production are identified and discussed, and special emphasis is placed to the role of the organisational culture in this process. Environmental Management Project System (EMPS) is developed and proposed to be used within the construction project. For a given construction project, the EMPS can be supplemented by an Environmental Impact Assessment if required.

INTRODUCTION

The awareness of the importance of global sustainable development is increasing ever since a global framework for environmental goals and activities was provided in 1987 by the so-called Brundtland report (Our common future … 1987). It has caused many industrial and service sectors around the world to place more attention to the sustainability issues, and encouraged them to try to strive to achieve these goals. In order to attain them, specific policies and measures targeted to various industrial and service sectors have been established in several countries.

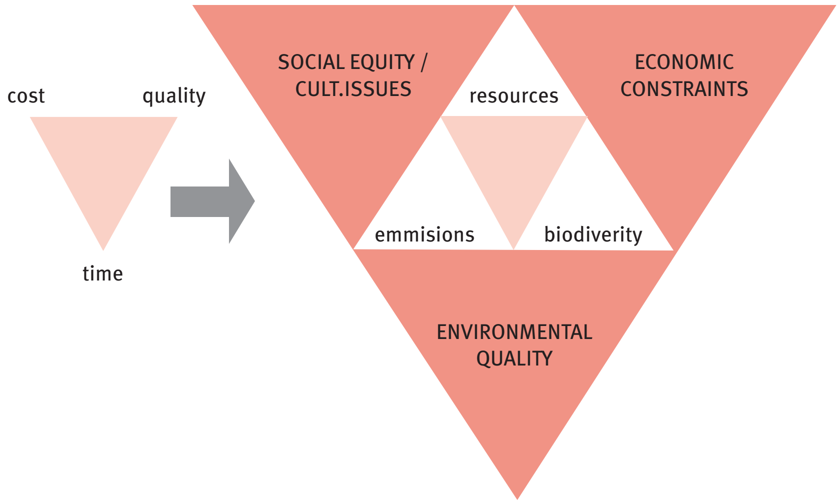

Figure 1. **Extending the conventional construction project goals to the sustainability field (Agenda 21 … 1999)**

Contemporary view of the construction sector includes, in addition to the traditional goals related to production efficiency (i.e. scope/quality, time and cost), requirements related to resource efficiency, emission control and preservation of biodiversity, that can be further extended to the field of ensuring environmental quality while taking into the account social equity and respecting economic constraints, as schematically presented in Figure 1.

The above listed goals manifest themselves in various sub-goals and subsequent actions. **Environmental goals** are expressed as striving to reduction of environmental effects

- in manufacturing processes where construction materials and products are being made (construction product level). Construction product producers, such as cement or construction steel manufacturers should aim to reduce their environmental influences in all areas: use of virgin raw materials, energy consumption, and emissions to air, water and land;
- during construction (project and organization level), the majority of processes being executed are associated with a range of adverse environmental impacts, such as noise, energy consumption, emissions into air, water and ground and raw material consumption. Despite the fact that site conditions and one-off production limit the potential to rationalize the site processes, the personnel should strive to achieve their efficient execution, with minimized use of resources (material, energy, machinery and labour force); and
- for the final product, i.e. the building or engineering works (structure level), where whole life cycle of the structure should be taken into the account (Srdić and Šelih 2011). This means that environmental effects related to the operation and maintenance, as well as demolition stage should be minimized as much as possible.

In the area of the built environment, the **social equity goal** can be achieved by constructing buildings and facilities that provide the necessary infrastructure required by the local population. The results of this measure are improved public service facilities (e.g. schools, hospitals, libraries, …), available to all society members. As such, these facilities are even more important for the part of the population that is more vulnerable, e.g. seniors or pre-school children. As a consequence, overall living conditions are improved, leading to better educated and healthier population. On organization and project level, social equity goal is achieved through execution of several measures aimed at the employees as well as the local community. For the employees, providing appropriate working conditions; continuing education and training that correspond to the needs of the employee as well as to those of the company; providing activities for the employees that enhance their identification with the company; and ensuring equal employment opportunities to the members of various minority groups leads to fulfilment of social equity goals. A specific area within the social aspect of sustainability is cultural aspect linked to the built environment, which demands respect of the needs of various groups within population and acknowledgement of their cultural differences, thus ensuring that the constructed facilities and buildings respect and cater to the needs of all members of the society. On the construction process level, cultural differences among project stakeholders and employees should be respected.

Social and environmental aspect are supplemented by the economic aspect that requires cost efficiency and long term profitability for all organizations involved, as well as successful completion of an individual project within foreseen budget.

Research statement

Although sustainability and environmental management are being today often formally promoted within various organisations involved with construction and its accompanying processes, there is still no systematic approach to define the sustainability of the final construction project outcome, the structure. Further, on project level, there is lack of knowledge and concrete guidelines on how to efficiently implement environmental management into a construction project, as well as how to carry out the environmental impact assessment of the activities carried out on the construction site.

On the level of the construction contracting company and other stakeholders in the construction project, it can also be noticed that there is also not enough knowledge regarding the role of organisational culture upon successful implementation of environmental management into construction contracting organizations, nor on the key environmental influences as perceived by the enterprises.

Research objectives and methodology

In order to account for the sustainability issue in construction, the first aim of the paper is to present the proposal how to extend the concept of quality and its comprehensive management in construction to the field of sustainability. Extending the concept of quality into the area of sustainability is carried out by systematic building of a model, justified step-by-step, on the basis of relevant existing scientific works.

The second objective is to examine the existing body of knowledge available through relevant papers published in various scientific journals, and to identify and further specific measures to ease the implementation of an environmental management system (EMS) into the construction contracting organisation as well as into a construction project as a whole. Within this context, special emphasis is placed to the role of organisational culture within the contracting company and other construction project stakeholders.

The third objective is to define a uniform approach for the establishment of an environmental management project system (EMPS), to be used within a contracting company for all construction projects within the current project portfolio. Development of the model is based on literature research and identification of environmental impact areas relevant for construction. The proposed EMPS model may contain, if required, the environmental impact assessment model that can be used when environmental impact assessment of construction project activities needs to be carried out.

Extending the quality concept to sustainability performance

One of the major challenges related to the management of the construction projects is to provide a systematic, comprehensive view of the project. The model of Srdić and Šelih (2011) proposed a conceptual way to extend the quality model for buildings that needs to be established on the three above-mentioned levels, to the environmental field. On the *construction product level,* the essential requirements have to be met for the structure in order to ensure quality of the structure. According to the recent Construction Product Regulation (2012), the essential requirements include the 7th essential requirement "Sustainable use of natural resources" that *the structure* needs to comply to. Compliance to essential requirements is achieved a) if construction products that are permanently built in the structure comply with the relevant European product standards, and b) if design of the structure, execution of works and maintenance of the structure complies to the relevant standards.

Construction product compliance with relevant standard specifications is ensured by establishing Factory Production Control (FPC) in construction product production, which ensures that the targeted mechanical properties, durability specifications and dimensions are achieved within pre-defined intervals that are specific for each product/property under consideration and defined in the relevant product standard. The standard defines also the required confidence intervals. Construction Product Regulation (2012) provides further rules for the attestation of conformity of construction products, where the selection of the attestation of conformity procedure for a given product or family of products is specified by the European Commission. The selection of the procedure depends upon the importance of the part played by the product with respect to the

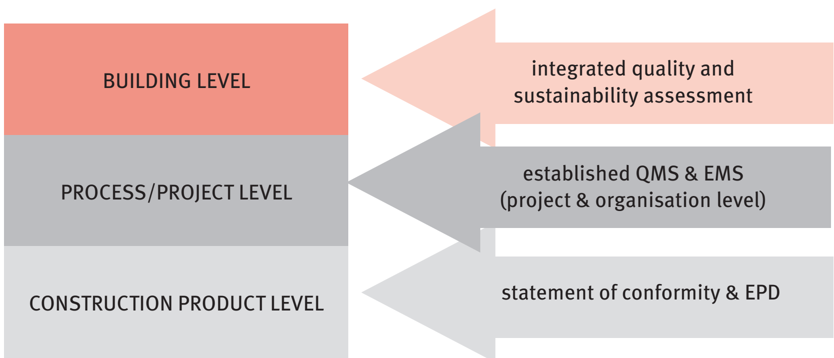

Figure 2. **Levels and elements of the proposed conceptual model for integrated quality and environmental assessment (adopted from Srdić and Šelih, 2011)**

essential requirements, in particular those relating to health and safety; the nature of the product; the effect of the variability of the product's characteristics on its serviceability; and the susceptibility to defects in the product manufacture (Srdić and Šelih 2011).

Bearing in mind the project orientation of the construction sector, and the fact that several business entities usually take part in a single construction project, *on the process/project level*, the model of Srdić and Šelih (2011) requires establishment of quality and environmental management systems both on project, as well as o organisation level. Preferably, the QMS and EMS (that are implemented on organisation level) should comply to the requirements of the international standards ISO 9001, and 14001, respectively.

A schematic representation of the three levels of the proposed model and associated elements is depicted in Figure 2.

Implementation of Environmental Management Systems into construction industry

On the organization/company level, contracting companies establish environmental management systems with the intention of gaining various benefits, such as improved regulatory compliance requirements; reduction of liability and risks; enhanced reliability among customers and peers; reduction of harmful impacts to the environment; prevention of pollution and waste (which can result also in cost reduction); improvements in site and project safety by minimizing injuries related to environmental spills, releases and emissions; improved relationships with stakeholders such as government agencies, community groups, and clients (Christini *et al* 2004; Campos *et al* 2013). In addition, regulatory requirements provided by the European and national legislature demand reporting on all environmental impacts generated by an enterprise as a whole, and its separate production units. An established EMS, when designed in an appropriate way, can facilitate collection of the data subjected to obligatory reporting. In addition, many companies realize that reducing environmental impact ensures optimal use of resources and enforces measures that improve the company's competitiveness (Kein *et al,* 1999).

Environmental management systems are often seen as technical rational management tool for analytical actions that helps to plan, systemize and evaluate the environmental management tasks issues in an organization (Von Maimborg 2002), however this view is often not sufficient. Several authors argue that in order to behave in a sustainable way, the companies will need to implement organisational actions that will need to go beyond technical actions, and that they should be accompanied by the actions aimed at changing the culture of the company (Harris and Crane 2002). Conscious, planned actions that aim to change the organisational culture towards better understanding of environmental management within the company can be extremely useful. However, one should bear in mind that changing the culture is a long term process. Further, in order to achieve successful implementation of an EMS, the companies need also a well developed system for environmental monitoring and information management (Von Maimborg 2002).

Challenges associated with project-oriented production

Construction production manifests itself, on company level, as a decentralized project organisation (Gluch and Raisanen 2012). As such, it has a temporary nature by definition, and therefore requires different planning and management techniques than serial production encountered in manufacturing sectors. In addition, several business entities are involved in the construction project:

- the client as the initator of the project;
- AEC companies specifying in details the properties of the facility to be constructed and the processes to be executed;
- general contractor and subcontractor(s) executing the works,
- the Engineer with the task to survey and control the construction works being executed in terms of scope, quality and time; and
- managing companies planning and executing the maintenance and repair of the facility during maintenance and operation stage.

The listed stakeholders differ in type of expertise, marketing strategy, number of employees, annual turnover, the type and magnitude of environmental impacts related to their activities (Šelih, 2007). Consequently, they need different approaches to environmental management within their organizations.

Typically, there are few business relationships of permanent nature among project participants, which in practice hinders efficient implementation of EMSs into the construction project due to different operation modes and organisational culture of project participants.

The organisational culture, defined as a set of shared mental assumptions that guide interpretation and action in organizations by defining appropriate behavior for various situations (Ravasi and Schultz, 2006), can have a significant impact upon ways of managing the work processes within the enterprise. There is empirical evidence, e.g. (Denison et al, 2004; Vallejo-Martos, 2011), that organisational culture has an impact on company's long term performance. Healthy organisational culture within a company results in a more cohesive teams, may increase overall productivity and facilitate communication. It is also important to note that several studies, as reported by (Možina et al, 2002) confirm that establishing an efficient culture needs time. Due to temporary nature of a construction project as well as varying nature of construction project participants, ranging from architectural design offices to specialized construction service providers, establishing a common project organisational culture (that is willing, among other, to respond to various environmental management issues) is an extremely challenging task often not achieved in construction practice.

Empirical research, e.g. the longitudinal study of environmental professionals in construction carried out by Gluch et al (2006) concluded that environmental practices have not yet become embedded in construction project culture and practice, and that environmental and project discourse have yet to be aligned. Presently, there are also no specific guidelines how to achieve recognition of environmental issues within a construction project (Glusch and Raisanen, 2012), and consequently, the need for further research in this field is still present.

Corporate culture, observed in construction enterprises that encourages conservative attitude towards introducing change and innovation into the construction project (Cheung et al 2011), can therefore present a barrier to successful implementation of environmental management project system within the construction project.

Development of an Environmental Management Project System

For a project-oriented company that carries out projects in which project participants may belong to other organisations, it is strongly advisable to follow, in the field of quality management, the guidelines specified in ISO 10006 (2003). As proposed by Srdić and Šelih (2011), Environmental Management Project System (EMPS) can follow the structure of the project QMS. Consequently, quality and environmental management systems within a particular project are compatible and can thus be integrated. Similar to the project QMS, the EPMS is used for all construction projects within the current project portfolio, and it is interconnected with the EMSs of the participating organizations (such as subcontractors). The environmental impacts related to the processes executed during the construction project are thus fully monitored and controlled (Srdić and Šelih, 2011).

Environmental impact assessment for construction projects

The increasing global awareness of the environmental impacts of human activities within the last two decades resulted in critical assessment of the environmental impacts resulting from various activities, including those related to construction. The report prepared by UNEP in 2009 (Buildings and climate change, 2009) states that the building sector alone contributes up to 30% of global annual greenhouse emissions and consumes up to 40%. Further, worldwide, it is estimated that approximately 40% of the total energy consumed, 40% of all the waste produced, and 40% of all virgin raw materials consumed are associated with the construction sector. (Jeffrey, 2011; Agenda 21, 1999) Total environmental influence of construction activities is clearly significant, and, in order to be able to manage the overall influence upon the environment, we have to establish environmental impact categories relevant for the construction sector and its product, the built environment.

Although not required by the standard ISO 14001 (2004), the EMPS established in the previous section can be supplemented by the environmental impact assessment model (EIAM) by which all environmental impacts can be monitored.

On the construction project level, two types of projects should be clearly distinguished from the viewpoint of environmental management:

a) construction, and
b) demolition projects.

The main difference is that demolition projects result in large quantities of construction and demolition (C&D) waste, while for construction projects, especially in certain cases of engineering works (e.g. dams), large quantities of construction materials are being consumed / built in the structure. Consequently, substantial depletion of natural resources is associated with such projects. Refurbishment projects can be considered as a combination of construction and demolition projects, as both listed activities are carried out with the same project, although in much smaller quantities.

Further, when a framework for environmental impacts is being defined, one should not forget to take into the account the differences appearing in the design and execution of buildings and engineering works. Even when the final use of buildings differs from one to another, there are several common features within the construction process of the buildings. Engineering works, on the other hand, are extremely diverse, ranging from roads and dams to energy supply networks. The accompanying environmental influences are diverse, and consequently, it is more difficult to prepare a generic list of environmental impacts, both for the construction as well as for operation and maintenance stage.

Chen et al (2005) identify the a list of environmental effects of the on-site construction activities, which includes soil and ground contamination, construction and demolition waste, dust, noise and vibration, hazardous emissions and odours, impact on wildlife and natural features, and archaeology impacts. Gangolells at al (2009) compiled an alternative list of adverse effects of the construction activities:

soil alteration, waste generation, atmospheric and water emissions, resource consumption and other potential impacts.

A generic list of n environmental impacts, accompanied by the assessment of severity index proposed by Šelih (2006) is presented in Table 1. Severity index, S_i, expresses the relative magnitude of consequences when the environmental impact under consideration, i, occurs. For the purpose of this study, it belongs to the following range:

$$S_i \in [1, \ldots, 5] \quad ; \quad i \in [1, \ldots, n] \tag{1}$$

where 1 means no influence, and 5 disastrous influence upon the environment. n environmental impacts are identified, and for each of them, i, the value of S_i is estimated by an expert (Table 1).

i	ENVIRONMENTAL IMPACT, i	SEVERITY INDEX, S_i (expert judgement)
1	Noise	4
2	Dust	3
3	C&D waste	3
4	Emission gases	3
5	Electricity consumption	3
6	Hydraulic oil consumption	3
7	Drinking water consumption	2
8	Waste water consumption	2
9	Fossil fuel consumption	2
10	Inert waste	2
11	Transport	2
12	Production waste	2
13	Ozone layer depletion	2

Table 1. **List of generic environmental impacts (n=13)**

The value of environmental impact coefficient for the environmental impact i , $C_{env,i}$ is determined by the equation

$$C_{env\,i} = \sum_{j=1}^{m} a_{ij} \quad ; \quad a_{ij} \in [0, 1] \tag{2}$$

where a_{ij} is the value assigned to the criterion j (for the impact i) determined by an expert (through observation or measurement of relevant parameters), and m is the number of relevant environmental aspects.

Final impact assessment coefficient for the impact i, CF_i, is determined by the expression

$$CF_i = S_i \cdot C_{env\,i} \tag{3}$$

Results of an environmental impact assessment for a selected case study are presented in Table 2. An environmental impact is considered to be important if $CF_i > 12$, where consequently surveillance is required during construction project execution.

Even with different proposed structure of categories for environmental impacts as described above, there is a general agreement that environmental management supplemented with environmental impact assessment is a must for contemporary construction contracting organisation. In particular, the companies can gain significantly by combining environmental impact assessment of their activities with formally established EMS that complies with one of the existing standards in this field, e.g. ISO 14001(2004).

Discussion and Conclusions

A comprehensive model for assessing sustainability of the built environment is justified and systematically built in this work. It has been shown that environmental impact assessment, supplementing this model, can be used also on construction site level, thus improving its environmental performance. When combined with the use of relevant Environmental Product Specifications for the construction products being built in the structure, and relevant process standards, the model can be used for the sustainability assessment of the selected structure.

In order to enhance the effectiveness of the project environmental management systems, the procedures within this system should be carefully defined, and their execution monitored on a continuous basis. Another field where there is still space for improvement is identification of appropriate environmental competence requirements for the personnel engaged in a particular construction project. The environmental competences should be clearly defined along with the methods of transfer (that may range from formal education to on-site environmental training of project team members) if they are to be used in practice in an efficient manner.

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i	ENVIRONMENTAL IMPACT, i	SEVERITY INDEX, Si (expert judgement)	C env, i	CFi
1	Noise	4	7,5	30,0
2	Dust	3	7,0	21,0
3	C&D waste	3	6,0	18,0
4	Emission gases	3	5,0	15,0
5	Electricity consumption	3	4,5	13,5
6	Hydraulic oil consumption	3	4,0	12,0
7	Drinking water consumption	2	6,0	12,0
8	Waste water consumption	2	5,5	11,0
9	Fossil fuel consumption	2	5,0	10,0
10	Inert waste	2	5,0	10,0
11	Transport	2	4,5	9,0
12	Production waste	2	4,5	9,0
13	Ozone layer depletion	2	3,0	6,0

Table 2. **Case study: environmental impact assessment**

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