The variant of Construction Projects and their Assessment Taking into Account the Impact on the Environment

Elzbieta Szafranko

1University of Warmia and Mazury in Olsztyn, Faculty of Geodesy Geospatial and Civil Engineering, Institute of Building Engineering, ul. Heweliusza 4, 10-724 Olsztyn, Poland
elasz@uwm.edu.pl

Abstract. The construction of various types of buildings and engineering structures invariably interferes, although to different degrees, with the surrounding environment. Every development project is executed in a strictly delineated area and under specific conditions. While planning a construction project, the investor is obligated to analyse several variants of its execution, including an assessment of different effects it may have on the environment. The investor can evaluate the impact on the surrounding ecosystems, in its various manifestations, both during the construction works and after a given building or a structure which has been put to use. Adhering to the latest trends, an assessment of the environmental impact caused by buildings and engineering structures should account for a whole life cycle of an object. Special attention should be paid to the process of obtaining natural resources and manufacturing building materials as well as the time period over which the latter will be used. Not less important for the environment is the moment when a building’s useful life ends, i.e. how it is demolished and how the construction and demolition waste is recycled or disposed of. The author’s studies have demonstrated that assessments of variant solutions made in construction engineering practice are very rarely based on criteria that encompass the whole life cycle of a building. This article presents an analysis of the current situation based on data extracted from reviewed documentation originating from several construction projects.

1. Introduction

In the construction sector, an ecological approach is most often understood as a course of action that does not do harm to the environment. It is expected to be eco-friendly at all stages, from planning a development project, through making a design, raising a building and during its useful life, to the final stage, when it is deconstructed or demolished (Figure 1). An ecological approach in construction involves the establishment of such standards and guidelines which will promote buildings and engineering structures erected and utilized with the least environmentally harmful components throughout their whole life cycle [1, 2]. To this end, for example, it is recommended to use more environmentally friendly materials, to reduce energy consumption, and to restrain the negative impact on the environment and on the land adjacent to a given building site. Actions which comply with the ecological approach in the construction industry pertain to many aspects, such as the selection of an appropriate building site, avoidance of noxious and harmful materials both while raising and using a building as well as after its demolition [3], the reduction of emission
of harmful substances during the useful life of a building, and reduction of the consumption of energy during construction works and afterwards, when a new building is put to use [4].

2. Problems of the impact on the natural environment produced by buildings and building structures

The first group of effects that occur as early as the stage of planning a development project comprises the right location. At this step, we analyze such solutions which will make the slightest intrusion into the valuable ecosystems. The following are analyzed: details of naturally valuable areas, protected areas, and even the number of trees which will have to be cut down because of the planned development [5, 6].

At the stage of designing a building, decisions on construction details, technological solutions and building materials are made. The accepted plan of a building or a structure will be pivotal to the possible noxious effects generated by the construction works and throughout the building’s lifespan. Building materials thought to be environmentally friendly include natural raw materials. Wood and other plant materials such as straw, bamboo, natural stone, and metals as well as recycled used materials are considered to be ecological ones. The Environmental Protection Agency (EPA) supports environmentally sound recycling of industrial waste, e.g. coal combustion residuals, welding sand or building rubble. Building materials should be extracted and manufactured near a building site so as to minimize the consumption of energy needed to transport them [7, 8]. Also, whenever possible, building elements should be manufactured outside a building site and then transported to their destination in order to maximize the benefits derived from their industrial production (including maximum reduction of waste, recycling, manufacture of high quality elements, limiting the noise and emission of dust). During the construction activities, one of the priorities should be to decrease quantities of materials disposed of in landfills.

In general, large amounts of waste are generated after the buildings have reached the end of their lifespan, i.e. during the deconstruction of buildings as well as during their refurbishment, renovation or
reconstruction. Natural building materials can be salvaged and reused, but even if they are disposed of they will not be a threat to the natural environment. By selecting appropriate materials and using zero-waste technologies, it is possible to conserve the landfill space and reduce the raw energy demand [8, 9, 10].

An important aspect of raising buildings and building structures is the ability to limit the negative effects of a given development project on the environment during its construction and long-term exploitation.

3. The research method and identification of the assessment criteria
Several criteria can be distinguished among the factors applied to assess ecological aspects of construction projects. These parameters may pertain to direct and indirect impacts of an investment on the natural environment.

3.1 Determination of the assessment criteria in the whole life cycle of a building
Compliant with the guidelines for the life cycle impact assessment of buildings, the following criteria were distinguished:

1. The stage of preparing a development project
   - economical use of natural resources – protection of fossil resources, use of renewable resources, use of recycled materials;
   - avoidance of hazardous chemical or biological contamination – minimizing toxic emissions to the environment at the manufacturing stage, an absence of risk during the production of building materials and once they have been incorporated in a building, positive influence on human well-being and health;
   - saving energy – reducing energy inputs to production, transport and processing, energy optimisation of the production process;
   - the use of materials which will limit the building’s demand for energy (e.g. Styrofoam thermal insulation);
   - evaluation of the durability of materials – high durability of materials, minimising repairs, recyclable materials;
   - salvage of building materials, possible recycling – easy disassembly or deconstruction, recyclable materials;
   - safe disposal of waste, minimising amounts of waste and avoiding the need to set up special landfills, minimising the waste of materials during construction works;
   - selection of a safe site, avoiding naturally valuable areas;
   - occupational safety and health provisions included at the stage of planning;
   - determination of the number of trees to be felled.

2. The stage of conducting construction work
   - resourceful use of space – protection of natural areas adjacent to a construction site;
   - economical use of raw and building materials;
   - construction works carried out inclusive of eco-friendly processes – the reduction of emissions harmful to the environment;
   - implementation of energy-saving technologies;
   - reducing the transport of materials the construction site to the necessary minimum.

3. Stage of the exploitation of a building or building structure
   - reducing the emission of wastewater, sewage and municipal waste;
4. The demolition process,

- demolition can be accomplished in a safe manner;
- construction and demolition residuals can be sorted out, which allows their recycling or reuse;
- salvage and recovery of materials, possible recycling – ease of disassembly or deconstruction, possible reuse of some items or materials;
- safe disposal of waste, minimum quantities of waste stored under ordinary conditions, without the need to create special landfills, minimum amounts of waste when reusing materials for construction.

Moreover, all the analyses of variants of a planned building or a building structure comprise universal criteria considered at the stages of preparation for a development project, its execution and exploitation of a new building or structure, such as: suitable location, transecting or interfering with watercourses, encroachment on valuable nature areas, parts of habitats that might be damaged due to the planned development, disruption of animal migratory routes.

3.2. Identifying the scope of the research

Pursuant to the binding European Union directives, the seventeen public purpose development projects which were chosen for the research were required to have variant plans developed and analysed with respect to their impact on the environment. The documentation prepared for each project was studied and analyses were made regarding the application of assessment criteria based on the life cycle impact of the planned buildings or building structures.

4. Research results

In order to analyse the documentation including variant plans of the tested development projects, an evaluation form was designed, in which the most pertinent criteria, essential for making a complex assessment, were included. These parameters are presented in table 1.

The study took into consideration the most important assessment criteria derived from an analysis of the life cycle of buildings. Out of the parameters connected with the stage of preparing an investment project, the ones associated with the preparation of materials and economical use of raw materials are hardly ever used in practice. The criteria connected with the requirements imposed on the applied materials are not included either at the stage of the performing construction activities. However, the factor which appeared in all the analysed proceedings was the number of trees selected to be felled.

The criteria which were applied most frequently in all the analysed cases were the ones related to the lifespan of a building and its demolition as well as the universal criteria from the group termed as ‘other criteria.’ More detailed data were illustrated in Figure 2 and 3.
Table 1. The frequency of occurrence of environmental criteria in the studied documents

| No | Stage | Evaluation criteria                                                                 | Criteria no | Frequency of occurrence |
|----|-------|-------------------------------------------------------------------------------------|-------------|-------------------------|
| 1  | The stage of preparing a development project | economical use of natural resources                                                | 1.1.        | 0                       |
|    |       | reducing energy inputs to production, transport and processing, energy optimization of the production process | 1.2.        | 0                       |
|    |       | evaluation of the durability of materials                                          | 1.3.        | 3                       |
|    |       | salvage of building materials, possible recycling                                 | 1.4.        | 5                       |
|    |       | selection of a safe site, avoiding naturally valuable areas                         | 1.5.        | 7                       |
|    |       | determination of the number of trees to be felled                                   | 1.6.        | 17                      |
| 2  | The stage of conducting construction work                                           | economical use of raw and building materials                                       | 2.1.        | 0                       |
|    |       | construction works carried out inclusive of eco-friendly                            | 2.2.        | 5                       |
|    |       | reducing the transport of materials to the construction                             | 2.3.        | 0                       |
|    |       | protection of the nearest natural environment,                                      | 2.4.        | 10                      |
| 3  | Stage of the exploitation of a building structure                                    | reducing the emission of wastewater, sewage and municipal waste                      | 3.1.        | 14                      |
|    |       | reducing the consumption of electric and thermal power                              | 3.2.        | 16                      |
|    |       | using durable materials, which do not require frequent repairs                      | 3.3.        | 7                       |
|    |       | making any refurbishment using modern, eco-friendly materials                       | 3.4.        | 5                       |
|    |       | using existing buildings as long as possible, taking care of existing buildings     | 3.5.        | 15                      |
| 4  | The demolition process.                                                              | demolition can be accomplished in a safe manner                                      | 4.1.        | 3                       |
|    |       | construction and demolition residuals can be sorted out, which allows their recycling or reuse | 4.2.        | 8                       |
|    |       | salvage and recovery of materials, possible recycling                               | 4.3.        | 9                       |
| 5  | Others                                                                             | suitable location                                                                    | 5.1.        | 12                      |
|    |       | transecting or interfering with watercourses,                                       | 5.2.        | 15                      |
|    |       | encroachment on valuable nature areas                                              | 5.3.        | 16                      |
|    |       | possibility of destroying natural habitats                                          | 5.4.        | 17                      |
|    |       | disruption of animal migratory routes                                              | 5.5.        | 15                      |
5. Conclusions
An assessment of the impact of the planned projects in construction is essential. The most recent approach which recommends making an assessment of impact based on the whole life cycle is slowly being adopted in practice. The above study has demonstrated that the most frequently applied parameters are the ones that evaluate the location of a development project, including nature protection issues, as well as those which are connected with the energy-saving exploitation of the new buildings. The criteria which seem to be most difficult to implement in practice are those which measure the economical use of the eco-friendly materials and their production.
It is worth noticing that in all the cases, there were criteria from different stages in a building’s life cycle. The research has also confirmed a great interest in the application of assessment criteria to evaluate the impact of variant plans of a development project on nature, as well as a certain readiness to adapt new parameters in such assessment procedures.

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