Managing sustainable construction
– a steering model for the building process

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1. INTRODUCTION
A large part, about 40% according to Rees (1999), of the Earth’s turnover of resources is associated with buildings and building construction. But this is not only a question about natural recourses; human resources and economic, social and cultural considerations are also involved.

A complex relationship must therefore be taken into consideration when realizing construction projects, since economic and social aspects also affect individual people. A major part of the decisions that affect the final building are made in the building process quite a long time before the building is finished. In order to gain an overall perspective on this relationship during the building process, one solution is to adapt the concept of sustainable development to the construction sector in order to produce sustainable construction, and to steer the building process in this direction and to find the main thread of the sustainability aspects of the project.

The purpose of this paper is to propose a model for steering the building process in the direction of sustainable construction. The work has been carried out in the form of a control model that has later been evaluated in case studies. The paper refers mainly to the Swedish construction sector, but it would be possible to adapt the model to the local urban conditions of other industrial countries. Some of the main conditions of the model would probably have to be modified in order to adapt it to other types of local conditions.

2. SUSTAINABLE CONSTRUCTION
The terms sustainable development and sustainable construction are relatively new in the construction sector. These terms have no simple definitions and confusion in understanding them is quite common in the sector. According to Agenda 21, sustainable development involves three main factors: ecological, economic and social development. According to Barrow (1997) it is necessary optimize these three main factors in order to achieve sustainable development. Kohler (1999) defined sustainable building in terms of these three factors.

Using Kohler’s model as a base, Persson (2001) produced an extended definition of sustainable construction including aspects of the urban areas of the industrial countries, actual legislation, the terms of Factor 10, the demands of the local markets and individual human rights of democratic influence.
3. THE URBAN MODEL

Attention must be paid to the issue of sustainable construction in all the decisions arising out of the complex web of considerations associated with a common construction project. Another obstacle to understanding is that sustainable development and sustainable construction are cross-disciplinary issues concerning all the players involved in the building process. It is easy to hand over a specific question to the next person in the chain of decision makers without formulating any reason, the "solve one site" syndrome. As the project continues, all the project frames are set without addressing the issues of sustainable construction until it is too late for sustainability considerations. As the major part of the final cost of a construction project is set in the initial phase of the building process (Söderberg and Hansson 1993), the major part of the environmental and sustainability impact of the project is also fixed at the same time (indicated by Reed and Gordon 2000). As the building process continues, the decisions made have less effect of the final cost and the final environmental/sustainability impact of the project.

The following model, the urban model, is proposed for controlling the building process according to the principles for sustainable construction for the urban areas of industrial countries. Its purpose is to create a main thread of sustainability priorities throughout the building process. The model is intended to optimize the sustainability goals and targets of the property owner’s organization and of the specific conditions, related to the site and to the purpose, of the actual construction project. The urban model is one aspect of the complete construction management process.

3.1 Structure of the urban model

The main structure of the urban model consists of a verifiable sustainability programme, which is set as early as possible in the process. The model includes measurable requirements, which are given priority from an environmental and sustainability point of view. Figure 1 shows the principle of the model and the main information flow. The model is not supposed to be static with all its requirements fixed at the programme stage. The function of the model is to be dynamic and to allow requirements to be changed as decisions and conditions changes during the building process. After the end of the project, the model supports the planning of maintenance and could be used as a base of sustainability information for users and tenants. The model has to be compatible with the environmental management system of the property owner’s organization.

The principle of the urban model can be described by three main boxes, containing the specific conditions for the project, the general conditions of the property owner’s organization and the sustainability programme for the project. The last-mentioned box act as a synthesis of the two first-mentioned and its concepts correspond to the environmental management standard of EN ISO 14001 (1996).

The specific conditions for the project contain parts of the sustainability review, significant sustainability aspects and documented decisions made during the building process.

The sustainability review is a review of the conditions specific of the site and surroundings of the building described in ecological, economic and social terms. With the sustainability review as a base, an evaluation of sustainability impacts is done, and significant sustainability aspects are set. The process of documenting decisions during the building process changes the
conditions for the final product - the building - and the conditions for sustainability targets on a continuous basis.

**Figure 1** The principle of the urban model.

The general conditions of the property owner’s organization include the project-related conditions, which are directly linked to the organization and its way of working. A main condition is the property owner’s *environmental policy* and *environmental management system*, containing environmental objectives and the relevant parts of environmental targets. The general conditions of the property owner’s organization also include conditions from
relevant general descriptions, standard solutions and standard blueprints according to the activities of the organization.

The sustainability programme for the project, which is a result of an analysis and of prioritizing the specific conditions of the project and of the general conditions of the organization, consists of three main parts: the sustainability objectives, priority of the sustainability objectives and the sustainability targets.

The sustainability objectives for the project depend on the environmental policy of the organization and the significant sustainability aspects of the sustainability review. This main part decides the direction of the project in a sustainability point of view; it formulates the main thread of the project as regards sustainability.

Priority of the sustainability objectives is a relative order of preference of sustainability objectives because of preparation for forthcoming relative conflicts and to meet other forthcoming demands of the project.

The sustainability targets are sustainability objectives in detailed and measurable units at levels from those of the system to those of single components. The methods of verification of the measurable sustainability targets are also established. It is possible to adjust the sustainability targets during the building process with confirmation in connection with documented decisions.

A plan of sustainability checks is drawn up by all players involved in the project, based on the verifiable sustainability targets. The aim is to verify all the sustainability targets according to the methods mentioned in the sustainability programme for the project. Divergence and change of verification are a part of the documented decisions. The plan of sustainability checks is a part of the plan of quality checks.

The sustainability programme for the project and the verifications according to the plans of sustainability checks act as the basis of the final documents for the project together with other documentation related to the project. From the final documents, sustainability information for the project is able to find its way to the property owner’s organization for operation and maintenance, to users and to tenants, according to the organization’s environmental management system.

The property owner’s organization for operation and maintenance exerts influence on the project through documented decisions based on its experience of operation and preventive maintenance. It is important to have continuous dialogue between users/tenants and the property owner during the process. In this way the users/tenants can influence the sustainability targets.

The international standard for environmental management system, EN ISO 14001 (1996), is the basis of the main structure and the terms of environmental (sustainability) objectives and environmental (sustainability) targets. If the organization uses this standard for environmental management, it will find it easier to apply the model when it comes to environmental objectives, environmental targets and to adapting the final project to the organization’s way of operating the building.
3.2 Case studies
Persson (2001) tried the urban model in three case studies. One study concerned "Futurum", a general concept for the green building of apartments in urban areas by Riksbyggen and Lund Institute of Technology. One study concerned a new commercial building, an office, "Tyrenshuset" by Whilborgs and Tyréns, Malmö, Sweden. The third study related to a major maintenance project for apartments by LKF, Lund, Sweden. Figure 2 shows the significant sustainability aspects as a result of the case studies.

4. CONCLUSION
The results of the case studies indicate that a sustainable construction requires optimization of the general significant sustainability aspects of ecological design, relevant rent for the users/tenants, low operating costs, co-operation between the property owner and the users/tenants and finally a well documented risk analysis of the indoor environment.

The procedure for steering construction in a sustainable direction depends on the specific nature of the construction project itself. The main aspect of sustainable construction is to steer the construction process from an overall perspective with respect to the level of sustainability potential that the property owner is able to achieve, the specific conditions for the project and the level of the organization’s environmental management system. The urban model has the potential to make the environmental objectives of the organization accord with the sustainability objectives of the specific construction project and with the environmental objectives of the operational organization. Coupling these factors together with a sustainable building process ensures that the organization’s demands for continual improvement is met and that the project’s ecological, economic and social aspects are optimized.
The urban model needs to be improved to make it an easily managed, project-flexible and user-friendly tool. The model also needs to be evaluated in more case studies of different types of construction projects.

5. REFERENCES


