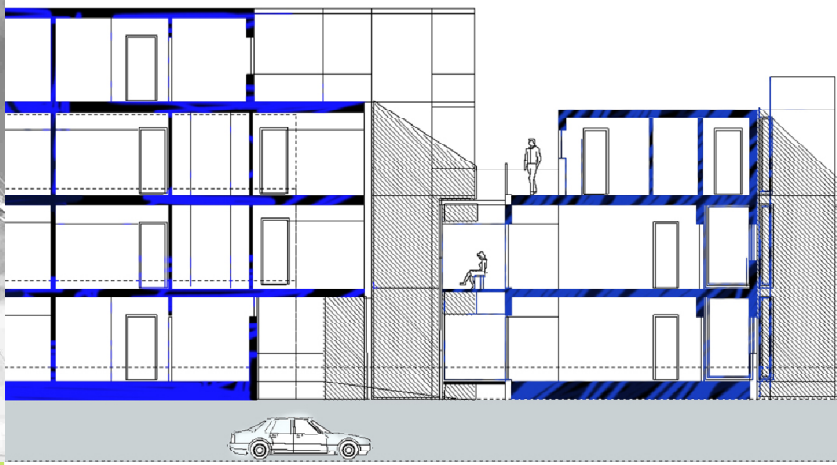
Agenda 21

on sustainable construction



CIB Report Publication 237

CIB

Agenda 21

on sustainable construction

CIB Report Publication 237
July 1999

CIB Report Publication 237
ISBN 90-6363-015-8

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FOREWORD FROM CIB

This Agenda 21 on Sustainable Construction is the final result of the process that commenced within CIB in 1995 whose principal component was an in-depth and searching analysis of the future directions of, and optimal ways to engage in international collaboration on research and innovation in building and construction.

CIB, as the leading international organisation for collaboration in this field, recognised early on the importance of environmental concerns and commitment in all its activities. Working groups whose scopes and terms of reference bore a direct environmental significance and orientation were already being set up in the beginning of the 1980s. The recognition of the importance of the building and construction sector for a sustainable development to be attained, prompted CIB to select Sustainable Construction as the Theme for the period leading up to the CIB World Building Congress 1998 in Gävle, Sweden. Not indeed as a topic for a three-year period only but rather as the Theme that will exercise a major influence for the future on the building and construction sector worldwide. This noticeable concentration of attention grew also from the conviction that CIB by this means would at best serve its membership of R&D organisations and industry.

To attain the broadest possible consensus in the work leading up to the Congress and the Agenda 21 for Sustainable Construction, CIB has co-operated and communicated with other international associations knowledged as being of the highest repute. CERF, RILEM, IEA and ISIAQ are among those organisations that have contributed experts and specialist knowledge as the process unfolded.

Christer Sjöström

Immediate Past President of CIB and
Chairman of the CIB Co-ordinating Committee for Sustainable Construction

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FOREWORD FROM PARTNER ORGANISATIONS

The Construction Engineering Research Foundation - CERF

CERF is an independent, non-profit organisation created by the American Society of Civil Engineers and headquartered in Washington DC. Operating since 1989, CERF's mission is to bring together diverse groups within the civil engineering community to "facilitate, coordinate, and integrate" research by the civil engineering community and the design, construction, and environmental industries. CERF operates innovation technology evaluation centers in the areas of highways, public works, the environment, and buildings to help the design and construction industry expedite the transfer of innovation into practice. By uniting voices and leveraging resources from across the industry, CERF identifies needs, sets priorities, and organises collaborative projects. The Agenda 21 on Sustainable Construction provides a valuable benchmark and springboard for the future for the building and construction sector globally.

Harvey M. Bernstein
President

The International Union of Testing and Research Laboratories for Materials and Structures - RILEM

RILEM provides a worldwide network of communication throughout 80 countries, to bring together specialists from research and industry with the common objective to promote progress in the design, testing, manufacture and use of building materials. The RILEM engagement in developing sustainable construction practices is demonstrated through the manifold activities of its Technical Committees. A life cycle view on material resources in building is an obvious need to reach the goal of sustainable development and an environmentally sound construction industry. The Agenda 21 on Sustainable Construction gives essential support to and direction for the work towards a sustainable building and construction sector.

Carmen Andrade
Vice President

The International Energy Agency Implementing Agreement on Energy Conservation in Buildings and Community Systems - IEA ECBCS

On behalf of the Implementing Agreement on Energy Conservation in Buildings and Community Systems of the International Energy Agency, I wish to express my support for this Document. The well-substantiated need to reduce the impacts of the construction industry on the global environment makes it imperative for the industry to undertake substantial and rapid improvements in the way buildings and other structures are designed, built and operated. The contents of Agenda 21 provide a summary of the issues and outline a path forward which can guide our policy-making and daily operations towards this desirable and indeed most necessary end.

Richard Karney
Chairman
Energy Conservation in
Buildings and Community Systems Executive Committee

The International Society for Indoor Air Quality and Climate - ISIAQ

The Board of Directors of ISIAQ, together with its 500 members spread over 40 countries, are strongly motivated partners with CIB in the Agenda 21 for Sustainable Construction. Sustainable buildings are those that protect and promote the health and comfort of the occupants while at the same time safeguarding the environment and making an effective use of energy. The ISIAQ mandate is to promote the design and construction of indoor environments that support people's health, welfare and productivity. ISIAQ intends to collaborate in Agenda 21 to the utmost of its professional and intellectual energy.

Marco Moroni
President

ACKNOWLEDGEMENTS

This Report has been compiled by Luc Bourdeau (CSTB) as Editor-in-Chief with contributions being forthcoming from several experts including CIB Members. Luc Bourdeau gratefully acknowledges all those researchers and experts in CIB and partner organisations who have contributed to the work with the Agenda 21 for Sustainable Construction and to the CIB World Building Congress 1998 in Gävle, Sweden. Special thanks must be extended to those who have made a significant contribution to the work of editing and particularly to Wim Bakens (CIB), Peter Barrett and Peter Brandon (Salford University), Alan Gilham (BRE), Pekka Huovila (VTT), Nils Larsson (Natural Resources Canada), Chrisna du Plessis (CSIR-Boutek), Asko Sarja (VTT) and Christer Sjöström (KTH). He also wishes to thank Chris Pollington, Deputy Secretary General of CIB, for assistance with the final textual and linguistic editing.

executive summary

sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

0 EXECUTIVE SUMMARY

Sustainable Development was defined in the Brundtland Report 1987 as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

The pursuit of sustainable development throws the built environment and the construction industry into sharp relief. This sector of society is of such vital innate importance that most other industrial areas of the world society simply fade in comparison. Proper housing and the necessary infrastructure for transport, communication, water supply and sanitation, energy, commercial and industrial activities to meet the needs of the growing world population pose the major challenge. The Habitat II Agenda lays stress on the fact that the construction industry is a major contributor to socio-economic development in every country.

The construction industry and the built environment must be counted as two of the key areas if we are to attain a sustainable development in our societies. As an example, in the European Union, buildings are responsible for more than 40% of the total energy consumption and the construction sector is estimated to generate approximately 40% of all man-made wastes. In addition, the construction sector is the Union's largest industrial sector, contributing with approximately 11% to the GNP and having more than 25 million people directly and indirectly engaged.

CIB, as the leading international organisation for research collaboration in building and construction, recognised early on the importance of environmental concerns and commitment in all its multifaceted activities.

In 1995 it was decided to take a definitive step and to make Sustainable Construction the focal point of the three year period leading up to the 1998 World Building Congress in Gävle, Sweden. The Congress Theme was defined as Construction and the Environment. Right from the very start the ambition was to make the Congress the important vehicle in the work process as the means to introduce and reinforce the Theme in all CIB activities, and also to be the stepping stone for the next goal - a global collaboration to attain a sustainable future in the construction sector. The need for an internationally agreed Agenda on Sustainable Construction to help guide the work in implementing the principles of sustainability in the construction sector had early matured and the 1998 CIB World Building Congress was assigned a key role in this process.

The Agenda 21 on Sustainable Construction is intended to be a global intermediary between those general Agendas in existence, i.e. the Brundtland Report and the Ha-

bitat Agenda, and the required national/regional Agendas for the built environment and the construction sector current or in the course of development. It should be a conceptual framework that defines the links between the global concept of sustainable development and the construction sector and enables other Agendas on a local or sub-sectorial level to be compared and co-ordinated and to define detailed measures appropriately responsive to the local context.

The three principal objectives for this Agenda 21 for Sustainable Construction are:

- to create a global framework and terminology that will add value to all national or regional, and sub-sectorial Agendas
- to create an Agenda for CIB activities in the field, and for co-ordinating CIB with its specialised partner organisations
- to provide a source document for defining R&D activities.

Concepts of Sustainable Construction

Sustainable construction adopts different approaches and is accorded different priorities in different countries. It is hardly surprising that there are widely divergent views and interpretation as between countries, with marked differences between developed market economies, transition economies and developing countries. The mature economies are in the position of being able to devote greater attention to creating a more sustainable building stock by upgrading, by new developments or the invention and use of new technologies while, naturally and hopefully, the developing economies focus more on social equality and economic sustainability.

The understanding or interpretation of sustainability in building and construction has likewise undergone change over the years. In the beginning the emphasis was on how to deal with the issue of limited resources, especially energy, and on how to reduce the impacts on the natural environment. Also a decade ago, the emphasis was placed on the more technical issues in construction such as materials, building components, construction technologies and on energy related design concepts. Today, an appreciation of the significance of the non-technical issues is growing and it is realised that these so-called 'soft' issues are at least as crucial for a sustainable development in construction. Economic and social sustainability must be accorded explicit treatment in any definition. More recently also the cultural issues and the cultural heritage implications of the built environment have come to be regarded as preeminent aspects in sustainable construction.

Issues and Challenges of Sustainable Construction

Sustainable construction is seen as a way for the building industry to respond towards achieving sustainable development on the various

environmental, socio-economic and cultural facets. The main issues and challenges which are detailed in this Agenda are introduced below.

Management and Organisation is a key aspect of sustainable construction and the subject must engage not only technical issues, but social, legal, economic and political matters as well. It is therefore a very complex and difficult subject to address due to the breadth of their inter-relationships and to a major characteristic of the construction sector which is the strikingly large number of actors involved in the process of activities, from the development phase up to the deconstruction or demolition phase through the operation phase of each component of the built environment.

The barriers to progress are high and the challenges to be tackled deal with several different aspects such as the design process, the environmental quality of construction, the re-engineering of the building process, the development of new building concepts, the human resources, the decision making processes, the building owners' and clients' demand, education, public awareness, standards and regulations or research.

Product and Building issues are concerned with how to optimise the characteristics of buildings and products in order to improve the sustainability performance taking into account such background factors as climate, culture, building traditions and stage of industrial development. By increasing the number of parameters and exploiting suitable indicators, building performance environmental methods will lead to a better assessment of the final construction works. As far as the manufacturing of products is concerned, the important issues are to reduce the embodied amount of material and energy of the products, to lower emissions from products in use and to improve repairability and recyclability. On another side, Indoor Environment Quality should be enhanced to reach healthy and productive living conditions inside buildings.

Resources consumption does of course pose an important challenge for the construction sector. Energy saving measures, extensive retrofit programmes and transport needs constitute strong challenges linked to energy use. Reduction in the use of mineral resources and conservation of the life support function of the environment require use of renewable or recycled materials, pertinent selection of materials and prediction of service life. Water management in buildings should be developed. In several countries, management of land is affected by construction. Some related issues are the choice of site and land use, the longevity of new buildings, and the use of land for production of building materials.

The impacts of construction on sustainable urban development are of paramount importance as far as continuing urbanisation reinforces the importance of creating a built environment that is sustainable for future generations. The built environment constitutes one of the main supports for economic development and social well being. The provision of infrastructure, buildings and utilities are major resources that are used by nations, communities and business. Major issues are linked to environment quality, life quality, dwelling quality and governance aspects, and urban growth and waste management are two main transversal aspects. Sustainability of settlements in developing countries raises additional specific questions.

Apart from waste, several other **environmental loads** of the construction industry are presented in the Agenda, linked to production, operation and decommissioning of buildings and construction works.

Finally, **social, cultural and economic issues** are briefly discussed. Although hitherto far less developed in the literature, they were nevertheless specifically stated in the Habitat II Agenda which stresses the fact that the construction industry is a major contributor to socio-economic development in every country. A sustainable construction can be seen as providing a contribution to poverty alleviation, creating a healthy and safe working environment, equitably distributing social costs and benefits of construction, facilitating employment creation, developing human resources, acquiring financial benefits and uplift for the community.

Resulting Challenges and Actions

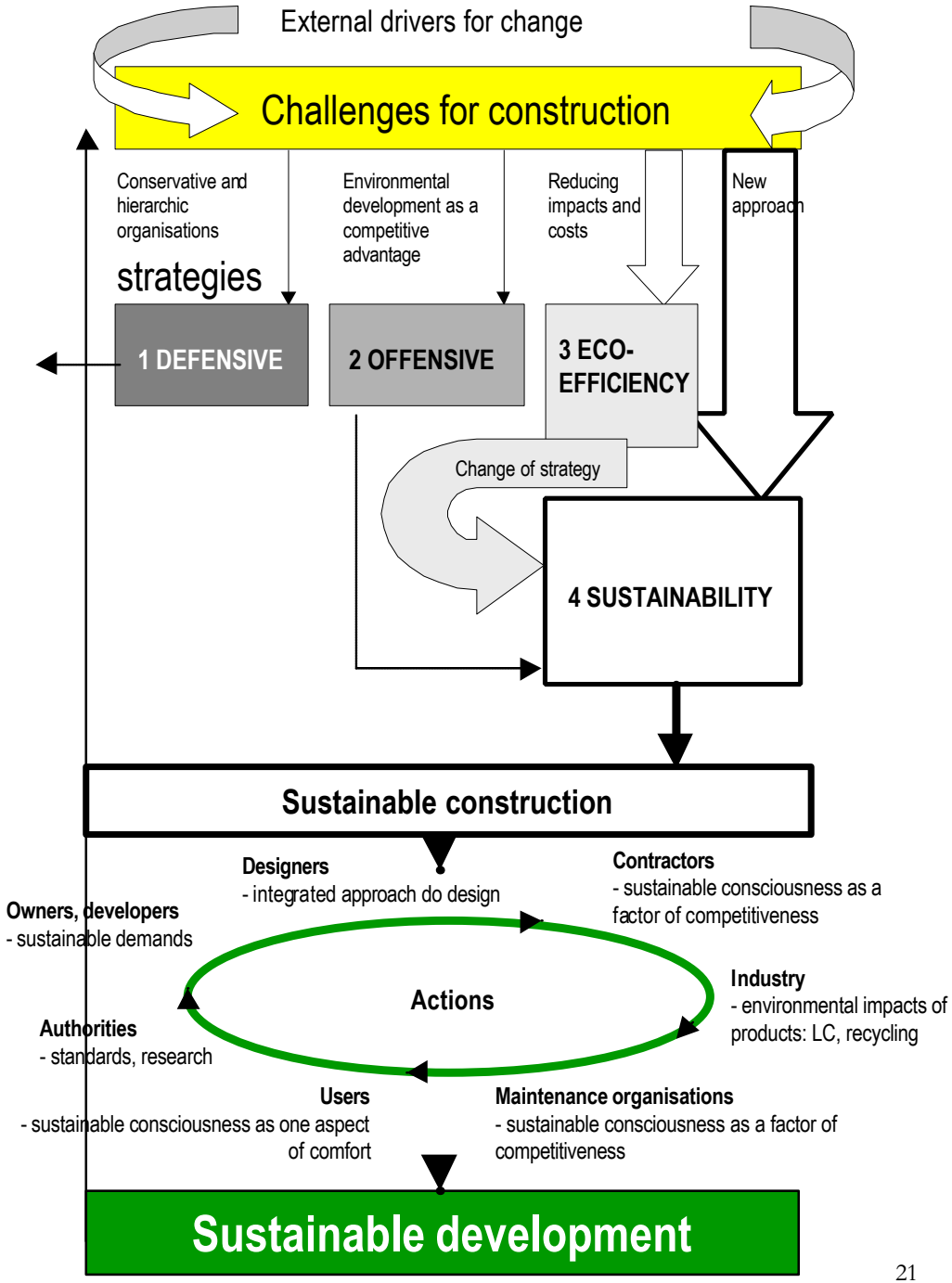
As previously stated, successful improvement strategies for sustainable construction will have to be more-or-less compatible with climate, culture, building traditions, stage of industrial development and nature of the building stock. However, this section on resulting challenges and actions gathers together a spectrum of initiatives that can be launched, while keeping in mind that the mix and relative emphasis on one or the other will depend on the local conditions and will have to be detailed in local Agendas.

Regulation, energy pricing, enabling and support mechanisms, incentives and demonstrations, measures to change market demand, research themes are some of the items which are introduced. Certain different detailed strategies are also discussed.

Specific challenges raised in the previous chapters have been formulated in such a way as to orientate them towards the various families of stakeholders in the construction sector, and some technical and R&D challenges are listed.

In conclusion, an Appendix catalogues on-going and planned CIB activities on Sustainable Construction.

Strategies and Actions



section one

context and scope

1.1 BACKGROUND

Ever since the Rio Summit in 1992 when the Agenda 21 was formulated, the concept of Sustainability and Sustainable Development has slowly but surely penetrated the discussions on the future direction and progress of all sectors of our society. Sustainable Development was defined in the Brundtland Report 1987 as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". It projects an attitude to and ambition for change and development of society that genuinely merits the definition of a shift of paradigm.

By virtue of necessity the Agenda 21 is very general and points out an action plan directed towards sustainable development including goals, commitments by stakeholders and strategic programme areas.

Agenda 21 has subsequently been interpreted in several local and sectorial agendas. One interpretation of more specific relevance to the construction sector is the Habitat II Agenda, which was the outcome of the United Nations Conference in Istanbul in 1996.

The pursuit of sustainable development throws the built environment and the construction industry into sharp relief. This sector of society is of such vital innate importance that most other industrial areas of the world society simply fade in comparison. Proper housing and the necessary infrastructure for transport, communication, water supply and sanitation, energy, commercial and industrial activities to meet the needs of the growing world population pose the major challenge.

In each country, the built environment normally constitutes more than one half of the real capital and construction represents a major part of the Gross National Product (for instance 10-12% in the European Union). From time to time in individual countries the construction sector's share of GNP may appear as high as one quarter. With some 30 million employees in the European Union, construction is the largest single industrial sector.

It is also a fact that the construction industry and the built environment are the main consumers of resources - energy and materials. Within the European Union, buildings are estimated to consume approximately 40% of total energy - and also to be responsible for some 30% of CO_2 emissions - and to generate approximately 40% of all man-made waste.

There is another attribute of the construction sector that complicates, but also seems further to underline the necessity of focusing on the sector's development, and that is that the industry is largely national, or even local, and diversified and fragmented. The fact that the absolute majority of construction

companies are small or medium sized enterprises operating with fewer than 20 employees points to specific barriers when aiming for new directions and changes.

1.2 TOWARDS AN AGENDA 21 FOR SUSTAINABLE CONSTRUCTION

CIB[1], as the leading international organisation for research collaboration in building and construction, recognised early on the importance of environmental concerns and commitment in all its multifaceted activities. New Working Commissions (Ws) and Task Groups (TGs) whose scopes were predominantly of direct relevance to environmental issues were set up during the 1980s. Energy Conservation in the Built Environment (W067), Water Supply and Drainage (W062), Indoor Climate (W077), Prediction of Service Life of Building Materials and Components (W080), and Design for Durability (W094) may be cited as a few examples of Working Commissions, established during the 1980s, that today are key players in the sustainable development concept of the Organisation even if that was not the prime cause for originally bringing them on to the scene.

Working Commission W080 has from the very start been a joint activity with RILEM[2], and since 1993 together with W094 has worked closely with ISO[3] in elaborating standards on the Design Life of Buildings.

In the early 1990s a number of CIB activities were initiated, where work programmes were expressly aimed at contributing towards achieving a more sustainable built environment:

- TG08 was established in 1992 and in 1998 was transformed into Working Commission W100 on Environmental Assessment of Buildings
- TG16 was established in 1993 on Best Practice for Sustainable Construction
- TG22 was established in 1996 on Environmental Design Methods in Materials and Structural Engineering and is a joint CIB/RILEM activity
- TG38 was established in 1998 on Urban Sustainability.

[1] International Council for Research and Innovation in Building and Construction

[2] International Union of Testing and Research Laboratories for Materials and Structures

[3] International Organisation for Standardization

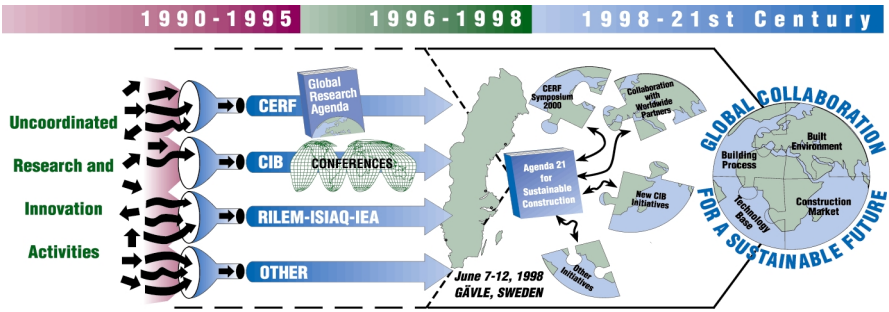
A number of conferences and seminars arranged by these and other Working Commissions and Task Groups focussed attention on environmental issues. To mention one, the First International Conference on Sustainable Construction, arranged in 1994 in Tampa, Florida, by Task Group TG16 was acknowledged as a major step forward in the process to increase the environmental awareness.

In the Appendix, a number of selected CIB activities crucial to the concept of Sustainable Construction is described in more detail.

1.3 THE CIB WORLD BUILDING CONGRESS 1998, GÄVLE, SWEDEN

In 1995 it was decided to take a definite step and to make Sustainable Construction the focal point of the three year period leading up to the 1998 World Building Congress in Gävle, Sweden. The Congress Theme was defined as Construction and the Environment. Right from the very start the ambition was to make the Congress the important vehicle in the work process as the means to introduce and reinforce the Theme in all CIB activities, and also to be the stepping stone for the next goal - a global collaboration to attain a sustainable future in the construction sector. The need for an internationally agreed Agenda on Sustainable Construction to help guide the work with implementing the principles of sustainability in the construction sector had early matured and the 1998 CIB World Building Congress was assigned a key role in this process (Figure 1).

Figure 1. International R&D activities co-ordinate to achieve common goals in the 21st century. Towards the 1998 CIB World Building Congress, Gävle, Sweden and beyond.



To attain the goal of global collaboration and the broadest possible international consensus on the Agenda 21 for Sustainable Construction, CIB established close cooperation in arranging the Congress with other renowned international Organisations – RILEM, CERF[4], ISIAQ[5] and IEA[6] - and these Organisations are also partners in producing the Agenda.

At the Congress all the important aspects of Sustainable Construction were addressed at five different symposia which CIB had arranged together with the partner organisations.

[4] Civil Engineering Research Foundation, USA

[5] International Society of Indoor Air Quality and Climate

[6] International Energy Agency – Energy Conservation in Building and Community Systems Programme

1.4 OBJECTIVES OF AN AGENDA 21 FOR SUSTAINABLE CONSTRUCTION

CIB Working Commission W082 some years ago started an international project to compare the visions and perceptions of sustainable development and the future of construction as they were held in different countries. The overriding question which the project sought to answer was "What will be the consequences of sustainable development on the construction industry by the year 2010?". The project was concluded just in time to be reported at the Gävle Congress.

By way of introduction, a principle issue for consideration by the different national groups participating in the project was the definition of the term Sustainable Construction. It is not surprising that there were widely divergent views and interpretation as between countries, with marked differences between developed market economies, transition economies and developing countries. The mature economies are in the position to devote greater attention to the creation of a more sustainable building stock by upgrading, by new developments or the invention and use of new technologies while, naturally and hopefully, the developing economies focus more on social equality and economic sustainability.

No one denies that environmental concerns have broadened over the last two decades. Initially environmental engagement meant reacting to clear and visible catastrophes such as dead fish on the shores etc. while creeping up on us we have had slowly to realise that any excessive, or inefficient, consumption of resources is actually no more and no less than an abuse of the environment.

The understanding or interpretation of sustainability in building and construction has likewise undergone change over the years. In the beginning the emphasis was on how to deal with the issue of limited resources, especially energy, and on how to reduce the impacts on the natural environment. Also a decade ago, the emphasis was placed on the more technical issues in construction such as materials, building components, construction technologies and on energy related design concepts. Today, the understanding of the significance of the non-technical issues is growing and it is realised that these so-called soft issues are at least as crucial for a sustainable development in construction. Economic and social sustainability must be accorded explicit treatment in any definition. More recently also the cultural issues and the cultural heritage implications of the built environment have come to be observed as pre-eminent aspects in sustainable construction.

What has been said earlier points to the evident fact that, even on the highest political level, priorities vary widely in different countries

depending on the economic situation, level of urbanisation, historic and cultural context, climate and national policies. In particular, the differences between developed and developing countries stand out clearly.

Opinions or nuances may differ on how the north/south issues have been handled in the process leading up to the CIB World Building Congress ("almost complete absence on the (Congress) agenda of the developing world and its problems" or "the elitism of the problems addressed") and the work on the Agenda 21 for Sustainable Construction. However, it is a fact that representatives from the mature industrial economies have dominated the process. The problem of securing appropriate involvement on the part of the developing world is always apparent in international R&D co-operation.

The Agenda 21 on Sustainable Construction is intended to be a global intermediary between those general Agendas in existence, i.e. the Brundtland Report and the Habitat Agenda, and the required national/regional Agendas for the built environment and the construction sector, current or in the course of development.

1. So, what could be the main added value of this Agenda 21 for Sustainable Construction? It should be a conceptual framework that defines the links between the global concept of sustainable development and the construction sector and enables Agendas on a local or sub-sectorial level to be compared and co-ordinated and to define detailed measures depending on the local context.

The three principal objectives for this Agenda 21 for Sustainable Construction are:

- to create a global framework and terminology that will add value to all national or regional, and sub-sectorial Agendas
- to create an Agenda for CIB activities in the field, and for co-ordinating CIB with its specialised partner organisations
- to provide a source document for defining R&D activities.

The Agenda 21 for Sustainable Construction should not be seen solely as an Agenda for CIB, although a CIB plan of action does run as a guiding strand throughout the entire document. It is designed to be of added value to every organisation that wants to develop its own agenda for a part or an aspect of the built environment and the construction industry. The co-operation with the partner organisations RILEM, IEA, CERF and ISIAQ has thus been of vital importance.

1.5 STRUCTURE AND CONTENTS

The Agenda 21 for Sustainable Construction brings to the attention of the interested reader the concepts of sustainable development and sustainable construction, the construction industry concerns and its impacts, against the background of international agreements such as the Kyoto and Rio Summits.

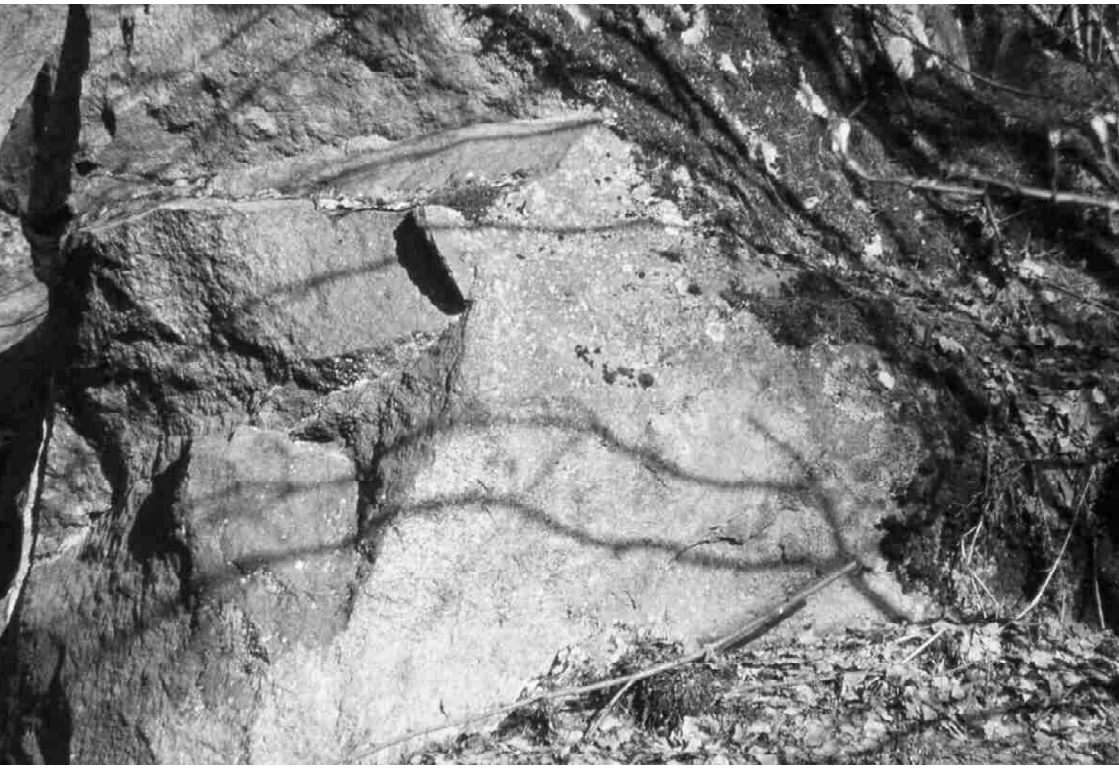
The characteristics of the construction process, i.e. the process itself, building operation, stakeholders, etc, are the point of departure for the analysis of the necessary changes implied by a sustainable development. The challenges as to market demand, functionality of buildings and structures, resources, construction process improvement, urban issues and social aspects are duly accounted for.

The main issues and stakes of Sustainable Construction are described on the levels of the current product (level of service, indoor environment quality, etc), urban impacts, resource consumption (land, energy, materials, water), the manufacturing of products, environmental loads, and social and economic aspects.

The resulting Challenges and Proposed Actions conclude the Agenda 21 for Sustainable Construction.

section two

concepts of
sustainable development and sustainable construction



2.1 BACKGROUND AND DEFINITIONS OF SUSTAINABLE DEVELOPMENT

Several initiatives have been undertaken since the "Brundtland Report", deserving of mention at the international level as being significant attempts to define what a sustainable development is or should be. One, of course, is Agenda 21 as formulated at the Rio Summit in 1992. A second one is the Habitat II Agenda of 1996, signed in Istanbul. There is also the Local Agenda 21 Planning Guide, compiled by the ICLEI[7] to provide guidance to local authorities on the formulation of a local Agenda 21 as prescribed in Section 28 of Agenda 21. At the regional level many other initiatives should also be cited such as the Amsterdam Treaty or the 5th Environmental Action Programme of the European Commission (unity policies and activities).

Several definitions of "Sustainable Development" can be extracted from these initiatives, such as:

- *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Our Common Future - "Brundtland Report", WCED[8] 1987);
- *"improving the quality of human life while living within the carrying capacity of supporting ecosystems"* (Caring for the Earth, IUCN[9]/UNEP[10] 1991);
- *"…with the goal of establishing a new and equitable global partnership through the creation of new levels of co-operation among States, key sectors of societies and people, working towards international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system, recognizing the integral and interdependent nature of the Earth, our home, proclaims that: …"* (Rio Declaration on Environment and Development, 1992);
- *"development that delivers basic environmental, social and economic services to all residences of a community without threatening the viability of natural, built and social systems upon which the delivery of those systems depends"* (The Local Agenda 21 Planning Guide, ICLEI 1996);
- *"sustainable development is the challenge of meeting human needs for natural resources, industrial products, energy, food, transportation, shelter and effective waste management, while conserving and protecting environmental quality and the natural resource base for future development"* (CERF 1996);

[7] International Council for Local Environmental Initiatives

[8] World Commission on Environment and Development

[9] The World Conservation Union

[10] United Nations Environment Programme

- "determined to promote economic and social progress for their peoples, taking into account the principle of sustainable development and within the context of the accomplishment of the internal market and of reinforced cohesion and environmental protection, and to implement policies ensuring that advances in economic integration are accompanied by parallel progress in other fields" (EU[11] Amsterdam Treaty, 1997).

Figure 2. Extracts from the EU Amsterdam Treaty

"The Community shall have as its task… to promote throughout the Community a harmonious, balanced and sustainable development of economic activities,…".

"Determined to promote economic and social progress for their peoples, taking into account the principle of sustainable development…".

"Environment protection requirements must be integrated into the definition and implementation of the Community policies and activities…, in particular with a view to promoting sustainable development".

"…the Commission undertakes to prepare environmental impact assessment studies when making proposals which may have significant environmental implications."

"The Commission, in its proposal… concerning health, safety, environmental protection and consumer protection, will take as a base a high level of protection, taking account in particular of any development based on scientific facts."

"A high level of human health protection should be ensured in the definition and implementation of all Community policies and activities."

[11] European Union

Figure 3. The 12 Key Environmental Problems Evaluated in the Second Assessment of Europe's Environment

Key Environmental Problem	State of Environment[1]	Policies	European environmental action takes the form of five-year action programmes. The Fifth Programme (93-98) established long-term objectives and targets to be reached by the year 2000 in each key field of five priority sectors. A clear picture of the state of the environment in Europe and the main areas requiring action at national or international level are presented in a report, Europe's Environment: The Second Assessment. The report builds on and updates the first pan-European state of the environment report published in 1995 by the European Environment Agency ("The DOBRIS Assessment"). That comprehensive report covered 46 countries and, based largely on data up to around 1992, provided an assessment of the state of the environment throughout Europe at that time. This Figure gives an overall summary assessment of progress over (roughly) the past five years for each of the 12 key European environmental problems identified in the DOBRIS assessment and evaluated in this report.
Climate change	-	+/-	
Stratospheric ozone depletion	-	+	
Acidification	+/-	+	
Tropospheric ozone	-	+/-	
Chemicals	+/-	+/-	
Waste	-	-	
Biodiversity	-	+/-	
Inland waters	+/-	+/-	
Marine and coastal environment	-	+/-	

Soil degradation	-	-	
Urban environment	+/-	+/-	
Technological and natural hazards	+	+	

+: positive development
-: little or unfavourable development
+/-: some but insufficient development

2.2 HOW THE CONSTRUCTION INDUSTRY IS CONCERNED

The various initiatives mentioned above were very general and did not deal specifically with the construction sector. Agenda 21 is primarily an action plan for sustainable development that includes goals, actions to be taken, commitments by the stakeholders and strategic "programme areas". The Habitat II Agenda, which followed it, is more relevant for the construction industry as it deals with human settlement and shelter. This section will firstly illustrate how the construction industry is concerned by the concepts of sustainable development introduced in some major initiatives and will secondly, present a synthesis of the main visions and perceptions of sustainable development and the future of construction as they resulted from an international project carried out by CIB Working Commission W082.

2.2.1 AGENDA 21

Agenda 21 introduces several programme areas that impact on the construction industry and delineates actions that should be taken to increase sustainability in these areas. At least the programme areas and actions presented in Figure 4 and abstracted from Agenda 21 have impacts on the construction field.

2.2.2 HABITAT II AGENDA[12]

While the Habitat Agenda covers the broader issues of human settlement, there are several sections that deal specifically with the construction industry and how governments should encourage the industry to behave.

Paragraph 25 states that governments should encourage the construction industry to promote "locally available, appropriate, affordable, safe, efficient and environmentally sound construction methods and technologies in all countries, particularly in the developing countries, at the local, national, regional and sub-regional levels to emphasise optimal use of local human resources and to encourage energy-saving methods that are protective of human health". Paragraphs 69, 70 and 71 specifically set out actions for government and the construction industry regarding planning, design, construction, maintenance and rehabilitation; the procurement, use and promotion of sustainable building materials and the production of sustainable materials. In fact, the entire Chapter 4, Section C highlights the important issues of planning, designing, constructing and maintaining of human settlements and the actions recommended.

[12] The Habitat Agenda can be downloaded from the Internet (http://habitat.unchs.org/unchs/english/hagenda/index.htm)

Figure 4. Chapters of Agenda 21 Concerning the Construction Field

- Chapter 4
  - Focussing on unsustainable patterns of production and consumption
  - Developing national policies and strategies to encourage changes in unsustainable consumption patterns
- Chapter 5
  - Developing and disseminating knowledge concerning the links between demographic trends and factors and sustainable development
  - Implementing integrated environment and development programmes at the local level, taking into account demographic trends and factors
- Chapter 7 (this Chapter deals specifically with Human Settlements)
  - Promoting adequate shelter for all (The Habitat Agenda defines what adequate shelter for all is)
  - Improving human settlement management
  - Promoting sustainable land-use planning and management
  - Promoting the integrated provision of environmental infrastructure: water, sanitation, drainage and solid waste management
  - Promoting sustainable energy and transport systems in human settlements
  - Promoting human settlements planning and management in disaster-prone areas
  - Promoting sustainable construction activities (defined later by Habitat Agenda)
  - Promoting human resource development and capacity-building for human settlement development
- Chapter 8
  - Integrating environment and development at the policy, planning and management levels
  - Making effective use of economic instruments and markets and other incentives
  - Establishing systems for integrated environmental and economic accounting
- Chapter 9
  - Promoting sustainable development and the protection of the atmosphere through energy development, efficiency and consumption
  - Transportation
  - Industrial Development
- Chapter 10
  - Integrated approach to the planning and management of land resources
- Chapter 18
  - Drinking water supply and sanitation
  - Water and urban sustainable development
- Chapter 19
  - Harmonisation of classification and labelling of chemicals
  - Information exchange on toxic chemicals and chemical risks
  - Establishment of risk reduction programmes
- Chapter 20
  - Promoting the prevention and minimisation of hazardous waste
- Chapter 21
  - Minimising waste
  - Maximising environmentally sound waste reuse and recycling
  - Promoting environmentally sound waste disposal and treatment
  - Extending waste service coverage
- Chapter 30
  - Promoting cleaner production
  - Promoting responsible entrepreneurship
- Chapter 36
  - Reorienting education towards sustainable development
  - Increasing public awareness
  - Promoting training
  - Capacity building in developing countries
- Chapter 40
  - Providing information for decision making (decision support)
  - Bridging the data gap
  - Improving availability of information

The full text of Agenda 21 is available at http://www.infohabitat.org/agenda21/

2.2.3 CIB W082[13]

The construction industry is a vitally important industry. It manufactures the built environment and it puts in place a physical stock of facilities and infrastructure that determines our degree of freedom and flexibility for anything up to 100 years after construction. This puts it in a very different league to, for example, the producer of photocopying paper, washing machines or cars. This importance is matched by responsibilities which are shared by all sections of society but which have a special relevance to construction. The Kibert definition[14] for sustainable construction: "*the creation and responsible management of a healthy built environment based on resource efficient and ecological principles*" can be considered as a starting point for defining Sustainable Construction more precisely.

The word *sustainable* (suggesting the idea of constant, permanent or continuous) is translated in some languages (e.g. Dutch, Finnish, Romanian or French) as *durable*. The concept of "durable construction" may alter the vision on the intended objectives, in that it lays stress on resistance over time.

Sustainable construction has different approaches and different priorities in different countries. Some of them identify economic, social and cultural considerations as part of their sustainable construction framework, but it is raised as a major issue in only a few countries. The main emphasis in national approaches so far has been on ecological impacts to the environment (bio-diversity, tolerance of nature and resources).

The problems of poverty and underdevelopment or social equity are sometimes part of the definitions of sustainable construction. In addition to economic prerequisites or social questions, numerous other variables and their importance vary from country to country. Features such as density and demography of population, national economy and standard of living, geography and natural hazards, availability of land and water, energy production and supply, the structure of the building sector or the quality of the existing building stock, etc., all have a measure of influence and interpretation in national approaches.

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[13] Sustainable Development and the Future of Construction, CIB Publication 225, 1998

[14] The First International Conference on Sustainable Construction, Tampa 1994

Figure 5 (based on Vanegas, DuBose & Pearce, 1996) tries to illustrate how traditional engineering will be widened, when environmental demands are considered. The economic and socio-cultural issues are presented in the global context together with the environmental issues.

The categories of problems identified behind the notion of sustainable construction can also be classified as:

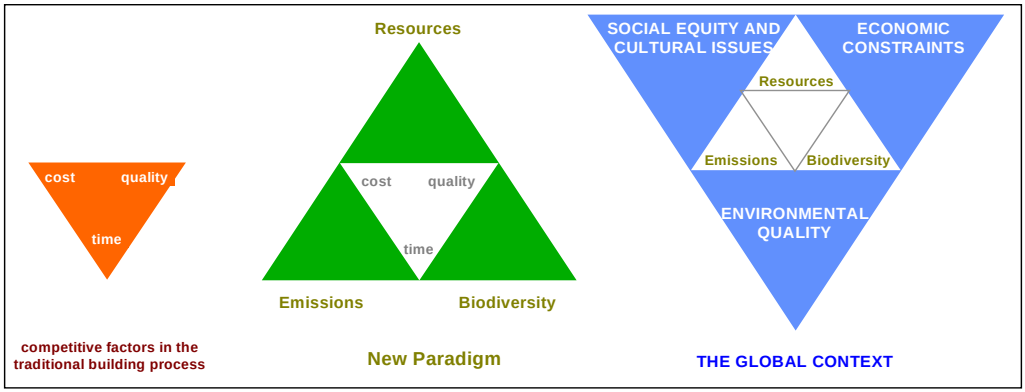
- physical problems linked to the issue of resources
- biological problems linked to the life of mankind
- sociological problems having socio-political, socio-economic or socio-cultural facets.

Some examples of approaches in various countries are given in Figure 6.

The key elements in the various national sustainable construction approaches are:

- reducing the use of energy sources and depletion of mineral resources
- conserving natural areas and bio-diversity
- maintaining the quality of the built environment and management of healthy indoor environment.

Figure 5. The New Approach in a Global Context



At a more detailed level, the following extrinsic or intrinsic topics have also been identified:

- quality and property value
- meeting user needs in the future, flexibility, adaptability
- prolonged service life
- use of local resources
- building process
- efficient land use
- water saving
- use of by-products
- distribution of information relevant to their decision making
- immaterial services
- urban development and mobility
- human resources
- local economy.

Concise definitions of Sustainable Construction such as Kibert's are considered as sound guidelines or as a general framework to be elaborated further and to be agreed on at a regional or national level. However in their concise form they remain too general and are thus often judged to be too vague and ambiguous. At a detailed level, local constraints, specific features and national priorities have to be taken into account. Therefore, to seek agreement on a common short definition is not a good approach. However, to define a global framework with a whole set of concepts in which each country or region will pick up its own priorities seems essential. This is one of the objectives of this Agenda.

Figure 6. Examples of Various National Approaches for Sustainable Construction

Finland

Sustainable construction, according to the definition, *"in its own processes and products during their service life, aims at minimising the use of energy and emissions that are harmful for environment and health, and produces relevant information to customers for their decision making"*. For building construction this means:

- intensified energy-efficiency and extensive utilisation of renewable energy sources;
- prolonged service life as a target;
- saving of the natural resources and promotion of the use of by-products;
- reducing waste and emissions;
- recycling building materials;
- supporting the use of local resources;
- implementation of quality assurance and environmental management systems.

The intention is to achieve an environmentally responsible industry and building owners together with environmentally conscious consumers.

France

Sustainable construction is described in a form of 24 criteria in the following treelike outline (aim: design a sustainable building):

- characterise the design phase
- allow a technico-economic optimisation
- capability to meet functional requirements (*indirect criterion*)
- capitalistic impact (*indirect criterion*)
- envisage good construction conditions
- construction logistics (*direct criterion*)
- working conditions (*indirect criterion*)
- impact on personal standing and employment (*indirect criterion*)
- building site pollution (*direct criterion*)
- lead to minimal resources withdrawal
- impact on raw materials withdrawal (*direct criterion*)
- impact on energy resources withdrawal (*direct criterion*)

Master the operation phase

- insure maintaining of use functions
- life duration - robustness (*indirect criterion*)
- optimised maintenance (*direct criterion*)
- consumption/wastes (*direct criterion*)
- master management of interfaces
- cost of access to collective services (*indirect criterion*)
- people: safety/health (*indirect criterion*)
- non material services: TV, phone, ... (*indirect criterion*)
- participate and contribute to urban life

- transport means inter-modality (*indirect criterion*)
- integration of proximity services (*indirect criterion*)
- integration of avoided social costs (*indirect criterion*)
- impact on property value of location (*indirect criterion*)
- impact of the construction on local environment (*direct criterion*)

Manage/retrofit/demolition phase

- allow retrofit/refurbishment
- capability to be adapted (indirect criterion)
- capability to change end use (indirect criterion)
- capability to improve performances (direct criterion)
- allow deconstruction
- aptitude to demolition (*direct criterion*)
- deconstruction - aptitude to waste reprocessing (*direct criterion*)

Japan

Building Agenda 21, developed by the Architectural Institute of Japan (AIJ), proposed seven principles for future research activities:

- establishment of the methodology to evaluate life cycle impact of building to the environment, as well as creation of measures to constrain impact by using the methodology;
- producing a code of practice of planning together with reconsideration of the present life style from the aspect of energy consumption;
- prolonging the life of buildings in order to prevent rapid resource consumption;
- reducing energy and water consumption in building operation and setting up measures to use renewable resources;
- planning for sustainable land utilisation and for preventing pollution to water, air and land;
- creating measures for a healthy environment;
- promoting technology transfer and information exchange for international co-operation.

The Netherlands

The official definition for sustainable construction is *"a way of building which aims at reducing (negative) health and environmental impacts caused by the construction process or by buildings or by the built-up environment"*.

A more precise definition of sustainable construction is suggested as "the reduction of the use of natural resources and the conservation of the life support function of the environment by construction processes, buildings and the built-up environment under the premise that the quality of life is maintained". The key verbs in the definition: reduce, conserve and maintain can be interpreted as key issues and principles as follows:

criterion	*key issues*	*principles*
Reduce	Use of energy sources	Minimise depletion through:
	Use of mineral resources	- reuse
	Use of water resources	- recycling
	Use of land	- use of renewable resources
		- efficient use
Conserve	Natural areas	Conserve through:
	Bio-diversity	- restricted land use, reducing fragmentation

		- prevention of toxic emissions Restore through: - remediation
Maintain	Healthy indoor environment Quality of built-up environment	Maintain through: - low emission materials, (energy) efficient ventilation, compliance with occupant's needs - provision of amenities, transport, recreation, security - abatement of noise, pollution and odorous Restore/improve through: - renovation, rehabilitation

At the building level, a sustainable building can be defined as a building that:

- consumes a minimum amount of energy and water over its life span;
- makes efficient use of raw materials (environment-friendly materials, renewable materials, enhanced life cycle, demountability);
- generates a minimum amount of waste and pollution over its life span (durability, recyclability);
- uses a minimum amount of land and integrates well with the natural environment;
- meets its user's needs now and in the future (flexibility, adaptability, site quality);
- creates a healthy indoor environment.

South Africa

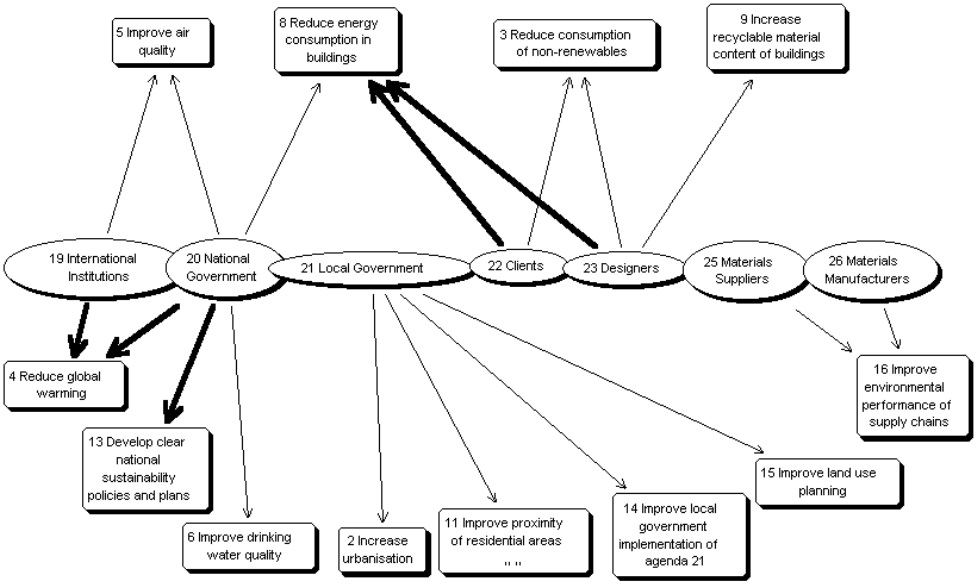
We are reminded that the concept of sustainability has been practised by indigenous people worldwide for thousands of years. However, few, if any, have managed to couple sustainability with what the western mindset terms "development". Those cultures who have lived the most sustainable lifestyles were often also the ones considered extremely "backward" or "underdeveloped".

- The definitions of sustainable development are often vague and ambiguous. Achieving "quality of life" and "quality of the built environment" does not necessarily go in hand with sustainable development as long as "quality of life" is not redefined. In South Africa, social equity is much higher on the agenda than environmental concerns, and therefore more thought is given to the impact of construction on social and economic sustainability.

2.3 A SPECIFIC CHARACTERISTIC OF THE CONSTRUCTION PROCESS: THE ROLE OF VARIOUS ACTORS

A major specific characteristic of the construction sector is the notably large number of actors who are occupied in the process of activities, from the development phase to the deconstruction or demolition phase through the operation phase of each component of the built environment.

Figure 7. Map Depicting Strongest Performance Objectives/ Stakeholder Links Emerging from a Delphi Round



The recent IDS[15] project carried out an analysis of the main links between these actors and some identified performance objectives representing recurring key issues of sustainability distilled from relevant literature. The results of this study (a Delphi study carried out on a national panel) have been summarised in Figure 7.

[15] Integrated Delivery Systems for Sustainable Construction, Salford University, 1998

The following five links between performance objectives and stakeholders received the highest level of agreement from the national panel:

Stakeholders	Performance Objectives
International Institutions	Reduce Global Warming
National Government	Develop Clear National Sustainability Policies and Plans
Clients	Reduce Energy Consumption in Buildings
National Government	Reduce Global Warming
Designers	Reduce Energy Consumption in Buildings

The map indicates that panellists consider that international institutions and national governments hold key responsibility for global and national sustainability issues such as air quality, drinking water quality, energy consumption and the reduction of global warming. The development of clear national sustainability policies and plans was also regarded as a major responsibility of national government. The performance objectives for which panellists considered local government to hold key responsibility were principally concerned with land use planning and implementation of Agenda 21.

Clients and designers were together considered to be responsible for reducing energy consumption in buildings and the consumption of non-renewable resources, whilst additionally designers were believed to have key responsibility for increasing the recyclable material content of buildings. Material manufacturers and suppliers were both strongly linked to only one performance objective on the map, namely improving the environmental performance of supply chains, whilst contractors did not feature in the map at all.

2.4 MAIN CHALLENGING DOMAINS FOR A SUSTAINABLE CONSTRUCTION SECTOR

Considering the large number of actors involved in the construction process and the different approaches and priorities raised in various countries, there can be many ways to structure the main challenges and general requirements for a sustainable construction sector and a sustainable built environment.
One of them would be to refer to the various Chapters of Agenda 21 which can concern the construction field as listed in Figure 4.
Another would be to refer to national or at least regional contexts and priorities.
The method which has been chosen is more global and takes account of the general comments and conclusions mentioned earlier in this Section.

As a matter of fact, different facets of sustainable construction have been introduced. These facets deal with an economic sustainability (market demand, life cycle economy, future values, construction process and management, ...), a functional sustainability (meeting needs, indoor environment quality, technical performance, durability, ...), an environmental sustainability (natural resources, bio-diversity, tolerance of nature, environmental loads, ...), a social and human sustainability (social stability, built environment, transport, health, aesthetics and cultural aspects, ...).

Consequently, the first section deals with the process and management issues that are raised by the various goals of economic, environmental and social sustainability. It introduces the main barriers to progress and the general challenges.

The second section considers the level of the building itself and the products it uses. It focuses mainly on aspects linked to functional sustainability and technical performances of buildings and products, (meeting current needs, indoor environment quality, durability, performance requirements, manufacturing of products, ...).

The third section deals with the problem of resources consumption (energy, materials, water, land) due to the construction activities and the use of the built environment. It concentrates principally on environmental sustainability.

The fourth section discusses the impact of construction on the development of urban sustainability.

Environmental loads are introduced in a fifth section and some social and economic issues not discussed earlier, are added in a sixth section.

section three

main issues and challenges of sustainable construction

The Objective for the Building Industry

challenges

Responsibilities
- ethical and human rights policies
- high environmental standards in the business

Legal matters

Economic matters Social matters

Political matters

Sustainable aspects on Management and Organisation

Building industry

Actions:

Integrated design process

Improvement of environmental standards

Re-engineering of the building process

Sustainable construction

New building concepts

Sustainability in decision making processes

Education and research

Public awareness

Standard and regulations

Human resources

Barriers to progress:
- defending the status quo
- poor understanding of the problems
- poor vehicles for participation
- market delay, insufficient data
- lack of communication, lack of client
- political insecurity

Sustainable development

3.1 INTRODUCTION

As mentioned earlier, sustainable construction is approached in various ways and with different priorities in different countries. If the main emphasis in national approaches so far has been on ecological impacts on the environment (biodiversity, tolerance of nature and resources), several countries also identify economic, social and cultural considerations as part of their sustainable construction framework.

Many variables and their intrinsic importance differ from country to country. Features such as density and demography of population, national economy and standard of living, geography and natural hazards, availability of land and water, energy production and supply, the structure of the building sector or the quality of the existing building stock, etc., all exercise a degree of influence and interpretation in national approaches.

The main differences should appear at the world level between Northern and Southern regions. Conditions in various regions around the world are vastly different, and an environmental strategy must be tailored to the regional needs, as well as to global concerns, if it is to be acceptable in the region. Some of the main points include:

- Primary environmental problems: in some regions (e.g. China) the main issue is national and regional air pollution which give rise to health risks. In other regions or countries the main priority is water pollution or diminished availability of potable water; in still others, primary issues are a loss of natural habitat, diminution of scarce materials or lack of capacity to handle solid wastes. The variety of problems, and their pressing local importance, should not be allowed to cause global issues to be neglected, primarily greenhouse gas emissions and ozone depletion.
- Strategies for implementation of environmental initiatives must take due account of the economic and industrial context if success is to be achieved. For example, countries with mature market economies may find that measures to alter market demand are the most effective, whereas non-market countries, or those with partially developed market economies, may find regulation a more effective mechanism.
- Another factor to be considered in the development of a strategy is the nature and state of the new and existing building stock. In areas with mature development and low population growth, the main focus may be on developing strategies for enhancing the performance of the existing building stock. In high-growth areas, the improvement of new construction may be the priority.

As a matter of fact, the principal issues and challenges of sustainable construction which are presented below may assume varying importance depending on the regions, countries or even local areas. As far as possible, the degree of criticality of the issue, challenge or problem, the pertinence of the solution and the actions to be favoured will be discussed. But it will mainly be up to local actors to assess these points.

3.2 PROCESS AND MANAGEMENT ISSUES

3.2.1 Objective

Sustainable construction is seen as a way for the building industry to respond to the achievement of sustainable development on the various facets presented in this Agenda.

Management and Organisation is a key aspect of sustainable construction and the subject must engage not only technical issues, but social, legal, economic and political matters as well. It is therefore a very complex and difficult subject to address due to the breadth of their inter-relationships.

However the responsibilities of the building industry within that framework can be summarised under a number of headings such as:

- The need to engage in and with the wider implications of commercial activity
- The need to adopt clear and effective ethical and human rights policies
- The need to adopt high environmental standards throughout the business
- The need to adopt strong environmental management systems through appropriate standards
- The need to be fully part of the region/city/locality in terms of devising and implementing Local Agenda 21 strategies and solutions
- The need to put into practice environmentally oriented design principles.

If we are to manage in a sustainable way then there are many aspects upon which we must be clear. These can be summarised as follows:

- A clear definition and understanding of what we mean by sustainability must be sought
- A philosophy which can lead to an understanding of the relationships between the different complex factors contributing to sustainability must be shared in a public consensus. This aspect cannot be exclusive to the construction industry and its clients alone
- A robust classification system for structuring the problem must be established in such a way that the complex inter-relationships can be modelled so as to aid communication, and

to stimulate understanding and the growth of knowledge
- A set of measures which allows progress to be calibrated and which is related to the aspects above must also be developed. Otherwise how can we know what progress has been achieved?
- A management framework must be developed which allows for planning, design, construction, monitoring and feedback on sustainability as an integral part of the development and occupation cycle. Without this framework the sustainability agenda is sterile and inoperable
- A protocol for decision making must be established within the above framework which challenges those involved in the decision process to respond to sustainability in a positive way. Where appropriate, it must engage the regulatory bodies and the judiciary to enforce the public consensus.

3.2.2 Main barriers to progress

Barriers to progress in that field are essentially linked to:
- professional and institutional inertia defending the status quo
- lack of understanding of the problem among construction professionals
- inadequate or defective vehicles for participation by the stakeholders
- market delay
- insufficient data
- lack of communication between data sets that do exist
- lack of client "Buy in"
- political insecurity (government electoral periods limit the horizon).

3.2.3 Challenges and action

Introduction

At a general level, suggested challenges to be taken up are for instance:

- to develop a consensus around a philosophy and a classification system to aid communication and understanding
- to provide harmony between competing demand (over time) through a holistic approach
- to engage greater participation from all stakeholders both present and future to ensure ownership of the problem
- to develop systems and protocols which provide for endurance through change
- to develop robust evaluation methods to establish current benchmarks and to calibrate and measure progress (wider range of indicators, methods of integration, …)
- to provide a global framework suitable for local conditions in order to allow development of local protocols
- to provide education and training for all participants in the construction and development process.

Design process

Because the design process will increase in importance and complexity there is an urgent need for an integrated approach requiring among others co-engineering partnerships between designers, engineers and manufacturers and the development of advanced (environmental) design tools. Information technology should be used in integrated design models to furnish a seamless flow of information during the life of a project providing continuous feedback loops. This will enable all project participants to work together in exchanging design information and to apply design tools to optimise the design and construction process.

Environmental product information systems and environmental accounting of buildings will assist clients and designers in designing more environmentally friendly buildings. Environmental awareness of architects can also be stimulated by post completion design assessment and feed back as mentioned by several countries.

Environmental quality of construction

Improvement of environmental standards in the construction industry is more difficult than in most other industries, because in almost all countries it is highly varied in the size and skill levels of its constituent organisations and individuals. This increases the difficulty of developing a single integrated strategy to tackle the problems. An essential first step therefore is to carry out an analysis to determine priority targets for improvement. Logically, priority should be given to those parts of the industry with

the greatest environmental impact, possibly linked to the effort and time needed to achieve improvement in that sector. For example, it may be that the irrational development of new construction in the outskirts of urban areas is causing the disappearance of valuable agricultural land and disrupting ecological features. If such development is led by a few major firms, the solution may be technically (if not politically) easy, simply by introducing a system of regulations and incentives. On the other hand, if inappropriate construction techniques are widely used by a large segment of construction workers, a solution to change industry culture will take correspondingly more time and effort.

Re-engineering of the building process

A substantial number of challenges deals with the re-engineering of the building process. Important business opportunities can be such as:

- increased partnership between designers, contractors and manufacturers; new methods of procurement
- better management of the building process through total quality management and improved project co-ordination facilities
- specialisation in specific market segments (e.g. refurbishment) or construction systems (e.g. robotic construction)
- opportunities for recycling (in particular in the developing economies) and brokering services.

New building concepts

The penetration of new technologies will also lead to new building concepts. A closer co-operation between architects and building material manufacturers is expected in product development. As a consequence subsystems will become fully integrated in building components for roofs and facades (function integrated systems).

Human Resources

On the building sites specialised jobs should gradually disappear in favour of multi-skilled autonomous teams. The emphasis should lie on assembly and disassembly techniques and the ability to handle both new and traditional materials.

The building process itself will become more complicated demanding a high level of management skills and integrated knowledge of the whole process (life cycle thinking). Information technology will impact on all aspects of the building process, requiring the skills necessary to cope with this level of information transfer.

Increasingly, new forms of partnership should be adopted like design build and operating contracting. Professional barriers will become less important and the focus will be on risk management.

Total quality management and better use of feedback mechanisms should be used to improve the performance of all partners involved in the process.

Decision making processes

The incorporation of sustainability into the decision making process requires:

- public participation
- new decision support systems fully utilising information technology
- skills in negotiating and facilitating.

The building owners' and clients' demand poses a major challenge to be confronted, since this will lead to progress in all processes and by all actors. What is lacking today is a set of tools for setting the sustainability requirements and for managing their fulfilment.

Education

To overcome professional barriers and to improve knowledge on the cause-effect relationship of decisions taken, interdisciplinary education of designers and construction engineers is needed. This refers in particular to specialisation in environmental issues.

Other important groups of actors featuring in the area of better training in environmental matters are building owners, building operators and facility managers.

A consensus emerges about the need for an improved education of facility managers and building owners with respect to environmental issues, leading to recommendations such as:

- use of feedback mechanism to increase awareness
- use of facilities maintenance and management systems, manuals and guides
- adoption of performance standards for existing buildings.

Public awareness

Full acceptance of the concept of sustainability by the public at large can be achieved by demonstration projects and information campaigns. Incorporation of environmental costs in the tax system may also contribute to a greater awareness.

Standards and regulations

Sustainability is a new aspect among the many issues governing decision making in the building process. This requires more specialisation of stakeholders in environmental matters. Eco-labelling, certification and environmental standards are mentioned by many people as an expedient to that cause.

To render the environmental performance measurable and certifiable, more tools are needed such as:

- performance based standards in the building codes
- 'green' certification and eco-labelling systems based on Life Cycle Analysis.

In some countries standards will have to be adapted to suit local traditions and indigenous building technologies.

Research

Research and development activities are major tools for innovation. A host of technical challenges are faced by experts in order to produce environmental quality for buildings and their components. Many of them will be detailed in the following sections. Some non-exhaustive examples of such challenges are given in Figure 9 in Chapter 4.

3.3 PRODUCT AND BUILDING ISSUES

3.3.1 Overview

It is no easy matter to generalise about the characteristics of buildings being produced in a wide variety of regions. As a principle, however, the development of a strategy for improving sustainability performance must take into account background factors of climate, culture, building traditions and stage of industrial development, all of which will place constraints on the types of solutions developed. In some cases, there are multiple streams of factors at work, as in many Asian countries where traditional forms and norms of building co-exist alongside extremely technologically sophisticated approaches. In general terms, any approach which involves solutions that run contrary to local norms will fail, or will require considerable effort over a long period of time. An effective approach, therefore, will consist in analysing the characteristics embodied in current industry norms, and in developing a strategy that achieves most of the objectives without significantly deviating from regional norms.

3.3.2 An outline of issue areas in the building sector

A framework of relevant issue areas may be useful in carrying out an analysis of existing performance, or for specifying the performance of buildings. It should be based on the assumption that a sustainable building approach includes at the least consideration of all factors that may affect the natural environment or human health.

The framework thus comprises a wide variety of factors, some of them technical and others related to human behaviour and response. It should also be noted that some are quite general and deceptively simple - for example, *suitability for intended purpose* may appear out of place in a framework dealing with environmental issues, but it is quite clear that excessively large houses (e.g. in North America) or public buildings (e.g. everywhere) exercise

a significant environmental impact on the need for more materials and increased operating energy and emissions. Similarly, one *loading on community and region* are the increased automobile traffic, infrastructure needs and regional air pollution caused if the building is located in a low-density suburb where public transport is uneconomical.

Among many others, such a framework for the assessment of performance of buildings is the GBC[16] Framework, which includes factors such as :

- Resource Inputs
- Energy
- Materials
- Water
- Land
- Capital and operating in vestments
- Functionality or Level of Service
- Suitability for intended purpose
- Flexibility, adaptability and durability
- Maintenance of perfor mance
- Quality of Indoor Environment
- Air quality and ventilation
- Thermal comfort
- Illumination and day-lighting
- Noise and acoustics
- Controllability of systems
- Environmental Loads
- Loads on site and adjacent areas
- Loads on community and region
- Regional air pollution
- Ozone depletion
- Greenhouse gases
- Management
- Planning of construction process
- Planning of building opera tions
- Management of building operations
- Building maintenance.

3.3.3. Indoor Environment Quality

Objective

In the Rio Declaration, the first principle states that "Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature". Basically the main goal of buildings is to provide a more fitting environment for humans than the ambient environment.

Many people stress the importance of safeguarding Indoor Air Quality (IAQ) and climate in connection with the strong penetration by energy saving technology in building design.

However, health aspects of the indoor environment are not only related to energy conservation measures, but can also be influenced by new building materials and techni-

[16] GBC: Green Building Challenge (Natural Resources Canada)

ques. Also changes in the thermal and acoustic indoor environment, besides lighting etc, might be of importance.

In Scandinavia for instance there is quite a number of buildings with odour problems and "Sick Building Syndrome" (SBS) of the occupants where the deposit of emission products had not been anticipated.

Many people around the world have become aware that productivity is dependent on a good indoor environment. This is why the expression Indoor Air Quality (IAQ) seems on the way to being replaced with Indoor Environment Quality (IEQ).

In most buildings in the service industry, wages and wage-related costs represent 85 to 90% of the total costs per workstation, and the increase in value is completely dominating the total economy. Our most important challenge in planning new and refurbishing old buildings is to create an environment that is ideal for productivity as well as for comfort.

Therefore sustainable development for buildings should be defined in such a way that a quality indoor environment is a primary component. Moreover, sustainable development should not be considered as having been attained unless and until the quality of the indoor environment in buildings meets commonly accepted standards.

An important dimension in the application of sustainable development principles to the building sector is that which concerns health risks as they relate to the occupation of buildings. Today we are constructing buildings that will still be used in decades to come, and the recent examples of public health crises related to buildings oblige us to adopt a cautious approach based on the analysis and management of the risks involved, and driving us closer towards the mythical “zero risk” level.

Due to indoor contamination sources of different kinds, the indoor air is as a rule more polluted than the ambient air. The sources of contaminants are, broadly speaking, all materials which we have indoors, building materials, fittings, furnishings, consumer products etc. Not least are we - the occupants, with all our activities - major contributors to the contamination. Cleaning, cooking, painting, gluing, using deodorants and perfumes and other body care products all exert a negative effect. Lastly the biological metabolism itself makes contributions which should be eliminated.

State of the art

Air quality problems are reported in many developed countries, linked or not to a lack of ventilation. Major health problems, due for example to asbestos, lead paint or wood dust, are also recognised and are under treatment. Public awareness and sensitivity to these health aspects are growing rapidly and

must be accorded appropriate consideration.

It is an undisputed fact that IEQ in many countries has declined precipitously, even as the outdoor environment has improved due to stringent air emission standards. In the US, for example, as many as one half of all buildings are estimated to have significant indoor environment problems; the US Environmental Protection Agency further estimates that the indoor environment may be as much as ten times more contaminated than its outdoor counterpart. The statistics over the past 25 years paint a dramatic contrast. While gross domestic product increased by 99 percent in the US, emissions of the six leading air pollutants declined by almost 30 percent. In effect, the environmental problem has shifted from the outside to the indoor environment.

Indoor climate has become more important for health and comfort during recent years. As people remain indoors for approximately 90% of the time, the quality of indoor air is even more important for health than outdoor air. Good indoor climate reduces illness and the symptoms of sick building syndrome. It also influences comfort and working efficiency. For example, the costs caused by poor indoor climate in the Finnish building stock has been estimated to correspond to the costs of energy consumption of buildings.

Good indoor climate is one of the most important factors in assessing the quality of a building. Research and practice have, unfortunately, shown that good indoor climate is not always achieved. Indoor climate is influenced simultaneously by several factors, such as heating, ventilation and air conditioning, construction methods and materials, operation, maintenance and use of buildings.

Health effects due to inferior IEQ are of profound societal importance. Today decreased IAQ is reckoned among the prime suspects in the rise in the incidence and prevalence of allergic illnesses (from a few percent in 1950 to almost half the population in 2000). IAQ also is a main suspect as an important factor behind the high prevalence of airways infections (especially among children), and of lung cancer (radon, ETS), besides SBS. In total a majority of the population is involved. The cost of negative health effects, reduced productivity and other aspects on the economy attributable to inadequate IEQ is very great, exceeding in fact by several orders of magnitude the cost of energy consumption or cleaning.

Major challenges

The main goal should be to obtain the best internal environment quality including indoor air quality, thermal, acoustic and lighting environment. Both the design of the mechanical environment and aesthetic factors are significant

components of an environmental plan, eventually also including work-stress and psychological factors of different kinds.

The following areas can be identified as having a potential effect on air quality for people, especially for children and female office workers:

- dust and particulate matter generated during construction/ reconstruction
- inadequate ventilation and damp buildings
- the quality and design of air handling equipment
- maintenance procedures
- selection of interior building materials and furnishings
- emissions from office equipment, e.g. copy machines and laser printers.

Health risk assessment implies inventarising the various families of contaminants and sources of contaminants that can be found in buildings, some important examples of which are: nitrogen oxides given off by heating appliances and gas cookers, and also by people through cigarette smoking; chemical atmospheric pollutants, which are also found in buildings; biocontamination of the air by all families of micro-organisms present in the air; allergens associated with complex mixtures of pollutants; radon, which can be concentrated in homes.

In view of the fact that this environment is particularly vulnerable to the outbreak of public health crises and due to the numerous inherent uncertainties, methods for the assessment and management of risks have to be used. Much work remains to be carried out before they can be capable of formulating the priorities for defining risk management. In this situation, the possible recommendations must be considered in strategic rather than operational terms.

In particular, it appears important to create exchange sites where building trade professionals, users and public health professionals can learn to work together towards developing monitoring and warning procedures, capacities for informing the public and the players concerned, and also recommendations to enable public powers to act according to needs and constraints. At the same time the complete independence of their scientific expertise must be ensured by an appropriate status.

- Better thermal comfort, acoustic insulation and lighting conditions are three main additional challenges that confront building designers, researchers and industry. These have been traditional fields of development for several years which must not be forgotten when dealing with Internal Environment Quality, since many innovations, linked for instance to the control of ambiences in developed countries and to meeting basic needs in developing countries, are still needed.

3.3.4 Manufacturing of products

The construction industry is a large consumer of energy-intensive manufactured materials such as iron, steel and cement for structural elements, glass for windows, and synthetic materials for sealing and insulation.

The environmental issues directly related to the production of these materials are, of course, matters for the industries which produce them. With the exception of certain products such as cement, they are not specific to construction. However, through large scale use of materials, construction is contributing to the depletion of non-renewable resources. It is for this reason that the environmental aspects of material use in construction will be treated subsequently in a specific chapter.

As far as the manufacture of products is concerned, the significant issues are:

- reducing the embodied amount of material and energy of the products (renewable raw materials, low-energy recycling, increasing durability and technical life expectancy)
- low emissions from products in use (environmentally friendly coatings, pre-treatment)
- repairability (design for disassembly and repair in the factory) and recyclability (used products to be returned to their producer; product stewardship).

To reach these goals, designers and building material manufacturers should co-operate closely in developing new building concepts (lightweight components and new jointing and assembly techniques). Moreover, a better co-operation with related industries (e.g. plastic manufacturers, building services manufacturers) will promote the development of a new range of function integrated building components.

To assist in the selection of building materials, environmental labels should be introduced for the purpose of identifying such factors as expected service life, embodied energy, composition and recyclability.

The energy-reduction targets offer ample opportunities for innovative products in the fields of heating, cooling, ventilation, lighting and thermal insulation.

What can be expected is an increased responsibility on the part of manufacturers for their products from cradle to grave. This being more real than imaginary will result in strong pressure being put on manufacturers to develop:

- new materials, recycled or made from renewable resources
- plug-in systems, easy to disassemble and re-use
- standardisation and modularity of components
- improved tools for the prediction of service life of components and systems
- new logistics for closed-loop recycling

- on-line product information systems (Internet).

Concern for the total environmental quality is gradually becoming more significant as natural resources, which are essential for the survival of mankind and his habitat, are being depleted at the current rate. The primary aim is to alleviate the adverse effects of artificial processes on the natural environment to restore the ecological balance.

In the context of buildings, as a component of the artificial environment, the three interrelated domains involved are the projects, elements and phases of the conceptual building model. It is necessary to subject these to a searching examination in terms of medium and effect oriented impact criteria based on mass and energy flows which manifest cumulative effects at local, regional and global scales. Certain criteria pertain to more than one building attribute while one attribute itself may also be evaluated by more than one criterion.

Life Cycle Assessment (LCA) according to an established method is one way to reach satisfactory and comparable results regarding environmental (and health) impact from emissions, raw material use and energy consumption, independent of material or construction. The results can be used for environmental product declarations, process and product improvement analysis, as a tool in the IS0 14000 work and other environmental work where the industry has to be competitive and fulfil external demands.

The construction and material manufacturing industries are perceived to be polluting industries. Consequently, it is very important to collect objective environmental information and environmental impact life-cycle data about construction materials and products, and to disseminate it among those with the capacity to influence the choice of constructions and materials, and by that the environmental situation of tomorrow.

However the greatest problem encountered when utilising LCA to answer building products Environmental Quality (EQ) questions is the widening gap between its outputs - and time requirements, and the complex and broad context of the reality in which some kind of decision-making is taking place which calls for insights into products' EQ.

As a matter of fact actors do want a risk analysis of building products. Since this procedure does not match exactly the same line of thoughts as LCA, it is suggested to merge the LCA with a Risk Analysis approach. This could help to provide usable answers to the questions asked. The constraints have mostly to deal with transparency on assumptions made, indications of possible bias, uncertainties and their consequences and of

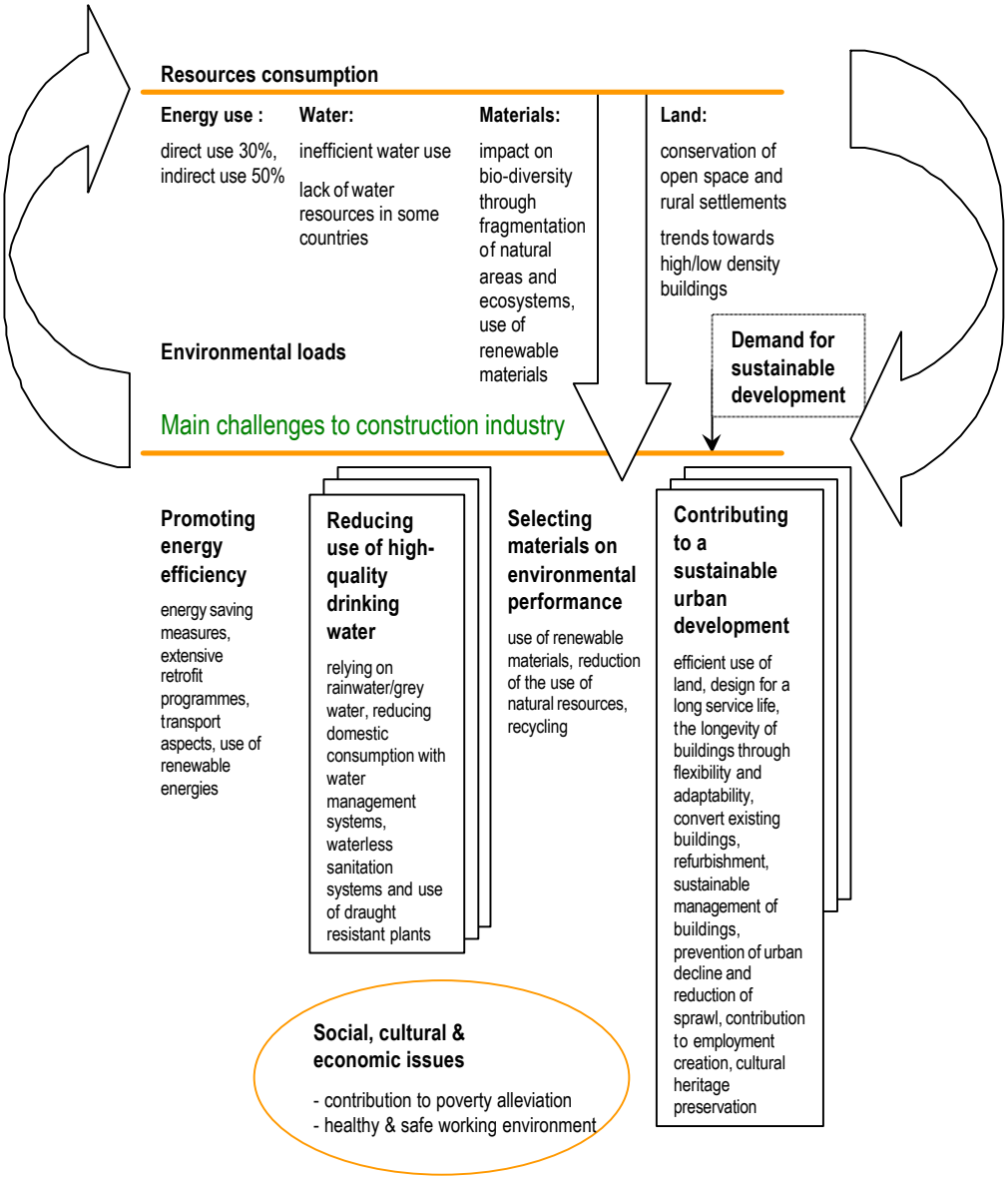
limitations on the depth of the review and significance of results, etc.

3.3.5 Buildings

One of the main tools hitherto developed as a means to increase the sustainability quality of construction is the refinement of building environmental performance assessment methods. By increasing the number of parameters to be taken into account, these methods have made a pre-eminent contribution towards a broader understanding of environmental quality.

However, since the notion of performance can take on different facets due to the various interests and requirements proposed by the different actors, these methods assume various roles in the process, consider various ranges of environmental/sustainability issues, introduce various ways of rating the performance and communicating the results.

Consequently, what has tended to occur up to now is that these methods are frequently subject to limitations because they have conceptually specific levels of assessment and output, they hardly accommodate national or regional variations, they have different measurement scales and weighting of criteria, ... There has been increased effort to establish some degree of standardisation of methodologies, but this presupposes that there is an agreement on what constitutes "performance". Other needs are linked to a wider understanding of sustainability, to the occupant's expectations and use patterns and the formulation of agreements about the type and number of assessment criteria (indicators) as well as the format that criteria and assessment protocols, procedures, methodologies take, while accommodating specificities due to regional aspects or project types.



Issues and Challenges of Sustainable Construction

3.4 RESOURCES CONSUMPTION

3.4.1 Energy

State of the art

Energy use, which is the basic driving force behind climate change and a number of air pollution problems, remains at a consistently high level all over the world. If in the European Union and the New Independent States, energy consumption has fallen by 23% since 1990 as a result of economic restructuring, it is expected to rise again as economic resurgence takes off. Greater efficiency in the production and use of energy is a key requirement for a more sustainable energy policy. Relatively low energy prices have not succeeded in generating sufficient stimulus for energy efficiency improvements in several countries such as in Western Europe, where currently energy efficiency is improving by only about 1% per year, while GDP is continuing to grow by about 2 to 3% per year.

Considerable scope exists for further improvement in energy efficiency in Western Europe, particularly in the transport and household sectors, but experience suggests that, while fossil fuel prices remain depressed, more vigorous policy measures will be needed to achieve such improvement. In Eastern Europe, economic convergence with the West could reverse the current trend towards lower energy consumption and lead to a resumption of growth in emissions of greenhouse gases and other air pollutants, particularly in the industrial, transport and household sectors. So here, too, new measures to promote energy efficiency in the production and consumption of energy are likely to be needed.

Although the figure differs from country to country, buildings use about 30% of total energy directly, but if the indirect use is included the proportion is closer to 50%. If the impact on local pollution is not the problem as it is for transport in cities, it is self evident then that the impact on the global environment is equally profound. The resolutions of the Kyoto Conference provide sufficient cause for concern in many countries as to how the goals can be met, but the situation could well arise whereby long before 2010 arrives the CO_2 reductions are deemed not to be sufficiently stringent, with the consequence that all aspects of the economy will be stretched to find the most efficient ways to reduce energy demand, especially fossil fuels.

Demand-side measures in the building sector have been elaborated over several years in many developed countries. However, the main focus has been put on rational use of energy in new buildings. Although the potentials for energy saving within the existing building

stock are quite high, the topic of improvement of the energy performance of existing buildings is given serious consideration only by a small number of countries. There is a need for new retrofit technologies that are economically affordable to building owners. A major effort is needed now in the existing stock, especially because the low energy prices which we are currently witnessing act as a powerful disincentive when it comes to saving energy. In the developing countries, there should be a similar thrust where space heating is needed.

The use of renewable energies in most countries has yet to advance beyond the research stage. However several good quality products are now available and the only impediment to their wider use are economic constraints.

Main challenges

Energy saving measures

Emerging new energy saving technologies marked out for success in the next decade involve super insulation, passive heating/cooling, day lighting/passive lighting together with the use of renewable energy sources. These technologies will require new designs of roof, facade and foundations (e.g. for heat/cold storage). Another consequence is that architects and designers should integrate their building and system designs thereby allowing easy retrofit of these components during the lifetime of the building.

A high demand for energy saving technologies is identified. Systems that should be introduced in the near future are for instance:

- heat recovery and storage
- small CHP-units
- electrical heat pumps
- PV-cells
- passive and hybrid technologies for heating and cooling
- passive lighting systems
- translucent insulation
- advanced sensor technology and building domotics
- new acoustic/thermal insulation materials and systems.

The demand will not only focus on new buildings but also on the existing stock. The consequence will be that the developed systems must also be easily retrofitted in the existing building fabric.

Extensive retrofit programmes

The widening gap between the energy performance of old and new buildings calls for extensive retrofit programmes and organisation and management procedures:

- retrofit of installations
- domotics and energy management systems
- extended use of day lighting
- better control of indoor air quality, noise and health risks.

What should be avoided, especially in the mass housing market, is the continued use of high technology production systems and materials with high embodied energy and poor energy saving attributes.

Transport aspects

It is anticipated that energy conservation at the level of districts or whole cities will come to rely more on local sources and renewable sources. The main issue will be the upgrading of the energy performance of the existing building stock. New developments are expected for autonomous or self-sufficient buildings with respect to energy supply. An issue in several developing countries is the provision of energy for cooking and heating to the disadvantaged in a socially and economically sustainable way.

In the next decade traffic reduction should be an important issue. Transport infrastructure should be an integral part of site development along with advanced public transport systems. Information technology should be used to optimise the capacity of existing transportation networks. In the emerging economies if there is a need for modernisation of the transport networks the aim should also be to localise resource use in order to cut down on the needs for more super highways.

The minimisation of transportation needs for construction and deconstruction is also a not insignificant issue as regards potential for cost-saving.

3.4.2 Materials

State of the art

Bio-diversity involves maintaining the natural growth of renewable materials and the conservation of the life support function of nature including the biochemical processes essential for life (decomposition, regeneration and oxygen production). Construction work exerts a direct impact on bio-diversity through fragmentation of natural areas and ecosystems.

Mineral resources are consumed in large quantities in the built environment. Most of these resources are non renewable and require efficient use combined with closed-loop recycling.

Therefore the reduction in the use of natural resources and the conservation of the life support function of the environment by construction processes are important objectives.

Use of renewable or recycled materials is not common nowadays in the construction industry. A major exception is the reuse of construction and demolition waste as aggregates in road constructions for sub-base layers and in concrete. In several countries 85% is recycled in this way. In addition to the technical quality, the environmental properties of the aggregates are also investigated. The demolition process and the upgrading of the out-coming waste have to be executed in such a way as not to

pollute the recycled aggregates with, for example, asbestos or heavy metals.

Another example is the recycling of reinforced concrete in Sweden. A far from negligible number of residential buildings dating from 1960-75 have recently been demolished, usually in areas where there is little work. Other demolition projects have included older factories, bridges, hospitals and so on. From some of them, almost all the concrete has been completely recycled.

The interest in using recycled materials as integral components of concrete is well-documented. Recycled concrete, masonry block, brick, recycled post-consumer wood and rubber have been evaluated as "aggregates" and additives for concrete as a construction material. Fly ash, which is a by-product of the coal combustion process, has been used as a filler, cement replacement, and even palletised as an aggregate for concrete.

Some countries are well advanced in recycling. For example, in Sweden, about 90 per cent of all natural stone, sand and gravel in the construction and heavy engineering sector is re-used. Asphalt is for 60 per cent reused and wood is for about 80 per cent converted into energy. Concrete waste, on the other hand, is only 20 per cent re-used. In an average year, 6 million tonnes of waste are released by the alteration and demolition of roads, installations and buildings. Of this, 43 per cent is reused, 7 per cent is recycled, 5 per cent is incinerated for energy-production and 45 per cent is dumped or landfilled.

Main challenges

Introduction

The difference between countries with respect to the environmental performance of building materials and the recycling of building and demolition waste is not very large. The main topics involved are renewable materials, recyclable/reusable materials, easy disassembly, standardised dimensions, low embodied energy and non-toxic materials.

The advantage of the emerging economies and the developing economies is that they already have a long history in the use of traditional materials, many of which are sustainable. The aim is to continue this tradition in order to prevent problems from arising in the first place.

The developing world aims to improve the life expectancy of indigenous building technologies and materials and to ensure that labour intensive materials and methods remain in use. Although, to cope with housing shortages mass-produced units utilising high energy building systems will still be needed.

At the initiative and design phases

The selection of materials should

be based on their environmental performance, on their individual service life and on their health consequences. Optimisation can take place using eco-balance tools. Jointing and assembly should be designed to allow for easy disassembly (reversible building process).

In the developing countries a balance should be sought between improved indigenous technologies (self-built) and mass-produced units (prefab) in order to cope with the housing demand. In these countries there is also a need to improve the life expectancy of indigenous building technologies and materials, instead of replacing them with alien technology.

At the construction and deconstruction phases

For building contractors the challenges pertain mostly to material use and facilitation of material recycling:

- use of local materials and reuse of serviceable building parts
- construction for disassembly using modular approaches
- labelling of components to facilitate selective removal and recycling
- introduction of quality standards for recycled materials
- producing operating and maintenance manuals for buildings and systems.

In the developing world the creation of jobs is important and, where appropriate, contractors should use more labour intensive construction methods and improved indigenous materials.

In developed countries, an additional challenge is the prediction of service life. The building structure is one of the most important areas in a society. In the developed countries, the building stock and infrastructure constitute more than 50 per cent of each country's real capital. To pursue sustainable development and make maintenance more efficient and reduce costs, there is a need to predict the service life of building components and materials. Service life is defined as the "period of time after installation during which all conditions of a building or a building part meet or exceed the performance requirements".

It is expected that the importance of renewal engineering will exceed that of new constructions at least in the developed market economies. Opportunities for contractors lie in:

- developing refurbishment processes which cause minimal disruption to occupants and the immediate environment
- developing modular systems for refurbishment.

Demolition contractors should develop new deconstruction and stripping techniques to facilitate optimal recycling and re-use of building materials.

At last, since major efforts are needed to upgrade the ageing under-

ground infrastructure (sewage systems, water supply networks, etc), new in-situ environmentally friendly repair techniques should be developed. In the developing world the emphasis should be on catching up with the backlog of infrastructure provisions and installing more sustainable options at the start.

At the manufacturers' level

The expectation is for an increased responsibility of manufacturers for their products from cradle to grave (see §3.3.4).

3.4.3 Water

State of the art

Lack of water resources in many countries, leakage from distribution systems in other ones, and inefficient water use in all countries are problems which continue to grow. To reduce the maximum admissible concentration of lead in urban waste due to domestic lead piping is also an objective.

This topic is receiving increasing attention at least in highly populated countries and developing countries (like South Africa and Malaysia). Both new and existing settlements should reduce their consumption of high quality drinking water by relying more on rainwater and the cascade use of drinking water. Most countries are concerned with urban water management and groundwater protection. The major issues are to create closed water systems and to reduce urban run-off (porous brick paves).

Everyday domestic consumption may admittedly be relatively modest when compared to industrial demand, but citizens and industrialists can still do their bit by saving water at home. Few countries have already considered water management measures at the level of the buildings. However, some attempts and development of systems do exist.

Main challenges

Drinking water conservation and reduction of sewage water can be helped through water saving equipment in new buildings. Water management in existing buildings may well also lead to substantial savings. Possible water saving equipment are rainwater and grey water storage and use facilities together with water saving guidelines for building managers. This includes rainwater storage systems, low flow showerheads, dual flush toilets and self-composting toilets.

In some countries where water resources are very scarce, the focus should also be on waterless sanitation systems and landscaping with drought resistant plants.

3.4.4 Land

The prevention of urban decline and the reduction of urban sprawl are concerns expressed by most countries. In the Western and Eas-

tern European countries, conservation of open space and safeguarding the structure of rural settlements are major issues. Some divergence is noticeable between high-density building versus low-density building. In highly urbanised countries (e.g. the Netherlands) there is a tendency towards high density building while in other countries with high density megacities (e.g. Japan and Greece) the move is towards low density building. Efficient use of land is sought in increasing the longevity of new buildings through flexibility and adaptability and more refurbishment activities to increase the life span of existing buildings.

To achieve social and economic equity, in some countries such as South Africa, city planners will have to deal with new concepts that integrate the current spatial and racial segregation into viable city structures.

The issues with respect to the use of land address three aspects:
- efficient use of land
- design for long service life
- adaptation/conversion of existing buildings.

The choice of site and land use not only entails local environmental effects, but also social and economic impacts. Efficient use of land appears to be vital for those countries where population density is high and mainly confined to urban areas (e.g. the Netherlands, South Africa, Malaysia). Solutions are sought in buildings combining more functions simultaneously, better use of the underground (industrial/ commercial buildings) and optimising the use of the roof surface (parking, recreation).

Improving the longevity of new buildings is also a concern for most countries as a means to conserve space and to stem the need of new land for development. Consequences are:
- design for flexibility and adaptability including support/fit-out modularity
- better use of (environmental) life cycle costing techniques and quality control
- better understanding of the needs and requirements of future users.

To extend the service life of existing buildings, refurbishment and retrofit activities will increase substantially requiring in turn new technologies like lightweight constructions for building extension and new tools like decision support systems (refurbishment / redestination versus demolition) and condition assessment techniques.

Topics often mentioned also are:
- improved site management to protect nature
- redevelopment of heavily polluted or derelict areas.

Sustainable management of buildings also implies the extension of the service life of buildings in order to prevent the uptake of more land for new developments. For

building managers, the following issues should be considered:

- adapt buildings for the future needs of occupants
- re-commission old non-functioning buildings for new functions
- consider within both an ecological and economic context the benefits of decommissioning versus regeneration
- use planned maintenance and refurbishment programmes.

The indirect use of land for the production of building materials is extensive. Large scale quarrying of minerals for the construction industry in densely populated areas may lead to unacceptable loss of natural areas. The challenge on that score is to improve the environmental performance of building materials by:

- use of renewable materials and the use of local resources
- considering full life cycle energy cost
- improved durability
- low emissions during use
- recyclability.

For components that can be easily reused, the first priority is durability and long service life. For components that are difficult to reuse the requirement will be easy biodegradability.

Most countries stress the need for efficient use of land and the conservation of open space and the structure of existing settlements. The consequences for the built environment and city planners can be summarised as follows: Better use of available space within the city limits leading to:

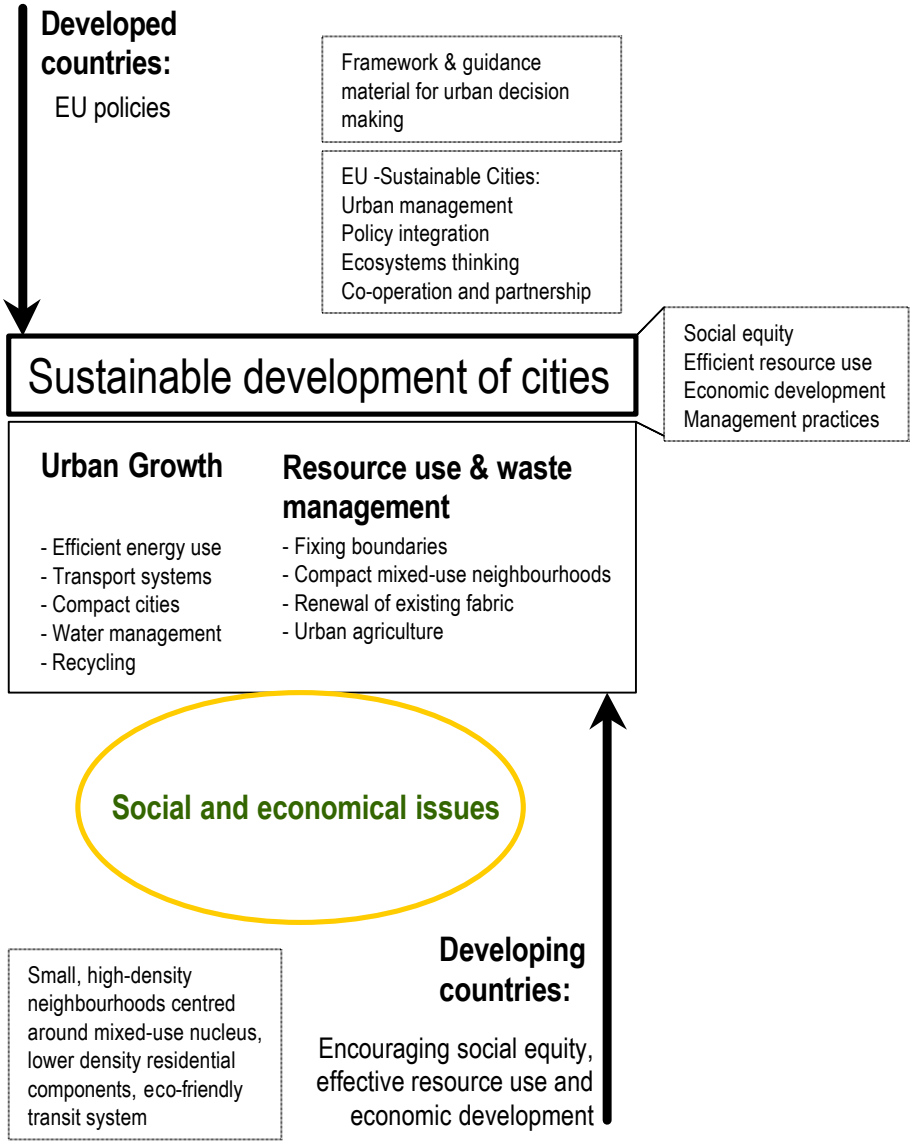
- restricting urban sprawl and avoiding fragmentation of the countryside
- remediation of brownfield sites involving new soil cleaning technologies
- adaptation and regeneration of the existing built environment taking account of future needs.

Countries with a high degree of urbanisation and a high population density like the Netherlands and Japan expect a more intensive use of land involving underground building and the double use of land thus simultaneously creating new open space for recreation.

Compact communities where housing, work, services, facilities and public transports are all within walking distance will emerge. Some of these will be developed as self-sufficient settlements with ecological closed-loop systems.

The separation on racial and economic lines confronts some countries with the special concern of spatial integration of employment and residence. Development corridors should be used to integrate the various areas into one metropolitan management structure and should contribute to social sustainability and improved service delivery. Urban agriculture should be actively encouraged to compensate for the loss of land through urbanisation.

Issues of Sustainable Urban Development



3.5 CONSTRUCTION IMPACTS ON SUSTAINABLE URBAN DEVELOPMENT

In the context of achieving Sustainable Development continuing urbanisation reinforces the importance of creating a built environment that is sustainable for future generations.

It must be emphasised that the built environment constitutes one of the main supports for economic development and social well being. The provision of infrastructure, buildings and utilities are major resources that are used by nations, communities and business. As a result of inputs to the industry the use of resources such as land, materials, energy, and water have significant impacts on the urban environment. The demand for labour - the human capital - also makes demands on the urban environment by requiring good communication links and ease of transport for goods and services.

There is general agreement that the criteria for sustainable cities or settlements describe a city that protects its life support systems, bio-diversity and cultural environment, minimises pollution and uses resources efficiently. A sustainable city should also provide equitable economic opportunities for all, ensure equal distribution of responsibility and benefits, follow ethical business practice and support local economies. Furthermore, it should strive towards improving the quality of life for all its citizens through the provision of a good quality environment and opportunity for self-improvement. Finally it should encourage social equality and cultural integrity.

For example, as far as the quality of urban development is concerned, this includes: investment, planning and regeneration policies; integration of transport and service infrastructures; provision for safe and secure environments; health and welfare provision; access to education and leisure facilities. In addition to these tangible and measurable factors there is a need to stimulate participation from a wide range of stakeholders, increase public and private sector partnerships, integrate decision making structures and provide indicators of success that are transparent and meaningful throughout the planning and development process. Ownership and conditions of tenure are crucial factors which can encourage participation and a sense of belonging in urban development. Equally they can lead to social exclusion.

Taking all these aspects into account, it is clear that the whole construction industry has then a significant impact, both directly and indirectly, on achieving Sustainable Development in the urban environment.

3.5.1 Main issues for built environment sustainability

Considering the various aspects of sustainable urban development, a host of issues can be mentioned as far as the built environment is concerned. Without going into details, major issues are linked to environment quality (reduction of nuisances such as waste, acoustic nuisances and air pollution, management of resources such as water, energy, materials and land, management of risks such as natural risks or soil pollution), to life quality (accessibility to services, public space quality, cultural heritage, density, transport, local life, ...), to dwelling quality (global comfort, indoor environment quality and health, operating costs, social policy, ...) and to governance aspects.

Among these numerous issues, urban growth resource use and waste management are rather universal and justify more detailed treatment.

Urban growth

Every year in the world 20 million people migrate to the cities. There are already 20 "megacities" of over 10 million people. Of the 25 largest cities in the world, 19 are in the developing world. This kind of urban growth destroys valuable and increasingly scarce agricultural land, places a tremendous burden on local resources, creates health hazards through high pollution levels and gives rise to social problems, especially in developing countries where many migrants to cities live in absolute poverty and in unhealthy, overcrowded conditions. Urban growth also places pressure on existing infrastructure, causes transportation headaches and increases the amount of waste produced.

There are various remedies suggested for curbing urban sprawl and the negative effects of urban growth. These include fixing urban growth boundaries, encouraging compact, mixed-use neighbourhoods and multi-nuclei cities, the recycling or renewing of the existing urban fabric, and facilitating urban agriculture. These remedies can, however, lead to other problems and should be applied with care (see also § 3.4.4).

Resource use and waste management

The main environmental criticism levelled against cities regards their profligate use of resources and the fact that cities have a linear metabolism. Cities are huge consumers of water, electricity, fossil fuels and nutrients. A view is that an ideal sustainable city should have a circular metabolism where it uses only local resources (reducing its environmental footprint) and all wastes are recycled back into the system. While large Chinese cities like Shanghai have been able to sustain this way of living until fairly recently, pressure for urbanisation and global trade is destroying their sustainability, while easier accessible forms of energy like coal, are

creating tremendous pollution problems.

The remedies for more sustainable resource utilisation includes more efficient energy use and utilising energy from renewable resources; more efficient public transport systems and more compact cities to reduce consumption of fossil fuels through automobile traffic; water management through appropriate landscaping and more efficient reticulation systems, grey water management and reduced lot sizes; and efficient recycling, not just of inorganic waste (glass, metal, plastics), but also of organic waste, including sewage.

Two examples of approaches for sustainable cities or settlements are reported in the following sections. The first one deals with an Action Plan proposed in developed countries, the second one deals with sustainable settlements in developing countries.

3.5.2 Towards an Urban Agenda in the European Union

An Expert Group on the Urban Environment was established by the European Commission in 1991. In 1993, they launched the Sustainable Cities Project, focusing on sustainable urban development and the integration of environmental objectives in planning and management strategies. The main output of the project, "The European Sustainable Cities Report", provides a framework for local action and identifies a set of principles for application in setting goals and in evaluating and monitoring progress towards sustainability in urban areas.

The four principles are:

1. The principle of urban management

Management for sustainability is essentially a political process that requires planning and has an impact on urban governance. The process of urban management demands a range of tools addressing environmental, social and economic concerns in order to provide the necessary basis for integration. By applying these tools, urban policy making for sustainability can become broader, more powerful and more ambitious than has been generally recognised.

2. The principle of policy integration

Co-ordination and integration are to be achieved through combining the subsidiarity principle with the wider concept of shared responsibility. Integration should be achieved both horizontally, to stimulate synergetic effects of social, environmental and economic dimensions of sustainability, and vertically, between all levels of the European Union, Member States and regional and local governments to attain greater coherence of policy and action and to avoid contradictory policies at different levels.

3. The principle of ecosystems thinking

Ecosystems thinking emphasises the city as a complex system which is characterised by flows as continuous processes of change and development. It regards aspects such as energy, natural resources and waste production as chains of activities that require maintenance, restoration, stimulation and closure in order to contribute to sustainable development. "Ecosystems thinking" also includes a social dimension, which considers each city as a social ecosystem.

4. The principle of co-operation and partnership

Sustainability is a shared responsibility. Co-operation and partnership between different levels, organisations and interests is therefore crucial. Sustainable management is a learning process, within which "learning by doing", sharing experiences, professional education and training, cross-disciplinary working, partnerships and networks, community consultation and participation, innovative educational mechanisms and awareness raising are key elements.

In 1997 the Commission adopted the Communication "Towards an Urban Agenda in the European Union". The Commission indicated its intention to examine EU policies from the point of view of their urban impact and to improve policy integration at urban level. Reactions from EU Institutions, the Ministers' Regional Policy and Spatial Planning at their informal meetings and outside organisations have been very positive and the Commission has been urged to take further steps.

Many EU policies have, de facto, an important urban relevance that the EU cannot ignore. The Community has a responsibility to ensure that Community policies become more effective by taking closer account of the potential of urban areas and the challenges facing them.

The launch of the Communication from the Commission "Sustainable Urban Development in the European Union: A Framework for Action EU policy embraces" confirms the Commissions' commitment to make EU policies more "urban sensitive." Whilst there is no attempt to attain new responsibilities for urban matters or to design specific urban definitions or solutions on a European level, the measures described are aimed at ensuring that they facilitate integrated urban development.

Within this EU Framework there are four independent policy aims:

1. Strengthening economic prosperity and employment in towns and cities
2. Promoting equality, social inclusion and regeneration in urban areas
3. Protecting and improving the urban environment: towards local and global sustainability

4. Contributing to good urban governance and local empowerment.

The needs for planning and development professionals are:

- to have guidance on decision making at the strategic development / planning / construction industry interface
- to be informed about the key issues and agreed best practice. Indicators of improved quality in terms of social progress need to be developed through self-assessment which will provide the basis for measuring improvement.

Specifically for urban sustainability the need is to develop a framework and associated guidance material for decision making that enables practitioners to achieve a more sustainable urban built environment. This will be achieved by:

- exploring existing decision making protocols employed throughout Europe in planning and development processes
- investigating more widely applied models of decision making from other industries or participating groups
- mapping out the interfaces between the different agencies operational and stakeholders and the tiers of decision making
- identifying the key priorities, values, differences, etc that drive each group
- identifying benchmarks of international best practice in decision making
- developing a common language to enhance understanding and effective communications that enable these factors to be integrated into the strategic decision making interface between development and planning professionals and the construction industry.

Evidence from European practitioners who function at this strategic decision making level confirm that sustainable decision-making is not an operational reality. Decision making protocols for balanced and effective consideration of "sustainability" factors do not exist in current development processes.

3.5.3 Sustainability of settlements in developing countries

Most of the current thinking on sustainability of settlements draws on past, pre-industrial models of urban living, but couple these with modern ideas of equality, quality of life and cleaner technology. This picture of an almost medieval village updated with more friendly versions of technology and a more democratic structure can be seen in the following descriptions of sustainable settlement.

Walter, Arkin and Crenshaw (1992) state that: *"A true 'sustainable community' or 'ecological city' is much more than a dense, efficient land-use pattern. It incorporates local food production and waste recycling. Its size is limited to its watershed and its capacity to recycle wastes without damage to the environment."*

They are supported by Van der Ryn and Calthorpe (1986) who maintain:

" *Sustainability implies that the use of energy and materials in an urban area be in balance with what the region can supply continuously through natural processes such as photosynthesis, biological decomposition and the biochemical processes that support life… The immediate implications of these principles are a vastly reduced energy budget for cities, and a smaller, more compact urban pattern interspersed with productive areas to collect energy, grow crops for food, fibre and energy and recycle wastes"*

The Habitat Agenda (1996) states that " *Sustainable human settlement development ensures economic development, employment opportunities and social progress, in harmony with the environment. It incorporates… the principles of precautionary approach, pollution prevention, respect for the carrying capacity of ecosystems, and preservation of opportunities for future generations…The sustainability of human settlements entails their balanced geographical distribution or other appropriate distribution in keeping with national conditions, promotion of economic and social development, human health and education, and the conservation of bio-diversity and the state sustainable use of its components, and maintenance of cultural diversity as well as air, water, forest, vegetation and soil qualities at standards sufficient to sustain human life and well-being for future generations."* The Habitat Agenda further mentions factors such as ease of access; people's need for a community; public health, education and security; preservation of cultural heritage; mixed use of housing and services and spatial diversification, as being vital for the development of sustainable communities.

It can thus be seen that a settlement should follow certain patterns that encourage social equality, effective resource use and economic development. These patterns fall within three categories: the structure of the city, its operations and its social interactions.

The structural patterns suggest certain remedies such as fixed growth boundaries, higher density, mixed use neighbourhoods, urban renewal and urban agriculture. The operational patterns suggest a circular metabolism that leads to efficient resource use, as well as different policies for transportation, waste management and procurement and the social patterns suggest settlements which are more conducive to creating community and providing healthy and safe environments.

The sustainable development of cities also calls for a constant redefining of objectives and parameters and is a holistic, continuous

process requiring flexibility and entrenched feedback loops to maintain a dynamic balance between its social, environmental and economic constituents.

From the above the shape of the sustainable city could be deduced as being a collection of small, high-density neighbourhoods each centred around a mixed use nucleus that is within easy walking or commuting distance from its lower density residential components, and inter-linked with the rest of the city by means of a reliable, eco-friendly and affordable mass transit system. Its operational systems encourage efficient resource management and the support of the local economy and its structure enables social patterns that provide safety, support and opportunity for self-improvement.

While in some ways it might appear to be a return to the pre-automobile, pre-Industrial Revolution society, in fact it transcends these earlier models. Access to new technology and knowledge allows cleaner, safer industries, more efficient urban agricultural methods, healthier and more sustainable methods of energy generation and waste management, as well as social revolutions like tele-commuting. Coupled with increasingly democratic management methods, the sustainable city strives to provide the best of both worlds.

The sustainable city calls for a radical departure from the planning avenues pursued since the beginning of this century. It looks back at the historical examples of both sustainable and unsustainable settlement patterns, and couples the lessons learnt with the opportunities and demands of modern technology to create cities that encourage social equality, efficient resource use, economic development, and management practices capable of flexibility.

3.6 ENVIRONMENTAL BURDENS

The major burdens which the construction industry and construction use place on the environment are attributable to solid waste. It is estimated that around 13% of all solid waste deposited in landfills world-wide comprises construction and demolition waste with a 1:2 ratio of construction to demolition waste. In the Netherlands, for example, this amounts to around 4.25 thousand million tonnes of construction waste each year. Insights into the causes of the generation of waste in construction projects are growing, however, and waste management policies have been developed in Europe. In response to increasing awareness of the environment, the Australian Government has established several strategies to implement Ecologically Sustainable Development

(ESD). One major arm of ESD is the National Waste Minimisation Strategy, with its target of a 50% reduction in waste, 15 % of which is from building and demolition work, going to landfill by the year 2000 based on 1991 standards.

Previous studies in this field suggest that high rates of success may be obtained by implementing waste management strategies in the construction industry. Other defined benefits include financial gains, through the sale of salvaged products or reduced disposal.

However, other burdens on the environment can be mentioned which are due to the construction industry and construction use.

A large part of greenhouse gases comes from energy use in buildings and transport activities (see § 0). Some building operations, e.g. decommissioning of building equipment can lead to CFC, HCFC and halon emissions causing ozone depletion. Production, operation and decommissioning of buildings and construction works can also give rise to regional air pollution (essentially dust).

At the levels of a community or a region, apart from solid waste already mentioned, liquid waste to municipal systems often (and rivers and aquifers sometimes) come from construction operations, including storm water waste peak. Increased traffic or loads on public transport must also be mentioned. Negative effects of construction works on the landscape, agricultural land, even breeding grounds of species, or historical site of cultural significance must of course be stressed also.

Finally, at the levels of the site and adjacent areas, the main deleterious phenomena are the loss of site topsoil, the effects on local conditions (adverse wind conditions at grade, solar heat absorption and re-radiation from building surfaces, reflected glazes from building surfaces, rejection of exhaust or waste heat to outdoor public spaces, interference with access to daylight or winter sun of adjacent property) and the noise from building affecting adjacent properties.

3.7 SOCIAL, CULTURAL AND ECONOMIC ISSUES

Apart from ecological principles, the concepts of sustainable development relate also to economic, social and ethical principles.

The economic principles centre on creating equitable, but viable economic systems with an ethical basis. They require equitable distribution of true costs and benefits between individuals and nations and between generations, as well as ethical procurement and investment and the support of local economies.

The social principles encourage greater equality and responsibility within social and cultural systems and values. It requires cultural and social acknowledgement, participation in decision-making, and general improvements in the quality of life such as opportunities for self-enhancement and self-determination.

Movement towards a "person-centred" and "socially inclusive" approach in the planning/ design/construction of a built environment should be encouraged by every key sector in society[17].

[17] Principle 1 of the European Charter on Sustainable Design and Construction, C. J. Walsh, Dublin, 1998

Figure 8. Main Economic and Social Principles of Sustainable Development (from du Plessis[18])

Economical	• Promote equality between nations and generations • Avoid unequal exchange • Do not impoverish one group to enrich another • Ensure real-cost pricing • Encourage ethical procurement and investment policies • Promote equitable distribution of costs and benefits • Support local economies
Social	• Allow improvement in the quality of human life • Promote social equality amongst all peoples • Allow for cultural and social integrity • Foster self-reliance and self-determination • Encourage participation and co-operation in decision making on all levels from the individual to the international • Empower people and provide opportunity for capacity enhancement

There is also an over-arching principle – that of adaptability. The adaptability principle requires that development is error-friendly, has entrenched feedback loops and checks and balances and can easily adapt to accommodate changes brought about by feedback.

These principles can be used, interpreted and adapted as is necessary and appropriate for each different interest group, situation and culture. They form the ethical basis underlying a certain moral code or attitude that can guide decision-making – a handrail for sustainable development. This handrail can be used by individuals, corporations and governments, and is broad enough to be of use to any group interested in accomplishing sustainable development. It also provides a firm foundation for each group to build a set of principles relevant to their specific area of responsibility.

[18] The Meaning and Definition of Sustainable Development in the Built Environment, Chrisna du Plessis, Pretoria, 1998

To answer the question as to how these principles can influence the construction sector is not easy. Today one can go no further than simply to mention some hints and questions concerning possible economic and social facets of sustainable construction.

For instance a sustainable construction should be seen as contributing to poverty alleviation, creating a healthy and safe working environment, distributing in an equitable manner social costs and benefits of construction, contributing to employment creation, full-cost accounting and real-cost pricing policies, developing human resources, acquiring financial benefits and uplift for the community through labour intensive methods drawing from the local workforce… A major point is to understand how sustainability interrelates with profit and value.

Questions deal with the development impact on the local economy and the benefit for local business, the ethic of the procurement practices in social and economic terms, the sensitivity to local cultural values and social systems, the discrimination against certain categories of people categories, the self-determination and self-reliance aspects…

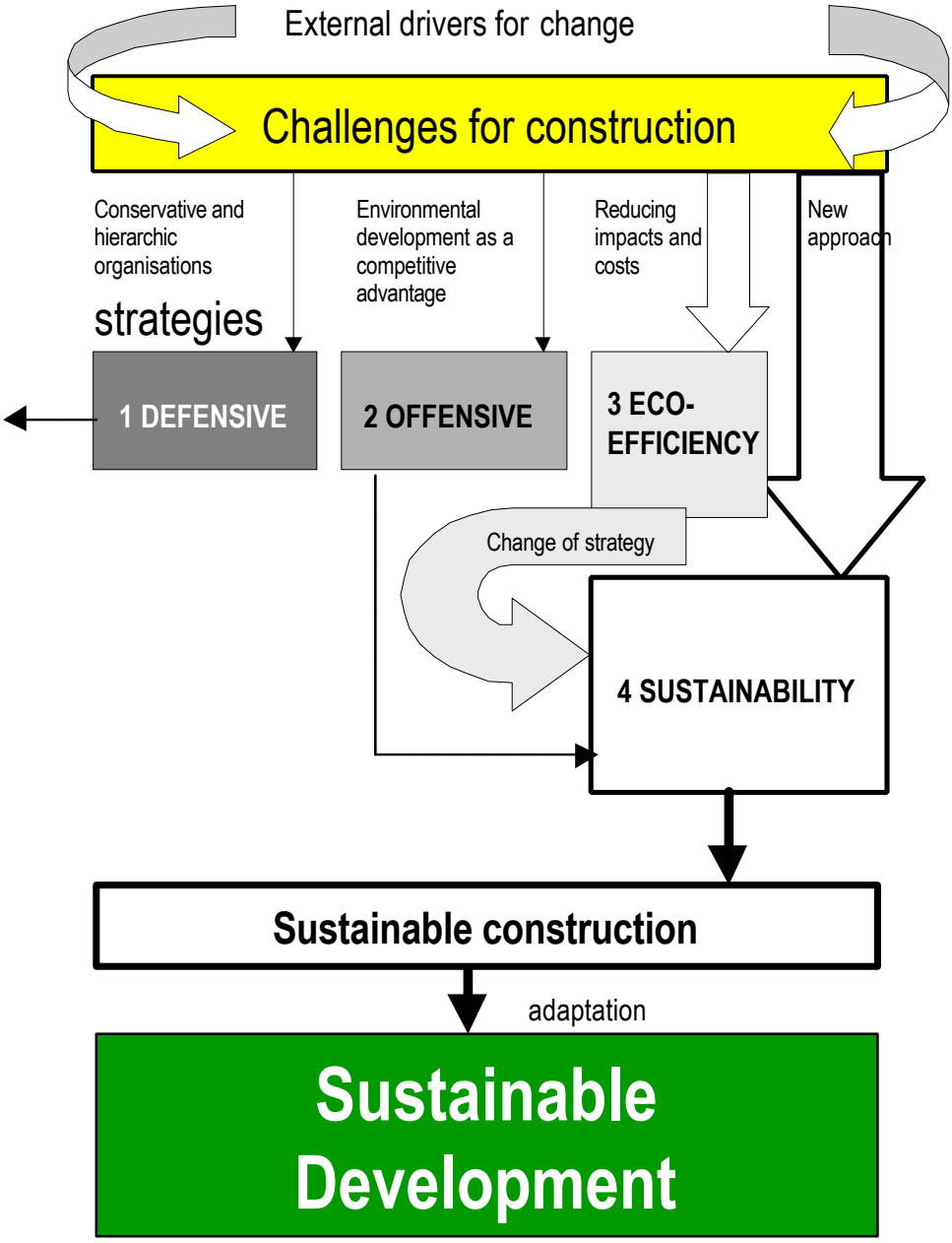
Social sustainability must be accorded considerable attention as much in city planning as in urban renewal. Issues frequently mentioned are:

- respect for the existing city fabric and retaining rural settlement structures
- develop city master-plan based on sustainability principles (sustainable renewal)
- function integration at city and district level
- more public involvement in new developments and interventions in existing settlements
- 'affordable housing' projects
- crime prevention through environmental design.

The Habitat II Agenda (cf. Chapter 0) lays stress on the fact that the construction industry is a major contributor to socio-economic development in every country. Its paragraph 25 specifically states that governments should encourage the construction industry to promote "locally available, appropriate, affordable, safe, efficient and environmentally sound construction methods and technologies in all countries, particularly in the developing countries, at the local, national, regional and sub-regional levels to emphasise optimal use of local human resources and encourage energy-saving methods and are protective of human health".

section four

resulting challenges and actions



Various Strategies

4.1 GLOBAL APPROACH

As previously stated, successful improvement strategies for sustainable construction will have to be more-or-less compatible with climate, culture, building traditions, stage of industrial development and nature of the building stock. That said, it is useful to outline a spectrum of initiatives that can be launched, remembering that the mix and relative emphasis on one or the other will depend on the local conditions.

Regulation is the most basic tool, and measures such as building or energy codes are effective once adopted. However, regulations almost always represent a consensus on the minimum performance improvements necessary, and in consequence they are unlikely to create the substantial levels of improvement necessary to fulfil international climate change commitments.

Energy pricing is a powerful lever to improve energy performance. Currently, energy is clearly too inexpensive to provide a meaningful direct financial incentive for substantial performance improvements, especially in North America. In liberal democracies, the subject is also fraught with political dissension and a widespread public consensus is therefore required before governments take action in this area.

Enabling and Support Mechanisms, such as information, training, software and other tools, are all necessary to equip the industry to do a better job, but are not sufficient to move the industry as a whole. Specific measures include:

- information materials that outline priority issues and that suggest appropriate measures
- more detailed technical information materials that will help industry actors to implement suitable solutions
- hands-on training for key industry groups, to ensure that they fully understand related technical issues
- appropriate tools to help industry personnel to implement desirable steps, such as software analysis and design tools and monitoring equipment.

Incentives and demonstrations, such as the tax benefits, the Demand-Side programmes operated by the electric utilities in the 1980's or the C-2000 demonstration programme from Canada, can stimulate a broader range of owners to design to higher standards of performance. However, such programmes are costly and are usually limited to a small proportion of potential owners and developers and primarily those who fall into the category of being "early adopters" of new techniques and processes. It should be noted that incentive programmes that lack exit strategies, such as follow-on regulations, can distort the marketplace. Experience shows that even small demonstra-

tion programmes can exert a positive effect, but they have the highest influence on the small portion of industry professionals who are already leaders in the field.

Although the approaches outlined above are useful in encouraging the adoption of sustainable construction, *measures to change market demand* are the most promising method for achieving substantial change in market-oriented economies. In many market-oriented regions, it is a truism to say that developers and investors build to suit what they believe the market is willing to pay for, and that they would be perfectly willing to design to much higher levels of energy and environmental performance if there was a market demand for it.

One of the main reasons why poorly-performing new buildings continue to be constructed is in fact because, despite the desire of enthusiasts, the market demand for sustainable constructions is weak. A potentially valuable measure to affect market demand is, for example, the implementation of a rating and labelling programme, to provide non-professional investors and tenants with a tool that will allow them to identify high-performance buildings. Such programmes have been established in the UK and are under active development in the USA, Canada, Hong Kong and several European countries.

4.2 A REVIEW OF VARIOUS DETAILED STRATEGIES

4.2.1 The challenge for construction

For many in the construction industry the components of sustainable development pose unfamiliar challenges. They involve a wide range of stakeholders many of whom have not been direct participants in construction activities before and may also be experiencing dramatic change in their own sphere of activity. Whilst the construction process and built environment do have a substantial impact on people's lives many of the social, environmental and broader economic issues which characterise sustainable development are not considered in the current construction industry protocols and practices. Therefore, for construction activities to become sustainable those in the industry must find ways of "buying-in" to the principles of sustainable development by:

- initially, building an understanding of sustainable development
- secondly, identifying how their activities impact upon others, in relation to the aims of sustainable development
- thirdly, defining and accepting their role in its achievement
- and finally, putting theory into practice.

How can the industry transform the demand for sustainable development into an opportunity, to create and access new markets, devise innovative responses which satisfy traditional industry demands and the new societal demands for sustainable development?

The challenge for the industry is to identify new and innovative practices, technologies and ways of working which satisfy the need for a modern, competitive, efficient, responsive and socially responsible industry. This is an enormous challenge; however, the achievement of sustainable construction will depend on the construction industry's willingness and ability to drive much of this change. It is evident from the examples of better practice presented in this report that many organisations have achieved novel and exciting results from the innovative use of new and existing technologies, integrated planning and design, new partnerships and new ways of working. Yet it is also evident from the national reports that characteristics such as: conservatism; risk aversion; conflict and highly competitive trading environments, are common to many market lead and centrally funded construction industries with the consequential lack of change necessary to achieve a sustainable construction industry.

Typical concerns throughout the construction industry are common to many industries or sectors that are well established. Why should I change? What are the areas of risk

and security? How can I profit and what will it cost me? Who are the key stakeholders in sustainable decision making processes? Which construction activities contribute to or conflict with sustainable development? What are the market potentials and competitive threats? What should I do and how can I do it?

The following sections provide direction, ideas and, perhaps, understanding about how different organisations can adopt sustainable construction practices and thereby contribute to sustainable development.

4.2.2 External drivers for change

There is considerable evidence to suggest that the dominant driving forces for sustainable development will remain external to the construction industry. It is likely also that they will remain politically orientated at local, regional, national and global levels. In global terms we will all be aware of the commitments made at Rio in 1992, HABITAT II and Kyoto in 1997. The decisions and commitments made at these summit meetings are already having an impact on national policy in terms of energy efficiency, habitat protection, pollution control and social provision. Initiatives more closely aligned with regional and local construction businesses include Local Agenda 21, another example of a key driving force for change.

Whilst there has been little, if any, impact on business so far there is evidence that measures are being introduced to increase the integration of business into the principles and activities of local Agenda 21.

Such measures include:

- setting up a representative, multi-sectoral planning body or "stakeholder forum" as the co-ordinating and policy group for developing and monitoring a long-term sustainable development action plan
- implementing a consultation programme with community groups, NGOs, businesses, churches, professional groups and unions to identify proposals and priorities for action
- setting up monitoring and reporting procedures that hold the local authority, business and households accountable for the action plan.

An important factor that will affect how industry responds to sustainable development is the state of the nation. This could mean the wealth of a country, its economic and political structure, its position in the development cycle, its cultural heritage, national values and aspirations.

4.2.3 Possible strategies for change

A UK Report[19] lists four strategies for change which industry can take towards sustainable development:

- the defensive strategy
- the offensive strategy
- the eco-efficiency strategy
- the sustainability strategy.

These four strategy definitions provide a useful framework for analysing the opportunities which might be taken by construction businesses. From them, it is possible to build up a comprehensive picture of what sustainable construction might mean to different construction firms in different countries.

The defensive strategy - complying with regulation

This is a typical response from organisations in the construction industry where quality is largely governed by regulations. Typically, the cost of the environmental component in an industrial activity is counted as a cost of compliance with regulation and minimum standards. Often, the cost of non-compliance is the primary motivator to make improvements and so to reduce the environmental impact of industrial operations. For some the solution might be to find an environmentally less sensitive site or to conceal the impacts altogether.

Organisations motivated by predictability and security are likely to predominate in this approach. Organisations with a hierarchic culture are likely to concentrate on activities such as systems that monitor performance and report outcomes. Market orientated organisations will take account of regulation as a matter of good judgement to minimise future risk of non-compliance.

Typically, in organisations that follow this strategy, there will be low levels of environmental awareness and understanding although there are some notable exceptions.

Undoubtedly there will be many construction businesses which continue to respond to change in this way and, unless there is a dramatic change in the construction industry as a whole, this confirms the importance of continuously developing regulations which underpin improved performance in the industry. It is likely that the market opportunities arising in this category will continue to be in the form of:

- specialist consultancy
- systems development and monitoring
- development of technologies for monitoring and remediation
- environmental monitoring services such as pollution control etc.
- development of regulations.

[19] The Greening of Industry for a Sustainable Future, the Advisory Council for Research on Nature and the Environment and the Greening of Industry Network, 1997

The offensive strategy - beyond compliance

This strategy introduces, for example, the development of environmentally friendly products, or following a policy of going beyond simple compliance in order to gain a competitive advantage.

In the service sector particularly, the environmental component of a product or service can be portrayed as a market benefit, adding value for its clients and customers. Typically, organisations with a market orientation are likely to respond in this area. Improved quality and customer focus are key components required to move from a "defensive" strategy to an "offensive" strategy and these are in keeping with a market orientation. There is thus a close relationship between the requirements on industry to deliver improved environmental performance and the need continuously to improve commercial performance.

Eco-efficiency strategy

This strategy tries to identify win-win solutions by reducing environmental impacts and costs; it includes concepts such as total quality environmental management and industrial ecology.

This strategy extends one step beyond the offensive strategy and builds in a win-win outcome for supplier and client. There are examples of this response where supplier and customer collaborate to provide mutual benefit over and above the normally accepted contractual provision. However, to succeed, this strategy requires understanding and change on both the supply and demand sides.

"An important aspect of eco-efficiency strategy is its service provision" [2].

"Value enhancement must be sought through focusing on providing the service connected to their products to customers instead of selling as much product as possible" [2].

Sustainable development is built upon three pillars: economic growth, ecological balance, and social progress. Several authors propose that industry's contribution to sustainable development come through "eco-efficiency". Getting more from less. Three components can be identified which are necessary for this strategy to succeed:

- eco-efficiency (systems and processes)
- leadership - which he describes as having vision, being proactive, transforming organisations and people
- effective and innovative use of technology.

Successful "eco-efficiency" demands more than good environmental systems and processes. Successful "eco-efficiency" req-uires change in management skills and new working practices, examples of which are emerging in the USA and UK construction industries as Partnering.

The third component of successful eco-efficiency is the effective use of innovation and technology. This requires not only technological advances, but an understanding of how the technologies relate to the needs and requirements of the users, their ability to apply and maintain them and the pressures which these new technologies will bring to their normal modes of operation. The construction industry has experienced many failures which appear to be failures of technology. An interesting example is the "failure" of System Building in the UK during the 1960's, resulting in obsolete buildings and massive maintenance and repair costs. It could be argued that it was not the technology which was at fault but that rather it was a lack of the skills and training for those who constructed the buildings which resulted in poor quality and defective installations.

Many examples have been identified that exemplify the use of new and innovative technologies. Many are being integrated into existing buildings and many are providing completely new possibilities of performance and control.

Key components required to move from the offensive to the eco-efficient strategy include: the valuing and costing of environmental impacts; and identifying and valuing the full cost of development, over time, for all stakeholders.

Sustainability strategy

This strategy focuses on new and emerging partnerships between business and other stakeholders. This is the most advanced strategy, requiring an understanding and tolerance of complexity. It is likely that this strategic response will be achieved through decision-makers adopting new values that reflect the aims, objectives and aspirations of sustainable development. For businesses used to short time horizons with defined, discrete client groups and markets, the risk of including and responding to the range of stakeholders and potential "clients" may be too high. What shape might the sustainable business take? What shape might the sustainable business opportunity take? From a range of policy research projects, there are indications that sustainable business will be more holistic, systemic and integrated. Core values are likely to include:

- "Wholeness" - understanding and accepting the system relationships between industry behaviour and its impact (usually known as the externalities in economic theory). This means taking responsibility for the impact of the business, so recognising that businesses do not operate in isolation from their surrounding environment. This approach leads to a shared responsibility and unity between the business and its community.
- "Care for future generations" - where a "future generation"

representative may be included in the boardrooms of industry to challenge their time horizon for decision making, requiring more emphasis on whole life costing and long term impacts. The business takes respon-sibility for the impacts of its process but extends this over time.

- "Smallness" - utilising small work teams, defining responsibility at the lowest level possible, requiring an ability to attend to detail "at the coal face", with increased ability to respond flexibly and innovatively.

The change from eco-efficient to sustainability strategy poses, perhaps, the greatest challenge to construction businesses. However, there is evidence to suggest that changes are occurring at the community level in terms of long-term, multi-faceted integrated planning and within the industry itself in terms of new approaches to value management, partnerships, shared ownership, shared risks and benefits.

Within the construction industry there are developments taking place to increase the time horizon of decision-makers and to include wider criteria for consideration.

The management technique called Value Management provides the basis of an approach that is applicable to many decision making levels in sustainable development.

4.2.4 Mechanisms for achieving change in future construction markets

Whilst the demand for construction will continue, the broadening of societal values and interests challenge the motives and values which have previously driven growth and development and which have previously defined industrial success.

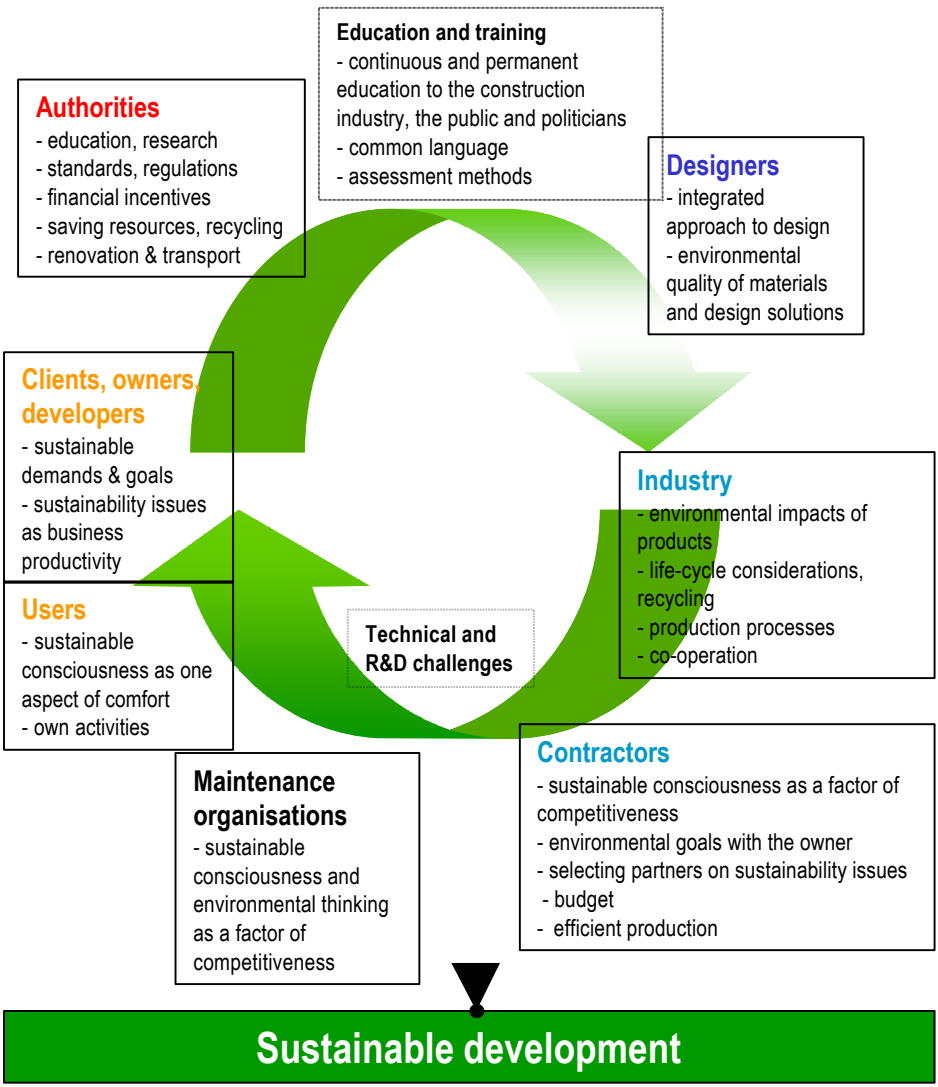
Therefore sustainable development, from a construction industry perspective, undoubtedly means change. For an industry which is inherently defensive the prospect of, and opportunity for, positive change is not always apparent, particularly in the context of the complexities of sustainability.

Whilst for many construction businesses, eco-efficient and sustainable strategies may well appear to be impracticable and too far from their current trading reality, there is evidence from the UK and USA construction industries that procurement strategies such as Design Build Finance and Operate, Private Finance Initiatives, Partnering and Value Management are providing a platform for the development of working practices which go some way towards achieving these strategies. In the Netherlands where a higher level of community responsibility is acceptable in business the response has been to issue standards of sustainable construction to which the whole industry can respond. In South Africa the opportunity is there to create

sustainable developments from scratch, using the indigenous knowledge of sustainable communities. In transitional economies such as Romania there is the demand for new and previously unavailable goods.

The industry will have to adapt to these new and emerging construction markets which have attendant environmental and social dimensions. Construction businesses will be expected to integrate into, and consider more fully, the issues valued by others at national, regional and community level where the driving forces will be a mixture of political, social and market forces, requiring products which respond to genuine needs and concerns.

Actions for Stakeholders



4.3 CHALLENGES TOWARDS VARIOUS STAKEHOLDERS

Due to the complexity of the sector, there are different ways of categorising challenges faced by the construction sector. These challenges deal with:

- Urban and rural area planning (including traffic and transportation planning)
- Life Cycle Design of buildings and infrastructure (including architectural, structural and building service planning)
- Production and manufacture of building materials and products
- Site production and manufacture
- Organising the entire building process
- Building and build facility management (economic life cycle planning and control, maintenance, repair, rehabilitation, modernisation, demolition)
- Recycling
- Waste

The numerous challenges raised in the previous Chapters have been categorised in order to orientate them towards the various stakeholders of the sector.

4.3.1 Clients, owners, developers and investors

These actors should have a very important role in disseminating sustainable construction, since they represent the demand of the building sector.

They should set concrete environmental demands on the parties involved in the design process, as well as on the final product, during the initial design phase. They should also set concrete goals regarding building maintenance that are based on environmentally friendly methods and incorporate these goals in, for example, the building maintenance agreements. They should also assure the productivity of their own business by emphasising environmental issues, quality and preservation of property values.

4.3.2 Authorities

In a market economy, the demand expressed by the building owners could be seen as the only factor which will lead to a development of sustainable construction. However, in many countries (with the exception of Germany and to a lesser degree Northern European countries), the lack of interest from the population does not pull the market. In France, for instance, the demand from the private or public building owners is very low, except when there is a regulation (waste) or when the population pressure is quite high (health problems or work site nuisances).

In these conditions as mentioned earlier, there can be a need for a voluntary policy on the part of the authorities. It explains why besides an education and training policy

mentioned later, challenges deal with financial incentives, regulation, labelling...

A general challenge is for instance concerned with establishing high-level national research groups, which would examine the concept of "sustainable development" and its practical implementation in a given country. A national forum should also be set up to develop a suitable response, in built form, to that concept and to act as a focus for construction related activities at national level. Human / social development should require special attention in these areas.

As far as formulating objectives and goals within the framework of a voluntary policy, officials should consider environmentally sound construction as one criterion in all buildings. They should envisage measures to reduce the adversarial nature of building design. They should also confirm the creation and existence of mechanisms that lead to life cycle thinking. Specific attention should be devoted to conserving resources (land - both above and below ground, energy, water, and raw materials) and to waste prevention and recycling.

The increasing of standards should be viewed as a global objective in general, with a specific need for introducing those standards that deal with longevity and multiple use of buildings in particular.

Stimulating the renovation of existing buildings is also seen as a necessary general objective for authorities.

Finally land and human settlements patrimony should be exploited in terms of resource more than constraint, in the perspective of real economic development with effects in all sectors.

As far as planning is concerned, the introduction of rules and standards for sustainability and eco-compatibility in the planning activities is referred to, at each level of the transforming activities of the land and human settlements. This should also deal with the interdependencies between the different levels of planning and design. Generally speaking, the planning system should be amended in order to promote sustainable development. More mobility planning should be attained. Car use should be reduced and public transport favoured. Home-working and combining office and living space should be increased.

A more stringent regulation on the use of land with more respect for open spaces and green areas should be envisaged. In certain countries refurbishment and use of brownfield sites is recognised as essential to make construction more sustainable and incentives from government such as fiscal measures should be created as the means for achieving this.

Finally, in certain countries, the need for completing the system of

infrastructures with the major concern of minimising negative environmental effects is important.

As far as construction materials and the products industry are concerned, authorities should encourage them to provide environment-friendly materials since these are not available at reasonable prices on the market today. Awards for good practice and fiscal incentives could be a solution. Imposing a minimum recycled material content for all building material can also be envisaged.

As far as construction is concerned, it is recognised that rules, standards and certification schemes for sustainability and eco-compatibility should be introduced into the design activities. More generally, officials should use appropriate guidance (regulations, supervision and sanctions) in order to achieve environmental goals. Measurable performance standards based on sustainability principles at the levels of both urban development and building design should be drafted, as well as defining long-term targets for a step by step approach for future development.

Just as products and materials, so fiscal incentives should also be developed for environmentally friendly construction activities.

Some control of the construction activity is also suggested, for instance through increased public responsibility on behalf of the construction companies or even through an increase of the environmental taxes on waste or emissions.

More drastically, a challenge is also to apply strict built quality standards on all building types to cover new build and refurbishment projects through, for example, the imposition of severe noise insulation standards.

Quality standards for reused/recycled materials, which minimise concerns over their use, without placing undue barriers on their resale, should also be introduced.

4.3.3 Education and training

There is a widespread consensus that education and training should be extensively utilised to make sustainable development concepts well known and accepted by all people. In particular, appreciating the impact of the construction sector on the global environment has not reached maturity in the whole construction industry or within authorities.

The need for a large concerted programme of awareness raising and education is striking. The programmes should aim, not only at all the actors in the construction industry, but also at the public, politicians, and government administrators. Sustainable building principles should be incorporated into the curricula of training courses for architects, designers and construction engineers.

Not only initial, but also continuous and permanent education of the operators should be promoted.

Designers should be better educated to adopt a more integrated approach to design, to appreciate the fundamentals of sustainable construction design, and to interpret environmental labelling.

Construction firms should be approached at the level of the executive board members about the significance of their responsibility to the global environment. Methodologies for environmental impact reviewing should be disseminated. Training of employees and operatives should be promoted. Agreements in terms of role sharing and responsibility allocation among the members of the "construction team" in the projects should be established.

Interdisciplinary training in design, construction and exploitation processes should be facilitated to the maximum feasible extent and best practice examples should be widely disseminated.

People operating buildings should be educated as regards the implications on sustainability for personal and professional activities in cases where a more efficient operation of buildings is applied.

In countries where the self-build movement is especially strong, greater information on self-building should be disseminated.

However, since sustainability effects do not emerge over the short term, communication will be successful only if certain conditions are met. As a minimum, the following conditions seem to be necessary:

- acceptance of a common language
- definition of a multilingual glossary of the sustainable development concept
- availability of a collection of methodology practiced worldwide for assessing constructions.

4.3.4 Designers

As already mentioned, designers should adopt a more integrated approach to design, and they should appreciate the fundamentals of sustainable construction design. Moreover they should possess the know how necessary to interpret environmental labelling.

Designers should consider the environmental qualities of construction materials as a starting point for the design. They should develop design solutions from the point of view of environmental goals of the final product, develop the design process together with other professionals in order to achieve the optimal situation, and use methods and tools which will enable them to control not just the cost but many other variables, such as life span and maintenance intervals, pollutants and health factors, heating and moisture, technology…

The attention of designers should focus on the exploitation stage during functional design (for example long service-life and flexibility of the building during its use). Technical design should focus on the durability of components, as well as the reparability and (de)construct-ability of components by adopting open systems and advanced jointing and assembly techniques.

4.3.5 Industry

Manufacturers of construction products should see the life cycle considerations (environmental impacts, life span) as the basis of product development. Another stake should be actively to minimise harm to the environment from their own production processes.

In order to inform users, manufacturers should feature in their product information the environmental qualities based on life cycle analysis, together with details regarding the conditions of use and recycling - and they should stick to these themselves.

Manufacturers should co-operate with designers in creating new designs (jointing/assembly technologies, flexible engineering and system modularity) for new construction designs as well as for renewal projects. Co-operation with related industries (e.g. plastic manufacturers, electronics) should be sought with the aim to develop new function integrated building components. Manufacturers should improve the durability, repairability and retrofit ability of their products.

In order to facilitate recycling of materials, it is also suggested to industry to establish some kind of brokering service for waste construction materials.

Another challenge in some countries is also to serve the trade and industry needs, by organising the work in such a way as to give rise to the minimum inconvenience.

4.3.6 Contractors

Contractors should see environmental consciousness as a factor in achieving competitiveness and they should develop their own services to be environmentally sound.

That means reducing the environmental impact of their own business processes, for example, in respect of site operations, logistics and material selections.

It also means informing owners of the environmental impacts inherent in the construction project, to ensure that environmental goals are part of the owner's demands and implementation plans and, if necessary, to set these together with the owner.

Another important implication is that the selection of the parties to be involved in the construction project must be based on their expertise on environmental issues, and readiness will be required from

other parties (sub-contractors, material and product suppliers) to work in co-operation towards environmentally sound goals. That should lead, for instance, to establish agreements in terms of role sharing and responsibility allocation among members of the "construction team" in the projects (including clients). It is also necessary to keep a budget for sustainable construction, or to set up information networks as a vehicle for introducing good practice to other departments of the firm. Environmental management systems should be evolved.

Efficient production in construction should be met by open industrialisation and by new methods such as making decisions (setting requirements) at different scale levels ("open building"). This would create a controlled process that would be beneficial to sustainability in terms of better quality, less squandering of raw materials, and less building and demolition waste. Large companies could take the lead by re-engineering their processes and by developing complete consumer-oriented (flexible) concepts that use standardised production methods that are universally applicable, independent of project type or size. A strong balance should be forged between demand-side (user requirements) and supply-side (production techniques). Small companies should specialise in market segments or specific trades, and should seek to attain a competitive edge by standing out in terms of sustainable construction.

4.3.7 Users

The building user should act as a demanding customer when it comes to selecting spaces and to considering the environmental qualities of the building over its life span as a specific selection criterion.

Users should see the environmental issues as one aspect of comfort and consequently as one factor that affects the productivity of the use of the spaces.

They should develop their own activities to be more environmentally friendly in the occupied building.

4.3.8 Maintenance organisations

Maintenance organisations should see environmental consciousness as a factor of competitiveness and should develop their own services to be environmentally sound.

They should correct their own processes so that they are based on sound environmental thinking, show initiative and provide feedback to the owners on environmental issues. They should expect co-operation from suppliers and partners regarding environmental issues.

4.3.9 Technical and R&D challenges

Many technical and R&D recommendations can be given. Some of them are listed in Figure 9.

Figure 9. Examples of R&D Challenges (from CIB W082)

Built Environment and Ecological Systems

- understanding the impact of the built environment and human activities on eco-systems
- producing research based information to contribute to the "ethical discussion"
- producing environmental qualities for building parts and buildings
- investigating problems and solutions for the sprawl of urban agglomerations …

Energy Saving

- going on with energy savings policy and having an integrated approach to the use of energy
- targeting technologies that produce buildings that consume 50% less energy than today
- innovative design, systems and products for energy-efficiency goals: integration of solar (and other renewable energy) systems, retrofitting adapted systems…
- developing energy efficient design of low cost housing
- assessment of embodied energy for the choice of materials and construction technologies …

Health and Comfort

- understanding the impact of the built environment on health and decreasing health risks
- improving air quality
- investigating social sustainability of self-build
- improving clean-up procedure for contaminated land …

Waste

- bettering waste management (work sites and communities)
- reducing the environmental impact of construction waste through minimisation and recycling …

Resources Saving

- foreseeing fresh water shortage
- developing water-saving devices in both new and existing buildings and systems for capturing rain water
- developing methodology for saving and recycling construction materials, re-use and substitution by renewable materials
- developing ways for an efficient use of materials (service life, system repair/retrofit, improved quality of materials, components and services)
- developing new and innovative materials and developing the use of indigenous construction materials
- understanding the natural sand transport phenomena and solving dynamic behaviour of constructions in soft soils
- developing on-line products information systems
- improving durability of coatings
- developing the life expectancy of indigenous construction materials and technologies

Building Stock

- upgrading performance of the existing building stock
- developing non destructive diagnostic tools for condition assessment
- developing models for service life prediction
- developing new technologies/systems for renovating and retrofitting

Tools

- developing methods and means to be used by professionals: assessment methods, performance-based environmental standards, reliable labelling scheme, assessment and certification of life-cycle performance of buildings, comprehensive data bases
- developing best practices in sustainable buildings and building handbooks
- placing increased emphasis on global studies such as life cycle analysis and multi-criteria evaluation of materials, services, constructions...
- inventory of all life cycle costs and suitable indices for measuring pertinent performance
- assessing the incorporation of environmental costs into the economic system
- modulating the "Building-to-Last" concept
- developing and disseminating methodologies for reviewing environmental impacts
- compiling a first set of "performance indicators" to cover: the process of construction, completed construction projects, the operation phase

Construction Process

- short- as well as at long-term forecasting of construction activities
- improving the construction process itself and highlighting life cycle thinking as the guiding principle for construction processes
- developing renewal engineering methods
- innovating in design technology, construction methods (open building, process reengineering)
- developing materials and systems: new function integrated building components, durability, repairability and retrofit ability of the products
- investigating social sustainability issues surrounding self-build

4.4 CONCLUSIONS

The challenge which the construction sector is facing today is not only to determine the optimal balance between the various contemporary constraints of the construction act (technical, architectural, social or economic constraints) but also to endeavour to favour "decisions without regret" in the compromise solutions necessitated by the construction act at every moment in the life cycle of a building, and especially in the construction phase.

The previous sections evidenced the complexity of the items which are raised and the role of almost all the numerous actors in the sector: (clients, owners, developers, investors, authorities, educators, designers, industrialists, contractors, users, maintenance people, researchers…). The main challenges raised can be summarised as follows:

Owners and clients should fill a very prominent role in disseminating sustainable construction since they represent the demands of the sector. They should set concrete environmental specifications for the parties involved in the design process. They should also ensure the productivity of their own business by emphasising environmental issues, quality and preservation of property values.

If the demand cannot be seen as a sufficiently cogent driving force then a voluntary policy by the authorities is needed. They should favour the development of a suitable response to the concept of sustainable construction, stimulate the actors, take measures, create mechanisms… In particular initiatives should be set in motion towards planning, industry and constructors through adapted regulations, standards or fiscal measures and incentives.

There is a significant consensus that education and training should be largely used to have sustainable development concepts well known and accepted by all people. Specifically, an understanding of the impact of the construction sector on the global environment has not reached a mature stage in the whole construction industry and within authorities. This raising of awareness and education programme should not only aim at all the actors in the construction industry but also at the public, politicians and government administrators. However a preliminary condition is consensus on a common language.

Designers should adopt a more integrated approach to design, appreciate the fundamentals of sustainable building design, and know how to interpret environmental labelling. They should consider the environmental qualities of construction materials as a starting point of the design, but also focus on the exploitation phase during functional design.

Manufacturers of construction products should see the life cycle considerations as the basis of product development. They should co-operate with designers in creating new designs and should facilitate recycling of materials.

Just as was stipulated earlier for designers, so should users see the environmental issues as one aspect of comfort and consequently as one factor affecting the productivity of the use of the spaces.

Maintenance organisations should consider environmental consciousness as a factor of competitiveness and should expect co-operation from suppliers and partners regarding environmental issues.

A plethora of technical and R&D recommendations are finally addressed in order to produce environmental quality. Most of these recommendations relate to energy saving, health and comfort, waste management, and conservation of resources. An important part of the recommendations is concentrated on the development of adapted tools to help designers and other actors to introduce concern for sustainability in the compromise decisions which they have to take at every moment. The improvement of the construction process itself is also considered as a significant topic for research activities.

Finally, a general challenge is to take immediate preventive action and to prepare the construction sector for changes which are needed in the construction process.

appendix

CIB activities on sustainable construction

This Appendix describes those CIB Activities (Task Groups - TG's and Working Commissions - W's) which were established and operational within the area of Sustainable Construction in the period up to 1999.

The following CIB Activities have Scopes and Objectives and Work Programmes, which were explicitly aimed at contributing towards achieving a more sustainable built environment:

- TG08, established prior to 1992, which was transformed in 1998 into Working Commission W100 on "Environmental Assessment of Buildings"
- TG16, established in 1993, on "Best Practice for Sustainable Construction", which completed its work at the beginning of 1999
- TG22, established in 1996, on "Environmental Design Methods in Materials and Structural Engineering", which is a joint CIB - RILEM Activity
- TG38, established in 1998, on "Urban Sustainability"
- TG39, established in 1999, on "Deconstruction".

Descriptions of these Activities, Scopes and Objectives follow together with a statement of their major achievements so far.

The following CIB Activities were all established before 1992. They have Scopes and Objectives which, at the time when they were established, were not considered to fall within the then accepted, somewhat more restricted interpretation of the definition of Sustainable Construction, but which today, following the gradual broadening of our interpretation of what should properly be bracketed under the heading of Sustainable Construction, are regarded as key elements of any programme aimed at contributing towards achieving a more sustainable built environment:

- W067 on "Energy Conservation in the Built Environment"
- W077 on "Indoor Climate"
- W080 on "Prediction of Service Life of Building Materials and Components", which is also a joint CIB - RILEM Activity
- W094 on "Design for Durability".

Detailed information on the Scope and Objectives, Work Programme, Publications, Meetings and Members of these - and all other - CIB Activities can be found in the CIB Home Page at www.cibworld.nl.

In addition other CIB Task Groups and Working Commissions with a more general Scope started specific projects dealing with aspects of Sustainable Construction. One example of such a project is "Sustainable Development and the Future of Construction" by Working Commission W082 on "Future Studies in Construction".

A brief summary of the results from this project is featured further on in this Appendix.

In addition within the CIB structure, although not directly related to any specific Task Group or Working Commission, the following two projects were initiated, which are regarded as crucial in achieving a more sustainable built environment:

- "Sustainable Construction and Integral Delivery Processes", in which it is assumed that the actual implementation of certain structural innovations, required under the heading of Sustainable Construction, can be implemented only in the context of a better integrated building process and which investigates the possibilities thereof.
- "Sustainable Construction and the Performance Concept", whose context encompasses an investigation into how the principles of Performance Based Building Codes and Standards, Performance Based Building Regulatory Systems, Performance Based Briefs and Performance Contracting can contribute towards making the types of decisions in the design and construction process which are more favourable to implementing Sustainable Construction.

1 ELABORATION OF SELECTED CIB ACTIVITIES CRUCIAL UNDER THE HEADING OF SUSTAINABLE CONSTRUCTION

Task Group TG08 / Working Commission W100 on "Environmental Assessment of Buildings"

This Commission focuses its programme on issues related to the implementation of environmental performance assessment systems for buildings. Specific issues include: sustainable management structures, target markets, training issues, the role of standards bodies and other issues that may arise as these systems are applied. The Commission will also attempt to establish a method for comparing the effectiveness of various assessment systems as they are applied in different countries. The overall goal for the work of the Commission is: to contribute to achieving a situation where environmental performance assessment systems are used for all significant building projects.

TG08 / W100 is responsible for organising a series of Bi-annual Conferences under the theme "Buildings and the Environment. The next Conference in this series is scheduled for May 2000 in The Netherlands.

Task Group TG16 on "Best Practice for Sustainable Construction"

The objective of this Task Group was to collect, analyse and disseminate information about international Best Practice for Sustainable Construction within a consensus

based conceptual framework that defines topics and aspects of Sustainable Development in Construction. The Task Group has been engaged in the production of a CIB Publication on Best Practice for Sustainable Construction, which was completed in mid-1999.

Task Group TG22 on "Environmental Design Methods in Materials and Structural Engineering"

This Task Group is engaged in methods and methodologies for structural design in order to meet the requirements of sustainable development throughout the entire life of a structure (resources, transport, manufacture, use, recycling and reuse, demolition, wasting). The environmental design will be presented as a part of integral structural design, which includes the mechanical, physical, economic, energy, health and environmental aspects. The integral design should manage the multiple requirements in a systematic way. It is envisaged that the work of this Task Group will result in a Guide for Environmental Structural Design, which will be presented at the CIB/ISO/RILEM Symposium on Integrated Life-Cycle Design of Materials and Structures (ILCDES 2000) in May 2000 in Helsinki, Finland.

Task Group TG38 on "Urban Sustainability"

Within the framework of achieving Sustainable Development continuing urbanisation reinforces the importance of creating a built environment that is sustainable for future generations. It is assumed that this will be achieved only in the context of the genuine needs and concerns of people who live and work in situations known to affect the quality of urban development, including: planning and regeneration policies, transport and service infrastructures, provision for safe and secure environments, provision for appropriate health, welfare and leisure facilities, decision making structures and levels of public participation, finance initiatives, investment policies and forms of procurement and job creation and opportunities for wealth distribution. The role of this Task Group is to consider the interrelations between these issues and how they impact on the whole construction supply chain and on the quality of the urban landscape. It will address the known concerns of planners, regulators, housing providers and designers in terms of assessing the sustainability of developments in the urban built environment. The Work Programme of this Task Group is targetted at publishing an International Best Practice Report on Urban Sustainability, which will be presented on the occasion of the CIB World Building Congress in April 2001 in Wellington, New Zealand.

Task Group TG39 on "Deconstruction"

This Task Group will focus on the technical, economic, and policy issues that must be addressed to foster disassembly rather than demolition of buildings, in order to make salvaged building materials a viable alternative to landfilling. Technical issues such as physical deconstructability of specific building types and building components will be identified to make the re-use of extracted materials feasible. Technical issues also include identifying existing tools and developing new tools to facilitate building deconstruction in a way that is economically defensible. Economic issues include the cost-benefit-analysis of salvaging specific materials, identifying expected income and market values, assessing supply and demand and identifying facilities for marketing these materials. On-site auctions, establishing re-use centres and adding to the established infrastructure may be necessary to facilitate deconstruction as an economically sound market. Policy issues include matters such as regrading and recertification of salvaged lumber for re-use in new construction.

Against this background the objectives of the Task Group are:

- to identify, document and develop new disassembly techniques for building deconstruction
- to examine economic issues that inhibit or support the concept of deconstruction
- to investigate national and international policies and regulations that impact on the deconstruction effort
- to develop lessons learned from case studies and successful deconstruction programmes
- to examine the potential for designing future buildings for deconstruction.

2 PROJECT "SUSTAINABLE DEVELOPMENT AND THE FUTURE OF CONSTRUCTION" BY WORKING COMMISSION W082 ON FUTURE STUDIES IN CONSTRUCTION

In June 1998 this Working Commission published a report containing the first results of the International CIB W082 Project which had been aimed at coming up with a meaningful response to the question: "What will be the consequences of sustainable development on the construction industry by the year 2010?" The study focused on investigating the relationship, and clearly defining the links, between the principles of sustainable development and the construction sector. The (Kibert) definition for sustainable construction being: "the creation and responsible management of a healthy built environment based on resource efficient and ecological principles" was taken as the starting point at the 1995 launch date of the project. The objective was to interpret and describe its meaning in different participating countries and, if appropriate, to give it a more apt definition from their national points of view. The project involved the collaboration of experts from countries throughout Western and Eastern Europe, North America, South Africa and Asia, also sharing the objective of producing this CIB Publication in time for the CIB Gävle Congress. The Publication assembles fourteen national reports and an international synthesis, which compare visions from various countries on what is comprised under the notion of "sustainable construction". The following countries supplied a national report: Belgium, Finland, France, Hungary, Ireland, Italy, Japan, Malaysia, Netherlands, Romania, South Africa, Spain, United Kingdom, United States of America.

Sustainable Construction has different approaches and different priorities in various countries. Some of them identify economic, social and cultural aspects as part of their sustainable construction framework, but it is only in a few countries that it is actually raised as a major issue.

The main emphasis in national definitions lies on ecological impacts on the environment (biodiversity, tolerance of the nature and resources). The problems of poverty and underdevelopment or social equity are sometimes ignored in the definitions of sustainable construction and in addition to economic prerequisites or social questions, numerous other variables and their importance differ from country to country. Such features as density and demography of population, national economy and standard of living, geography and natural hazards, availability of land and water, energy production and supply, the structure of the building sector or the quality of the existing building stock etc. also exert influence and interpretation in national definitions.

The contents of both the international synthesis and the 14 national reports are based on answers given to the following five questions:

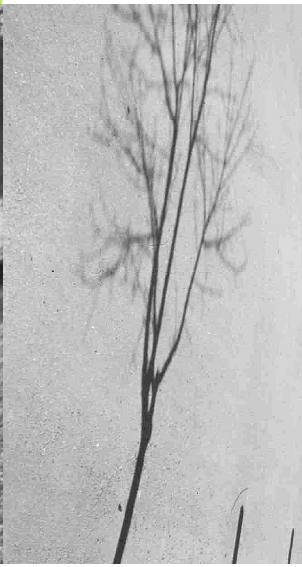
1. What kind of buildings will we build in 2010 and how will we adapt existing buildings?
2. How will we design and construct them? What does this entail for initiating, designing, constructing, maintaining, operating and demolishing buildings?
3. What kind of materials, services and components will we use then? What does this entail for manufacturers of building products and systems?
4. What kind of skills and standards will be required? What does this entail for the human resources and skills needed in the construction industry?
5. What kind of cities and settlements will we have in 2010? What does this entail for city planners and the built environment?

As well as answers to these five questions both the national reports and the international synthesis contain:

- strategic recommendations with the international synthesis including a separate chapter on Sustainable Construction and New Business Opportunities
- examples of Best Practices concerning the implementation of the various priorities for Sustainable Construction as perceived in the participating countries.
- Detailed information on the results available so far from this project can be found at http://bativille.cstb.fr/cib.htm
- A new project on "Construction Related Sustainability Indicators" is currently being launched.

This project will aim at:

- defining and validating construction related sustainability indicators
- implementing the indicators in measuring the sustainability of building projects, both buildings and the built urban environment, and different actors involved in their creation and maintenance at the national level
- implementing the indicators in comparing sustainability of building projects, urban environments, regions and nations at the international level
- to produce the knowledge and tools (in the form of sustainability indicators) needed to design and develop environmentally friendly products and processes in the construction industry.



ISBN 90-6363-015-8