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A FRAMEWORK FOR THE ATTAINMENT OF SUSTAINABLE CONSTRUCTION

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Introduction

Theorists and practitioners in the fields of development and conservation are giving increasing recognition to the interconnectedness of these specialities. Developers are beginning to realize that many of the natural resources available to humankind are finite, and should be conserved or used wisely. Similarly, conservationists are starting to recognize that attempts to secure the objectives of conservation will be futile in a world ravaged by poverty.

Development efforts which seek to address social needs while taking care to minimize potential negative environmental impacts have been called "sustainable development". This term was introduced by the "World Conservation Strategy", which was published in 1980 by the International Union for the Conservation of Nature and Natural Resources (IUCN, 1980). More than a decade later, in 1991, the same organization, now called the World Conservation Union, proposed a strategy for sustainable living entitled "Caring for the Earth". This document provided a number of definitions for the use of the term "sustainable". The authors of that document pointed out that the concept of sustainable development had been open to a wide range of interpretations, many of which were contradictory.

At this "First International Conference on Sustainable Construction", it would seem appropriate to summarize the evolution of the term "sustainable" within the context of the environmental movement, and to propose a practical framework for the attainment of this concept in the construction industry. The purpose of this paper, then, is to: outline the evolution of the concept of sustainable development; advance understanding of the concept of sustainable construction; enunciate principles to be upheld in order to attain sustainable construction, and, propose a practical framework for the attainment of sustainable construction.

Evolution of the concept of sustainable development within the environmental movement

The concept of sustainability was probably intuitively understood by early human civilizations such as the South African Bushmen. These hunter-gatherer people recognized the importance of utilizing the resources provided by nature on a sustainable basis and had practical experience of the fact that humans are dependant on the Earth's life support systems for survival (Van der Post, 1984). The World Commission on Environment and Development (WCED) observed that, while modern cultures have only now begun to search for sustainable forms of development, traditional cultures have practised sustainable resource use for millennia (WCED, 1987).

Over the course of this century, the rapid advance of scientific and technological knowledge has provided humankind with the power to drastically alter planetary systems. This new found power, together with increasing human numbers, has led to the excessive exploitation of renewable natural resources such as fish, wildlife and forests. There is growing scientific consensus that vast stocks of biological diversity are in danger of disappearing just as science is learning how to exploit this diversity through genetic engineering (WCED, 1987). Scientific and technological advances have also led many people in industrialized societies to become overly confident in the capability of technology to find substitutes for non-renewable natural resources depleted through over-exploitation.

By the middle of this century, people were starting to question the capability of the earth to sustain the affluent lifestyle of the developed world. This questioning was based on the view that technology, far from providing answers to the issues facing society, was actually responsible for the escalation of environmental degradation. Writers such as Leopold (1949) and Carson (1962) called for people to embrace a lifestyle which showed more consideration for the environment and which sought to reduce the environmental impacts caused by material- and energy-intensive development. Such writers sowed the seeds of the environmental movement by advocating qualitative forms of development which gave precedence to spiritual and psychological needs over material wants, the so-called "post-materialistic society" (Gardner, 1989).

In the developed world, public concern for the environment increased throughout the decade of the 1960s, and the first Earth Day was celebrated in April 1970 in Vermont, United States of America (Fuggle *et al.*, 1992). International concern was reflected in the United Nations Conference on the Human Environment which was held in Stockholm in 1972. The idea of ecodevelopment emerged from this conference as "an approach to development aimed at harmonizing social and economic objectives with ecologically sound management" (Sachs, 1978, in Gardner, 1989). Ecodevelopment was the precursor of the concept of sustainable development.

In the same year as the Stockholm Conference, the Club of Rome published "Limits to Growth", a document which emphasized that concerns about pollution, environmental degradation and natural resource depletion were crucial to the long term future of humanity (Stockdale, 1989). The limits-to-growth perspective challenged the pro-growth perspective of the previous decades, and, because this threatened important ideas and interests, reactions were intense. A synthesis of these conflicting perspectives eventually emerged in the perspective of sustainable development (Stockdale, 1989). This synthesis may be more usefully described as a continuum of perspectives in the middle ground between the extremes of the limits-to-growth perspective and the pro-growth perspective. Differing perspectives of sustainable development have been grasped by both the environmental pessimists and the technological optimists as a way to bolster their respective viewpoints. This clearly illustrates that the concept of sustainable development is value laden and is given different meanings by different groups.

In the 1970s, the practice of nature conservation still largely embraced a preservationist philosophy, which held that nature could and should be conserved within the neatly demarcated boundaries of conservation areas. Development and conservation were seen as two ideals which were in direct conflict with one another. In 1980, the International Union for the Conservation

of Nature and Natural Resources (IUCN) published the "World Conservation Strategy" (IUCN, 1980). The Strategy marked a significant shift in the way of viewing conservation which changed and, given the theme of this conference, is still changing the practice of development.

The emphasis in conservation was shifted from focusing solely on the practice of fencing off nature reserves to viewing conservation and development as integrated concepts. The Strategy defined development as "modification to the biosphere to satisfy human needs", and conservation as "the management of human use of the biosphere to yield the greatest sustainable benefit to present and future generations". Development and conservation were seen as both relating to human use of the biosphere. The goal of the Strategy was the integration of conservation and development to ensure that modifications to the planet secured the survival and well-being of all people, both now and in future (IUCN, 1980).

On a practical level, the "World Conservation Strategy" translated a concern for the conservation of life support systems, ecological processes and genetic diversity into priorities for action. The priority requirements for the conservation of genetic diversity were founded on the notion of the "Genetic Management Iceberg", which has important implications for the concept of sustainable construction. The Strategy used the iceberg to illustrate that efforts to conserve biodiversity in zoos, botanic gardens, seed and sperm banks and even in National Parks and nature reserves only reflect the tip of the iceberg, and that, if one wants to make a meaningful contribution to conserving genetic diversity and ecological processes, one should also focus efforts on the bulk of the iceberg, hidden beneath the sea, which represents areas outside of conservation management - the areas where most construction projects are implemented. In these areas, the Strategy urged that all development should aim to achieve "sound planning, allocation and management of water and land uses" (IUCN, 1980). The message was that development and construction activities can make an important contribution to the conservation of biodiversity by applying environmental management in the execution of projects.

In 1987, the World Commission on Environment and Development (WCED) again highlighted the notion that environmental degradation and the need for development are closely interrelated, particularly in underdeveloped nations. In a publication entitled "Our Common Future" (WCED, 1987), which is referred to as the "Brundtland Report", the Commission stated that the essential needs of vast numbers of people were not being met, and warned that a world where poverty and inequity were endemic would be prone to ecological and other crises. The publication described the concept of sustainable development as meeting the basic needs of all people and extending to all the opportunity to satisfy their aspirations for a better life without compromising the ability of future generations to meet their own needs. In contrast to the limits-to-growth perspective, sustainable development placed more emphasis on the social and economic goals of society, particularly in the developing countries, but stressed that the attainment of these goals was interconnected with the achievement of environmental goals.

Although the concept of sustainable development was now firmly entrenched within the environmental movement, debate continued on appropriate definitions for, and uses of, the concept. For instance, some felt that the term "sustainable development" was, in itself, a contradiction. "Sustainable" means something which can continue indefinitely, and it was questioned whether development could be conceptualized in this way.

One attempt to define the meaning of "sustainability" was proposed by resource managers in the term "sustainable utilization" of natural resources. However, in response to this notion, the question was raised as to how non-renewable resources, such as oil and minerals, could be exploited on a sustainable basis. As these resources can not be renewed in the short term, the reserves will at some stage become depleted. The term "sustainable utilization" was deemed, therefore, to be limited in applicability to renewable natural resources, for example, to water resources, plants and animals, and implies using them at rates within their capacity for renewal. The practical application of this term to renewable resources still raised a number of concerns, such as how to determine when a resource is being used on a sustainable basis, and who makes the decision as to whether exploitation is sustainable or not.

The list of definitions for the concept of sustainability expanded as more disciplines entered the terminological debate. Economists called for a "sustainable economy", agriculturalists for "sustainable harvests" and sociologists for "sustainable societies", but consensus on the definition of the term "sustainability" could not be achieved. In the 1991 update to the World Conservation Strategy, called "Caring for the Earth", the World Conservation Union stated that the term "sustainable development" had been criticized as ambiguous and open to a range of interpretations, many of which were contradictory. The authors suggested that this was because the term had been used interchangeably with "sustainable growth". They stated that sustainable growth is a contradiction in terms because nothing physical can grow indefinitely. "Caring for the Earth" defined "sustainable development" as development which "improves the quality of human life while living within the carrying capacity of supporting ecosystems".

The operationalization of this concept remains contentious because of difficulties in determining the "carrying capacity of supporting ecosystems" and difficulties in identifying the actions undermining ecosystems. Accusations between the nations of the North and the South over who is overextending the carrying capacity of local and global systems have become habitual, and formed the topic of heated debate at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro.

A comprehensive and "an almost practical step toward sustainability" was proposed by the economist Solow (1993). Solow argued that development will inevitably cause at least some drawdown of current stocks of non-renewable resources, and that sustainability should mean more than just the preservation of natural resources. To maintain the capacity to meet the needs of future generations, concern is required for society's total capital, taking into account the substitution possibilities between natural and other forms of capital. Solow proposed that fairness towards future generations requires that some of the proceeds from the exploitation and depletion of non-renewable resources should be invested in other assets, which could include human or physical capital (e.g., education and factories), to maintain productive capacity (Solow, 1993). Solow introduced the concept of sustainable income which is the Gross National Product (GNP) minus the depreciation on physical and natural capital. He proposed that "the level of sustainable income could go up from one generation to another if the earlier generation protected its environmental assets, consumed few non-renewable resources and invested a great deal in new productive capacity for the future" (Solow, 1993).

Solow's contribution to the elusive concept of sustainability does not mean that all other notions of sustainability should be disregarded in future debates on the topic. The divergence of opinions relating to the term proves that "sustainability" is so broad an idea that a single definition can not adequately capture all the nuances of the concept. It is probably true that the dichotomy of the development/environment debate in the 1970s and the 1980s has been replaced by a sustainable development synthesis, in that there is general agreement that uncontrolled exploitation of natural resources is not beneficial to humankind in the long term. Within that synthesis there is room for the differing perspectives of economists and conservationists.

Advancing understanding of "sustainable construction"

Having discussed, albeit briefly, the evolution and uses of the term "sustainability", the purpose of this section of the paper is to discuss the concept of sustainability within the construction industry and to advance an understanding of the term "sustainable construction".

The term "sustainable construction" was originally proposed to describe the responsibility of the construction industry in attaining "sustainability" (personal communication, 6 December 1993, Dr Charles Kibert, University of Florida, Gainesville, Florida). It is inevitable that the term "sustainable construction" will initiate a number of semantic problems. When one considers that the IUCN (1991) described a sustainable activity as one which can continue forever, it is clear that a construction project can not fall within the category of sustainable activities. Thus, the various definitions of sustainability hitherto proposed need to be examined in an attempt to find common ground between the ideals of "sustainability" in general and those of "sustainable construction" in particular.

The concept of sustainability proposed by Solow (1993) is of great value in understanding the concept of sustainable construction. While accepting that some depletion of non-renewable resources is inevitable when development is undertaken, Solow suggests that sustainability is concerned with the substitution of natural to human and physical capital. As the construction industry is constantly involved in this substitution, it is feasible to describe the industry as involved in operations which could be termed "sustainable" when interpreted in terms of Solow's explanation.

The definition of "sustainability" proposed by the IUCN (1991) also indicates an area of overlap with the goals of the construction industry. The IUCN stated that "sustainability" deals with the improvement of the quality of human life within the carrying capacity of supporting ecosystems. Construction is largely involved with improvement of the quality of human life, and, if it could demonstrate a responsible approach towards operating within the carrying capacity of supporting ecosystems, the ideals of "sustainability" could feasibly be attained from both an economic and environmental perspective.

Progress towards the goal of sustainability will, however, not be reached if terminological debates are not transformed into action by each discipline. What is required is action towards the common goal of managing human and environmental capital to maintain the capability of satisfying the needs and aspirations of both present and future generations (Fuggle *et al.*, 1992).

Principles of sustainable construction

This section of the paper outlines a number of key principles which must be upheld by the construction industry in order to attain sustainability. These principles have been derived for the practice of construction from general principles for sustainable development and sustainable living, and are listed below.

Economic and Social principles of sustainable construction

* Improve the quality of human life by ensuring secure and adequate consumption of basic needs, which are food, clothing, shelter, health, education, and beyond that by ensuring comfort, identity and choice (Yap, 1989).

* Ensure that development planning makes provision for social self determination and cultural diversity (Gardner, 1989), that the construction process minimizes social disruption, and that the operation of the development (after the construction process is complete) is compatible with local human systems and technology (Yap, 1989).

* Ensure that the social costs of construction are fairly or equitably distributed and, where this is not achieved, determine fair compensation for people adversely affected by construction operations.

* Ensure that the social benefits of construction are equitably distributed and, where this is not achieved in the intended use of the product or output of construction, seek to optimize benefits which arise during the construction process, such as employment opportunities.

Environmental principles of sustainable construction

* Maintain the Earth's vitality and ecological diversity, through:

    - conserving life support systems, which are the ecological processes which shape the climate, cleanse air and water, regulate water flow, recycle essential nutrients, create and regenerate soil and enable ecosystems to renew themselves

    - conserving the biodiversity of plants, animals and other organisms, the range of genetic stock within each species, and the variety of ecosystems

    - minimizing damage to renewable resources such as soil, wild and domesticated organisms, forests, rangelands, cultivated land, and the marine and freshwater ecosystems that support fisheries (IUCN, 1991).

* Minimize the use of energy, raw materials and specifically non-renewable resources. While non-renewable resources can not be used sustainably, their "life" can be extended by reducing their use in product manufacture, reusing a product a number of times rather than discarding after using once, recycling of the resource at the end of the usable life of the product, and switching to renewable substitutes where possible (IUCN, 1991).

* Minimize the risk of air, land and water pollution caused by construction operations, including noise, odor, dust, vibration, chemical and particulate emissions, and solid waste pollution.

* Minimize visual damage to scenically sensitive areas by landscaping and revegetating areas affected by construction, and avoiding intrusion into wilderness areas.

Process oriented principles of sustainable construction

* Ensure that environmental assessment and management of construction is: guided by predetermined environmental goals; undertaken using a systems approach which recognizes the interconnections between economics and the environment; adaptive in nature, in seeking to manage through monitoring, feedback and self-regulation of progress, and, interactive, in promoting transdisciplinary collaboration and partnerships between government, industry, non-government organizations and the general public (Gardner, 1989).

While this list is not exhaustive, it does serve to indicate the key principles that should be applied to ensure sustainable construction.

A framework for the attainment of sustainable construction

Where previous sections of this paper have developed the concept and principles of sustainable construction (the "what"), the following sections present a comprehensive framework for the attainment of sustainable construction (the "how to"). The process oriented principles listed in the previous section can be satisfied in the implementation of the proposed framework, which consists of two parts, to be applied at the planning and design stages of a project, and during construction. Sustainable construction can be achieved by:

- applying the South African procedure for Integrated Environmental Management (IEM), or an equivalent Environmental Assessment procedure, during the planning and design stages of projects, and,

- implementing an Environmental Management System (EMS) as described in the Code of Practice prepared by the South African Bureau of Standards, SABS 0251:1993, or an equivalent such as the British Standard, BS 7750:1992, during project construction.

The remainder of this paper outlines the role of both IEM and EMS in achieving sustainable construction, with emphasis on the role of EMS during construction. This framework is used to evaluate the implementation of Environmental Management Systems during the construction process of three South African civil engineering projects in another paper (Hill *et al.*, 1994).

The South African Integrated Environmental Management Procedure

In the planning and design stages of projects, sustainable construction can be achieved by applying the principles and procedure of Integrated Environmental Management (IEM), the South African equivalent of Environmental Assessment (EA). The IEM procedure was

"designed to ensure that the environmental consequences of development proposals are understood and adequately considered in the planning process. ... The purpose of IEM is to resolve or mitigate any negative impacts and to enhance the positive aspects of development proposals." (Department of Environment Affairs, 1992).

The IEM procedure makes provision for an Environmental Assessment to: identify potential impacts, resulting from actions at each stage of the project life cycle; evaluate alternatives, in order to identify the preferred option at each stage, and, formulate mitigating measures to reduce impacts and develop compensation plans for residual impacts which can not be mitigated to insignificance.

A comprehensive traditional EA would evaluate alternatives for the sourcing of certain materials, such as the siting of quarries for stone aggregate, but would be unlikely to consider the life cycle environmental costs of most materials and products used in the construction process. The traditional EA could be expanded to consider life cycle assessment of alternative materials and products which could be used in the construction process. The results of such a life cycle assessment should influence the purchasing specifications for materials and products to be used. The approach and methods of EA should also be applied, not only when evaluating siting, design, and material and product alternatives, but also during the stage when the planning and formulation of construction activities is undertaken. For instance, the choice of site for a concrete batching plant should be subject to the same rigor in assessing alternative sitings as is the case for the structure to be constructed.

After the EAs at each stage of planning and design are complete, the IEM procedure stresses the importance of formulating environmental management plans and the drawing up of an environmental contract to ensure implementation of the management plan, during project construction, operation and, where appropriate, even decommissioning. The IEM procedure provides few details as to how this should be done, and this is where the SABS Code of Practice for Environmental Management Systems is more helpful.

Environmental Management Systems applied to construction

Environmental Management Systems (EMS) provide a comprehensive framework for achieving sustainability during the construction stage of projects, provided this is preceded by an EA in the planning and design stages. This paper draws on the "Code of Practice for Environmental Management Systems" published by the South African Bureau of Standards (SABS, 1993). In the preface to this Code of Practice, the SABS acknowledges the valuable assistance derived from "Specification for Environmental Management Systems", published by the British Standards Institution (BSI, 1992). In South Africa, most formal EMS have been implemented by large industrial and business organizations. Although the SABS Code of Practice may not have been used as a guide in the development of the relatively embryonic EMS which have been implemented in a few major South African construction projects, the Code nevertheless provides a comprehensive checklist which should improve the practice of environmental management of construction.

The components of a generic EMS are presented in simplified form in Figure 1. In order to ensure implementation of environmental management during a construction project,

these components should be documented as requirements in the contract specifications and bills of quantities. In this paper, these EMS components are grouped under four key requirements for the sake of improving clarity. The purpose of this section of the paper is to outline these key requirements of Environmental Management Systems.

The first key requirement in developing an EMS for the construction stage of a project is to determine an environmental policy to judge all the activities which are to be managed. Such a policy would set the desired level of environmental performance. In construction projects, environmental policy would emanate from: the application of the principles of sustainable construction enunciated in a previous section of this paper; the EA for the project, and, relevant statutory requirements. Professional construction organizations could also adopt a general environmental policy which could inform policies for specific projects.

The second key requirement is to provide an organizational structure and to determine the responsibilities, authority, lines of communication and the resources needed to implement the EMS. In most construction projects, a range of different organizations interact in the undertaking, and an EMS would need to define the required interactions between the various contractors, consultants and clients involved in the project. Similarly, lines of communication should link the organizations involved, and should also provide a connection with a range of interested and affected parties external to the construction process. With the exception of the management representative charged with implementing an EMS and those carrying out specialized environmental management functions, many of the personnel within the implementing organizations would need exposure to environmental awareness training.

The third key requirement is to develop an environmental management programme (EMP) that stipulates environmental objectives and targets to be met and work instructions and controls to be applied in order to achieve compliance with the environmental policy. The programme would contain operational procedures for controlling various activities, both normal and abnormal (accidents, emergencies). These procedures would include: work instructions for defining the manner of conducting an activity; inspection procedures to ensure that mitigating measures are applied; procedures for dealing with accidents and emergencies, and, procedures for the measurement of performance indicators, for example, accidental and controlled release indicators, and site impact indicators. Documentation plays an important role in the implementation of an EMP: in addition to an environmental management manual describing procedures, records should be kept of the monitoring data collected to test the effectiveness of mitigation measures and impact controls. Data collected to monitor performance indicators would be compared with standards chosen to reflect the objectives and targets of the EMP. These standards should be quantified as far as possible to facilitate verification of objectives. In construction, where the primary goals of the contractor and the environmental management team may be different, the EMP may need to rely on penalties and bonuses to ensure compliance with standards. Records should also contain details of incidents of non-compliance with stipulated policy and standards, and should describe corrective action taken. Records should also be kept of environmental training activities.

The fourth key requirement is to undertake periodic audits of the environmental performance of the construction team and the effectiveness of the Environmental Management System.

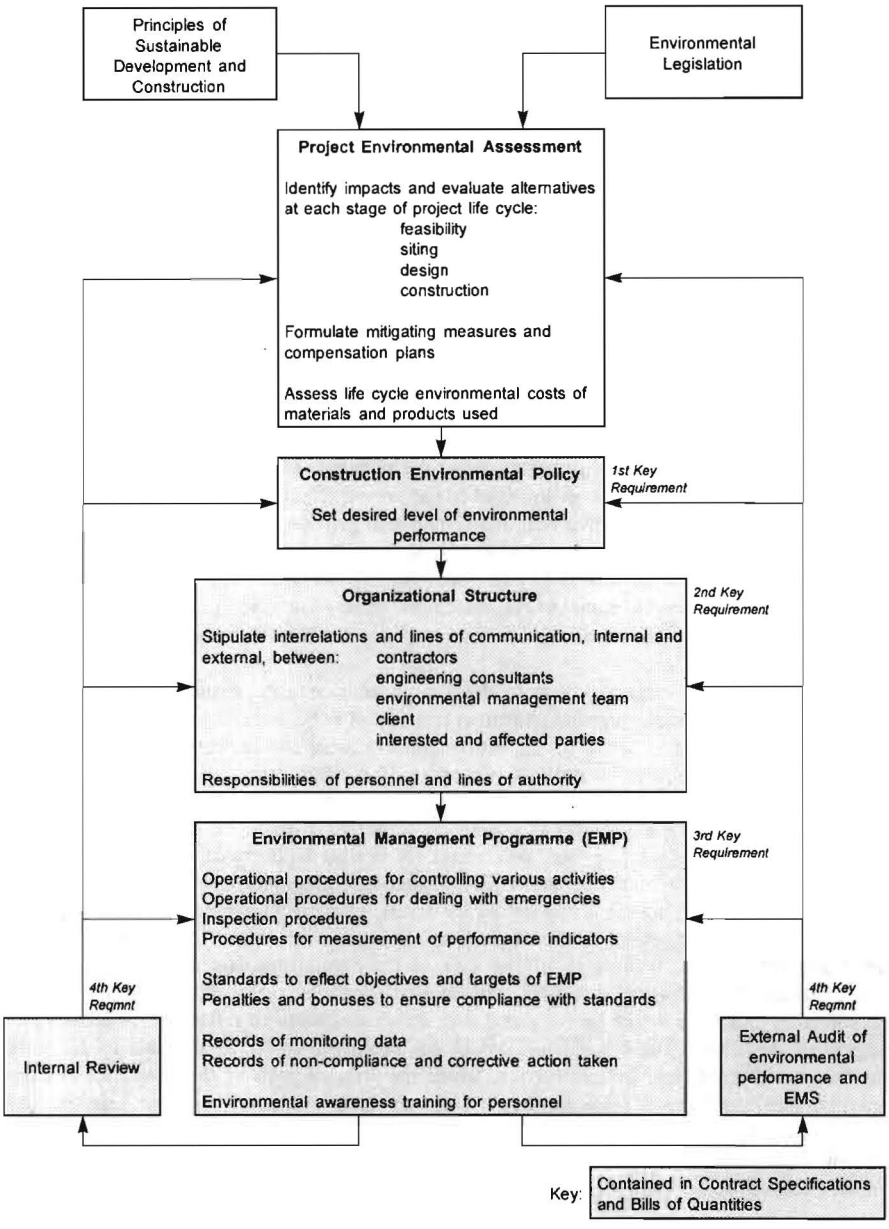

Figure 1. A generic Environmental Management System (EMS) for construction projects

An audit report provides an essential information feedback loop to senior management who can take corrective action to address the identified weaknesses of the EMS. For some years, a debate has been taking place as to whether environmental auditing should be a voluntary internal management tool or a compulsory external reporting mechanism (Soutter and Mohr, 1991). Auditing of an EMS for a construction project could be done internally by the environmental management team or externally by a consultant. Typically, an external audit would be preferred for a large construction project of extended duration with potential to cause significant environmental impacts. Ongoing internal review of the environmental performance of the construction team and the functioning of the EMS would complement the periodic audits.

The framework described above has been used to analyze and evaluate three South African construction case studies. The results of this evaluation are documented elsewhere (Hill *et al.*, 1994).

Conclusions and Recommendations

Consensus has not been reached on definitions for the terms "sustainability" and "sustainable development". This is because each discipline has attached different meanings to these concepts. It is probably true, however, that the dichotomy of the development/environment debate in the 1970s and the 1980s has been replaced by a sustainable development synthesis, although this synthesis may be better described as a continuum of perspectives.

From within the range of values and meanings attached to "sustainability" and "sustainable development", two have been singled out to advance understanding of the concept of sustainable construction.

The first is Solow's suggestion that "sustainability" is concerned with the substitution of natural to human and physical capital. Solow proposed that fairness towards future generations requires that some of the proceeds from the exploitation and depletion of non-renewable resources should be invested in human or physical capital to maintain productive capacity for the future. As the construction industry is constantly involved in this substitution, it is feasible to describe the industry as involved in operations which could be termed "sustainable".

The second is the World Conservation Union's definition that "sustainable development ... improves the quality of human life while living within the carrying capacity of supporting ecosystems". As construction is largely involved with the improvement of the quality of human life, the ideals of sustainable development could feasibly be attained if construction could demonstrate a responsible approach towards operating within the carrying capacity of supporting ecosystems.

Thus, in order to attain "sustainability", the construction industry should uphold a number of key principles which encompass economic, social, and environmental considerations.

The process oriented principles listed in the paper can be satisfied in the implementation of a proposed framework for sustainable construction which requires:

- application of Environmental Assessment (EA) during the planning and design stages of projects, provided that the traditional EA is expanded to consider life cycle assessment of alternative materials and products to be used in the construction process, and,

- implementation of an Environmental Management System (EMS) during project construction.

The components of a generic EMS for construction projects have been presented in diagrammatic form. In order to ensure implementation during a construction project, these components should be documented as requirements in the contract specifications and bills of quantities.

The key requirements in setting up an EMS for the construction stage of a project are to: determine an environmental policy; provide an organizational structure; determine the responsibilities of personnel; develop an environmental management programme (EMP), and, undertake periodic audits of the environmental performance of the construction team and the effectiveness of the EMS.

The adoption of the principles listed in this paper and the comprehensive framework for environmental assessment and management should improve the practice of sustainable construction.

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