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ENVIRONMENTAL MANAGEMENT IN PROJECT ORIENTED COMPANIES*

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Abstract

Construction industry is a typical project-oriented industrial sector. For a contracting company, production has a project character and starts only after the contract between the client and the contracting company has been signed. Construction activities are associated with a range of various adverse environmental impacts, such as noise, raw material consumption, energy consumption, emissions into air, water and ground and fuel consumption of construction machinery. In order to control and mitigate these adverse phenomena, an environmental management system needs to be implemented into a construction company.

The paper will review the main environmental effects of the construction project. A comprehensive conceptual model that extends the concept of quality into the area of sustainability is supplemented with Environmental Impact Assessment for a given construction project. In the last part, the paper provides an overview of the implementation of environmental management systems into construction industry on the basis of a recently conducted survey.

Keywords: construction industry, quality management, environmental management, project based production

* The complete text is available on CD-ROM / Šelih, Srđić, Campos, Trierweiller

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.

Within contemporary view of the construction sector, the traditional goals related to production (i.e. scope/quality, time and cost) are supplemented first with requirements related to resource efficiency, emission control and preservation of biodiversity, and then extended to the field of ensuring environmental quality while taking into the account social equity and respecting economic effects, as schematically presented in Figure 1.

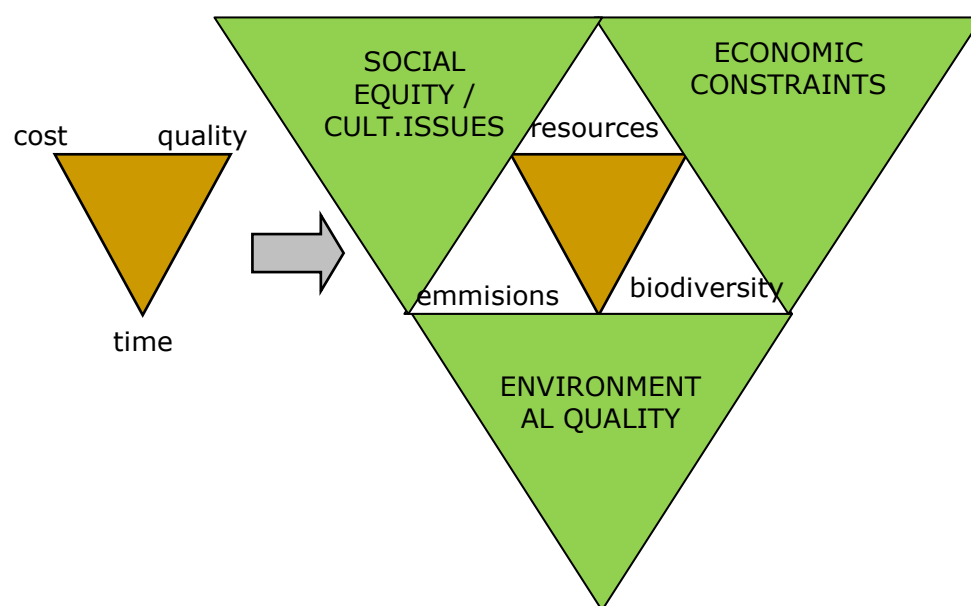


Figure 1. Extending the conventional construction project goals to the sustainability field (Agenda 21 ... 1999)

With respect to the built environment, 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)
- during construction (project and organization level)
- for the final product, i.e. the building or engineering works (structure level) (Srdić and Šelih 2011).

In the area of the built environment, the **social equity goal** can be achieved by constructing buildings and facilities that provide the required infrastructure for the local population. The results of this measure are improved public service facilities (e.g. schools, hospitals,...), and consequently general living conditions and available to the whole society, especially to the more vulnerable parts of the population. On project and organization level, social equity goal is manifested as providing appropriate working conditions, offering opportunities to the member of minority groups etc. **Cultural aspect** of sustainability, linked to the built environment, 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. Within this work, we will limit ourselves to the environmental aspect of the sustainable development in the area of construction.

1.1 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 lack of knowledge and concrete guidelines on how to efficiently implement environmental management into a construction project. Further, there is no systematic approach to define the sustainability of the structure. There is also not enough knowledge on 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.

1.2 Research objectives and methodology

The first aim of the paper is to present and justify the proposal how to extend the concept of quality and its comprehensive management in construction to the field of sustainability. 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 elaborate measures to ease the implementation of an environmental management system (EMS) into the construction contracting organisation as well as into a construction project. Emphasis is placed also to the role of organisational culture within the contracting company. Environmental Impact Assessment is to be determined for a selected project as the second goal.

The third goal is to determine the level of EMS implementation within construction industry. A web-questionnaire based survey was carried out on a sample of Slovenian construction industry, with the intention of identify the key environmental influences of the activities carried out within the construction project and their relative importance as perceived by the responding companies.

2. Extending the quality concept to sustainability performance

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 provides therefore the first assurance of conformity with the essential requirements for the structure. Construction Product Regulation (2012) provides also 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 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 on organisation level. Preferably, the QMS and EMS 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.

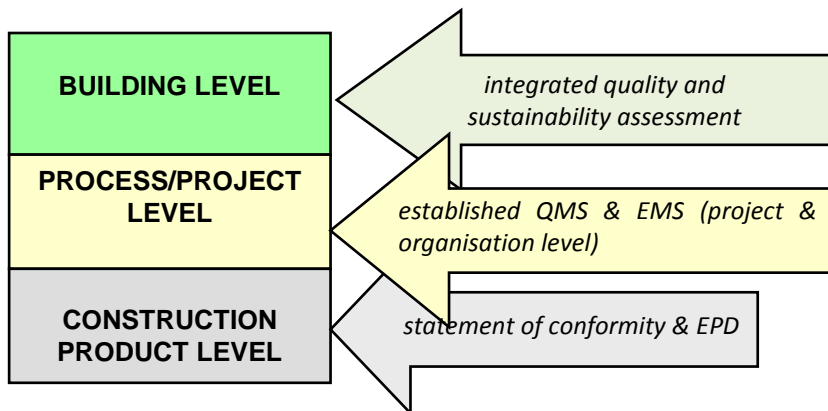


Fig.2 Levels and elements of the proposed conceptual model (adopted from Srdić and Šelih, 2011)

3. Environmental Management Systems and construction industry

This section focuses the attention to the organization and process/project level within construction, where significant environmental impacts may appear.

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, 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).

The project oriented production, characteristic for construction, manifests itself 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. In addition, several business entities are involved in the construction project:

- the client as the initiator 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 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.

The listed stakeholders differ in type of expertise, marketing strategy, number of employees, annual turnover, marketing strategy, organizational culture, the type and magnitude of environmental impacts related to their activities (Šelih 2007). Consequently, they need different approaches to environmental management within their organizations. In addition, typically, there are few business relationships of permanent nature among project participants; this, in practice, hinders efficient implementation of EMSs into the construction project.

Another barrier to successful implementation of project environmental management system within the construction project, as proposed by Srdić and Šelih (2011), is corporate culture, observed in construction enterprises that encourages conservative attitude towards introducing change and innovation into the construction project (Cheung et al 2011).

The longitudinal study of environmental professionals in construction carried out by Gluch (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, and consequently, the need for further research in this field is still present.

Further, 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 organizational 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 aimed at changing 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).

4. 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 built environment.

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 significantly smaller quantities.

Further, when a framework for environmental impacts is being defined, one should not forget to take into the account the differences designing and executing 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:

$$S_i \in [1, \dots, 5] \quad ; \quad i \in [1, \dots, n]$$

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).

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

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 2. Case study: environmental impact assessment

i	ENVIRONMENTAL IMPACT, i	SEVERITY INDEX, S_i (expert judgement)	$C_{env,i}$	CF_i
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

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

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

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

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

$$CF_i = S_i \cdot C_{env,i} \quad (2)$$

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, the researchers are in agreement that environmental management is a must for contemporary construction contracting organisation. The companies can gain significantly by combining environmental impact assessment of their activities by establishing a formal environmental management system that complies with one of the existing standards in this field, e.g. ISO 14001(2004), as discussed in the continuation of the paper.

5. Empirical study of EMS implementation in construction industry and environmental influences related to construction projects

In addition to the study of the environmental impacts related to construction activities, we are also interested in gaining an overview of the implementation of the environmental management systems in construction industry. A sample of Slovenian construction companies was surveyed, with the intention of finding out how well the environmental management systems are spread, and to which environmental areas the companies place their attention.

5.1 The method

A survey among Slovenian construction companies (Eloy Maurel, 2013) was carried out in order to determine the perceived importance of the above defined environmental indicators. The names and addresses of the 77 companies, selected for participation in the survey, were obtained from the database of Economic Chamber of Slovenia. A web-based survey was prepared and sent to these construction companies. As special attention was devoted to the identification of the person in charge of environmental management system, a reasonably high overall response rate (63,6%) was achieved.

Literature review on environmental influences related to construction projects was carried out in our previous works (Šelih, 2007) and the following list of environmental management areas was compiled:

- energy use,
- material recycling,
- waste material generation and control,
- noise prevention,
- air pollution, and
- other.

5.2 Results

Only a summary of the survey results, related to environmental management systems, will be presented in this paper. The persons filling out the questionnaire belong either to top management (22%), 32% are project managers, 12 % responsible for environmental management, and 8% of them are public relations officers. The number of employees of the majority of surveyed companies (31 out of 49 respondents, or 63%) is below 250, meaning that they can be classified as micro or small and medium size enterprises (MSMEs).

31 out of 49 (63,3%) respondents that answered question regarding environmental policy claim that they have established an environmental policy, and defined environmental goals and procedures. The companies were then asked to identify environmental management areas to which they focus to. Results presented in Table 3 show that that the area perceived as the most important is waste control; 58 % of the answering companies claim that waste control is the most important area of environmental management, and consequently place their main focus there, and 23 % consider this area as the second most important. 13% of the responding companies place the main focus to recycling of materials, while 48% of the respondents rank this area as the second most important. The third area of perceived importance is energy savings, where 35% and 48% perceive this indicator as the most, and second most important environmental area.

Table 3. Rank of importance of listed environmental areas (energy savings, recycling of materials, waste control, noise prevention, air pollution control, other)

ENV.AREA	RANK OF IMPORTANCE							Total
	1.	2.	3.	4.	5.	6.	7.	
Energy savings	11 (35%)	15 (48%)		5 (16%)	-	-	-	31 (100%)
Recycling of materials	4 (13%)	15 (48%)	7 (23%)	5 (16%)	-	-	-	31 (100%)
Waste control	18 (58%)	7 (23%)	6 (19%)	-	-	-	-	31 (100%)
Noise prevention	7 (23%)	5 (16%)	-	7 (23%)	5 (16%)	5 (16%)	2 (6%)	31 (100%)
Air pollution control	5 (16%)	11 (35%)	5 (16%)	5 (16%)	3 (10%)	1 (3%)	1 (3%)	31 (100%)
Other	4 (100%)							4 (100%)

Analysis of subsequent questions and corresponding answers shows that 64 % of the companies answering the questionnaire have implemented an ISO 14001 compliant environmental management system. 23% have established another type of EMS, and only 10% of the respondents do not have an EMS. 79% of the respondents claim that their EMS is integrated with the existing quality management system (QMS).

6. 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 assessment impact, being a part of this model, can be used also on construction site level, thus improving the environmental performance on this level. When supplemented it with the use of relevant Environmental Product Specifications for the construction products being built in the structure, and appropriate process standards, the model can be used for the assessment for the selected structure. The results of the presented study on implementation of environmental management systems in Slovenian construction industry shows that the EMSs are already reasonably spread within this sector, however more systematic effort should be devoted to the their implementation, in particular in the area of organisational culture.

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