Engineer Prof. E. O. E. Pereira Memorial Lecture

Sustainable Civil Engineering: Construction without Destruction

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Honorable Acting President, IESL, Engineer Dharmasiri De Alwis, Chairman, Civil Engineering Sectional Committee of IESL, Professor Anuruddha Puswewala, Past Presidents, Council Members, Members of the family and Well Wishers of Professor E.O.E. Pereira, Dear Colleagues, friends, ladies and gentlemen,

I consider it a great privilege to stand here today, to deliver the Professor E.O.E. Pereira memorial lecture to such a distinguished audience. I was fortunate to have joined the faculty of Engineering, University of Peradeniya in 1969, during the time that Prof. E.O.E. Pereira was still in the University, but not fortunate enough to study under him, as he had already been appointed Vice Chancellor, and had moved out of the Faculty. However, I do remember seeing him on a few occasions when he visited the Faculty. Everyone around seemed to be excited as if a very dear friend or close relative has come visiting, and we could see the love and respect the staff and students alike seemed to have for him. Our seniors used to call him 'the father of the Engineering Faculty', and I remember the time when there was a strike by the non-academic staff during his tenure as Vice Chancellor, how emotionally the senior students talked about him at the ESU Meeting, how we should rally around him and show our support. Even though we had not met him nor had anything to do with him up to that point, we were all convinced that he must be a really great person, to have commanded such love and respect from a group of youth, who, I am sure would have been shouting slogans against the administration under any other person. It was much later that we really got to know about the service Professor E.O.E Pereira had rendered to the field of Engineering Education in Sri Lanka.

As an engineering educator myself, I am so grateful to him to have paved the way for us to produce engineers who can work beside graduates from any University in the World, capable of taking up the challenges posed by the changing world, with the knowledge and confidence imparted by the Faculties of Engineering of the Sri Lankan University system.

Ladies and gentlemen, the topic I selected for today's lecture is "Sustainable Civil Engineering - or – Construction without Destruction"

Sustainable Civil Engineering – Construction without Destruction

'Sustainability' is a word that is very often heard these days, particularly when we talk about development. It has been defined by different people in different ways; one of the most commonly quoted definitions is the one in the Report of the 1987 UN World Commission on Environment and Development – Our Common Future, often referred to as 'the Bruntland Report': "**Sustainable Development is Development that meets the needs of the present without compromising the ability of future generations to meet their own needs**."

As we all know, Civil Engineering is one of the, if not *the* most important keystones of civilization, or development as we recognize it today. Historically too, the ruins or remains of great structures and infrastructure like the Dagobas and irrigation systems of Anuradhapura, Pyramids of Egypt, Stonehenge of England, buildings and fortresses of the ancient Roman, Greek and Maya cultures are the evidence that we have to learn about the height and the sophistication of civilization of those communities.

The Royal Charter awarded to the Institution of Civil Engineers, London defined Civil Engineering as "the art of directing the great sources of power in nature for the use and convenience of man,…" We call ours a 'People Serving Profession', or a profession with largely human interest in mind, and our role is to make use of the natural resources to make human life more comfortable, efficient and easy to do whatever they are interested in doing, be it food production, travelling, education, dwelling and working, communication, social, religious or spiritual activities. Civil Engineering involves providing irrigation for cultivation, construction of housing and offices, schools, hospitals, hotels and all sorts of buildings to provide living, learning and working spaces, roads and railways, both above and below ground, bridges to connect inaccessible points, harbours and airports for air travel and shipping and infrastructure like water supply and wastewater collection and disposal systems, storm drainage and flood protection schemes, coast protection structures and so on. Not only that, Civil Engineers are called upon to put up telecommunication towers for the telecom engineers to fix their equipment, pylons for the electrical engineers to support the power lines, and to design and install optical fibre cabling for the computer engineers.

We plan, design and construct all these facilities, and we have always been trained to do that with great attention to safety, comfort, serviceability and economy. A civil engineer would never design a building without checking the safety of the critical components against structural failure due dead loads, live loads, wind loads etc., according to the Codes of Practice, a dam without checking for overtopping, toppling or sliding, a drainage system without providing capacity for a predetermined rainfall intensity and return period, a highway or railway without providing the necessary curvatures to ensure safety and comfort and so on. Nor would a Civil Engineer plan or design a structure or facility that would seem insecure or is insufficient for the purpose for which it is meant. He or she would select all materials very carefully to ensure its strength, serviceability and economy. We have heard of the famous saying 'an engineer is a person who can do for one dollar, what any fool can do for two', and often we find engineers who economize even at the expense of aesthetics! Our thinking has been trained in this fashion, and it only feels right when we do our work according to these concepts.

While doing all this to provide a better quality of life for the population, we make use of, and sometimes render unusable, large amounts of natural resources, sometime even without realizing it. When we construct a building, for example, we use sand, minerals that go into cement, metal (stones), iron and aluminium, timber etc. as construction materials, fresh water, and fuel for transport of materials and people and for operation of equipment, which are all natural resources. But sometimes we tend to forget that we are making use of a very limited resource, land, to put up the building. It is the same with roads, railways, airports, carparks or any other land based construction. We deprive the land of being used for other productive uses, and reduce the vegetation cover, which cleans up the air, by absorbing the green house gases that cause global warming. Most of us do not think twice about removing the vegetation and topsoil from a construction site, or cutting down a tree that is obstructing a predetermined road or railway alignment or a power line. When we want to provide irrigation for agriculture, we have no qualms about putting up a dam across a stream and making a reservoir, drowning all plants and small animals and insects, particularly if no people are adversely affected. No wonder we give the impression to the public, particularly the so called environmentalists that we do not care for the environment as much as we should.

We used to assume that such destruction of the environment is the price people have to pay to get what they want – a trade-off situation that is inevitable.

However, now there is another dimension or a concept that has become very important as the world has realized the diminishing nature of the natural resources that are available to us.

The earth can be compared to a spaceship travelling at very high speed through the Universe, with all the materials needed for our survival are packed into it. The only external resource is the sun's energy, which is available to us as a perpetual resource. It is not like travelling in a train or bus, where we could stop at a station or bus stop and have a cup of tea and a bun or wadai. The earth has a life support system, which is governed by the natural recycling of matter and the one way flow of energy from the sun which can be converted to other forms, but loses a part of it as low quality heat every time it is converted. We learn about these as the law of conservation of mass and the two laws of Thermodynamics.

Some resources like trees and animals get replenished fast when used, and we call them 'renewable resources'. Some resources take a very long time to be replenished, like coal and fossil fuel – these are called 'non-renewable resources'. Then there are resources that are not affected by how much is used, like the sun light, flowing water, wind and tide. These are called perpetual resources. Energy produced from non-renewable resources like coal or petroleum is called 'nonrenewable energy', while energy produced from renewable resources like wood (dendro power), waste digestion (biogas) and vegetable oils (Bio diesel), or perpetual resources like flowing water (hydropower), sunlight (solar power), wind and tide is called 'renewable' energy. One thing we must remember is that even though renewable resources can get replenished fast, they can only last if we use them at a rate slower than they get replenished. If we use them indiscriminately, without concern for their re-growth, they will be the ones to disappear even before the non-renewable resources.

With the growing world population and the sophistication of our lifestyles, the limited resources on earth are getting depleted at a rate higher than the rate at which it is replenished naturally. We use them too much, and also make them unusable by polluting them. Added to this are the effects of climate change and global warming, experience by the world due to the increased emissions of green house gases carbon dioxide, methane and oxides of nitrogen by human activities such as burning fossil fuels and discharge of untreated wastes into the environment. This is why we have to make a conscious effort to limit our resource use and stop polluting the environment, allowing the earth to continue supporting life on earth by its own natural processes.

I think at this point I should speak a little about the important milestones in sustainable development in the global scene.

1972 - The Stockholm Agreement

In 1972, 113 nations attended the United Nations' Conference on the Human Environment in Stockholm, Sweden. It was the start of the global efforts to tackle environmental problems, where topics such as the human impact on the environment, population growth, social and economic development, help to developing nations, the part that governments should play in developing their own countries without harming the environment for other countries and the contributions that technology and education can make to tackling environmental issues were discussed.

1987 - Bruntland Commission Report 'Our Common Future'

The concerns for sustainability of the earth led to the appointment of the Bruntland Commission or the 'World Commission on Environment and Development (WCED)' by the United Nations in 1983, to address the growing concern about the accelerating deterioration of the human environment and the natural resources and the consequences of that deterioration for economic and social development. The Report of the Bruntland Commission 'Our Common Future' was published in 1987. The report suggested that international governments should meet to look at how to best reduce the effects of human activities on the environment for future generations. This led to the first Earth Summit, held in Rio, Brazil in 1992.

1992 - The Earth Summit

The Earth Summit, which was attended by 30,000 delegates, including 100 heads of state, led to agreements on:

- retaining the biodiversity of the planet;
- reducing climate change;
- management of the worlds forests and rainforests;
- a declaration on environment and economic development;
- a plan for governments to implement actions to address a wide range of environmental issues, known as Agenda 21. It still influences local and national sustainable development policies today.

1997 - Kyoto protocol

In 1997, the Kyoto conference looked at the issue of global warming and how to reduce the emissions of gases, such as carbon dioxide, that are causing it. It set up a framework that required countries to reduce their emissions of greenhouse gases to an average of 5% below the levels they produced in 1990. This reduction should be reached by 2012.

The Kyoto treaty assigned countries with a level of greenhouse gases that they were permitted to produce. Low CO_2 producers can sell their allowances to high CO_2 producers. This is called 'carbon trading'.

In 2005, a scaled-down version of the original treaty was agreed. The Kyoto agreement received a boost when the Russian government agreed to sign up. However, the United States continued to opt out of the treaty.

2002 - Johannesburg World Summit - 'Rio + 10'

Ten years after the first Earth Summit in Rio, a conference in Johannesburg met to review progress towards sustainable development.

This conference looked at social issues such as poverty and poor sanitation that affect an estimated 1.1 billion people world wide. It also considered global warming and climate change.

The Johannesburg conference looked at how to improve the living conditions for billions of people on the Earth. Proper sanitation and clean drinking water would reduce diseases such as cholera that annually kills millions, especially young children. Governments agreed to work towards making affordable energy available to more people and increase the proportion from renewable sources.

2007 - United Nations Climate Change Conference in December in Bali, Indonesia

187 countries agreed to launch a two-year process of formal negotiations on strengthening international efforts to fight, mitigate and adapt to climate change, an Action Plan called the 'Bali Road Map' under the United Nations Framework Convention on Climate Change (UNFCCC).

2009 - United Nations Climate Change Conference from 7th to 18th December in Copenhagen

World leaders will seek to adopt a new global agreement to address climate change. The meeting will represent the culmination of an intense, two-year Governmental negotiating process – launched in 2007 in Bali, Indonesia. The goal of that process is to agree on a climate deal that would enter into force after the first commitment period of the 1997 Kyoto Protocol expires at the end of 2012. A number of meetings were held in the past two years in preparation for this meeting, the summit on Climate Change called by the UN Secretary General Ban Ki Moon will be held on 22nd September in UN Head quarters, Geneva.

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There is a lot of awareness being created about the issue of climate change and how it is going to affect the world. We know that the predicted sea level rise due to the melting of the polar icecaps is going to affect island nations like Sri Lanka very badly. Of course, this is a phenomenon that everyone who uses a petrol or diesel motor vehicle, uses electricity generated by non-renewable resources, eats processed food, uses plastics etc. etc. can be held responsible for, to a greater or lesser extent, as the cumulative effect of all the single acts is the cause of this.

However, as users of large amounts of natural resources, water and energy in our work, we Civil Engineers can make a significant difference to the way things are happening, if we consciously make an effort.

Several Tools have been developed to assess and mitigate (i.e. avoid or minimize) the impacts of human actions on the environment.

Environmental Impact Assessment

Environmental Impact Assessments (EIA's) and Initial Environmental Examinations (IEE's) for proposed projects were introduced to ensure that projects are planned, designed, and implemented in such a way that no significant environmental impacts are caused by them. By carrying out these Environmental Assessments at an early stage in the project cycle, that is, at the feasibility study stage, it provides an opportunity for the engineers to look at alternative ways of doing things to avoid or minimize the probable negative environmental and social impacts, thus making it sustainable. Sri Lankan Environmental Regulations require that any project coming under the list of 'Prescribed Projects' need to obtain environmental clearance by carrying out an EIA or IEE depending on the significance of the anticipated impacts. The list of 'Prescribed Projects' has been prepared considering the extent and significance of the anticipated environmental impacts, depending on the size of project and location. Those projects located in 'environmentally sensitive areas' need clearance irrespective of the size of project. The procedures for EIA are fairly well established in Sri Lanka now, having come into force with the publication of Regulations in the Government Gazette dated 24th June 1993, with a few minor amendments subsequently.

However, the spirit of EIA is regulatory in nature, and even though it has the advantage of identifying the problems early and taking corrective action so that the projects are much less likely to fail due to social and environmental problems, there does not seem to be much incentive for the developer or the investor to carry out an EIA, as no tangible benefits can be seen for the money invested. The process depends heavily on the public involvement and technical competence and commitment of the approving agencies, both of which are rather inadequate in countries like ours. Except in donor-funded projects where the funding agencies also require environmental clearance, it is difficult to convince investors to carry out impartial Environmental Assessments and incur additional costs for mitigation and monitoring as it does not seem to bring back any direct monetary return on investment.

Strategic Environmental Assessment

Strategic Environmental Assessment (SEA) is another tool that is being used by Environmental Regulatory Authorities to help in informed decision making to guide development activities towards sustainability. SEA is carried out for policies, programs and plans before individual projects are identified or implemented, at a stage when the flexibility is available for assessment of environmental sensitivities and need for protection, resource availability and constraints, infrastructure availability and constraints, investment needs, external influences and threats etc. Even though SEA is not a legal requirement in Sri Lanka, Cabinet approval was obtained in 2006 for a memo submitted by the Central Environmental Authority (CEA) through the Ministry of Environment and Natural Resources recommending that in future all policies, plans and programs should be subjected to SEA. In 2008, the CEA carried out an SEA for the Trincomalee Development Plan, which I understand is being used for decision making for Project Approvals in the area under the 'Nagenahira Navodaya' Program, and another SEA is currently being conducted for the Development Plan for the Greater Hambantota Area. Once a Development Plan is prepared incorporating an SEA, decision making for approval of individual projects becomes much simpler, as much of the environmental and social concerns would already be identified in the macro scale.

While EIA and SEA are focusing on the protection of the environment through resource conservation and mitigation and monitoring of impacts, which may be looked at as a reactive approach, the Sustainable Engineering, Sustainable Construction or Green Construction concept is a proactive approach, driven by financial, environmental and operational considerations.

Sustainable Civil Engineering

The Royal Academy of Engineering, UK in their Report on "engineering for Sustainable Development: Guiding Principles" describes how 'we are faced with three types of concerns, as development progresses:

- Socio-centric concerns, or the human expectations and aspirations
- Techno-centric concerns, which encompasses techno-economic systems or the skills that Engineers must continue to deploy and the economic system within which we deploy them
- Eco-centric concerns or the ability of the planet to sustain us, both by providing the material and energy needs and by accommodating our emissions and wastes.

Sustainable Development can be thought of as the process of development where the socio-economic and techno centric concerns are kept within the eco-centric concerns, or the human expectations and aspirations are satisfied by deploying skills of engineers and an economic system in a way that the eco-centric concerns are satisfied, in other words, in a way that the planet can sustain us.

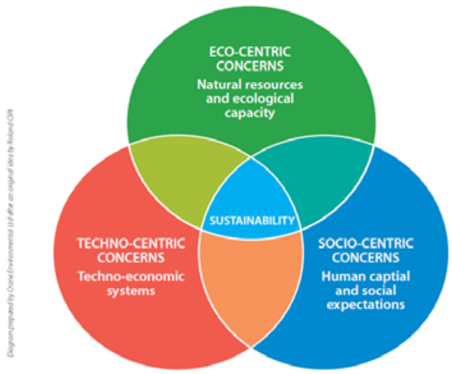
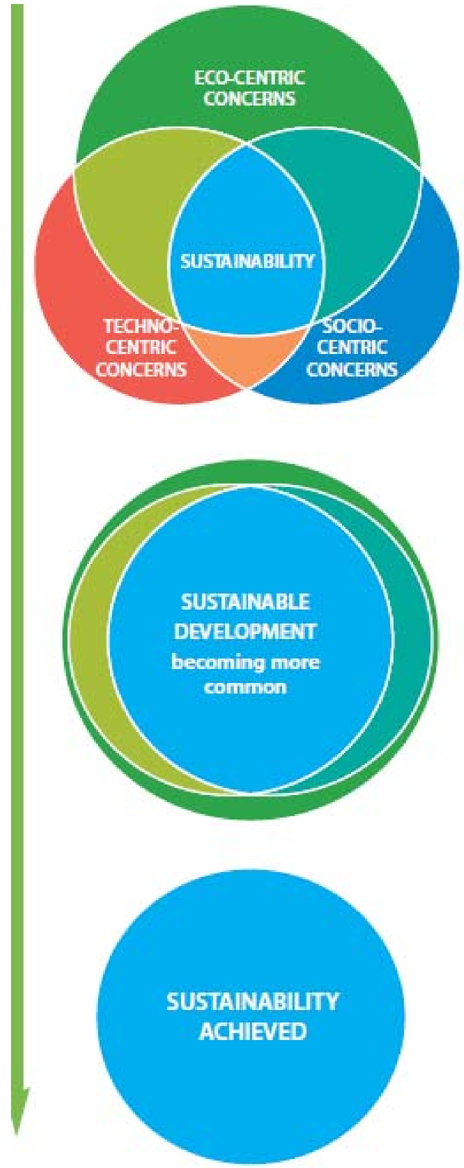


Figure 2a: Three dimensions of sustainability



Ref: Engineering for Sustainable Development: Guiding Principles, The Royal Academy of Engineering, 2005

We cannot use technology as if it has no environmental or societal implications. Often it is the Civil engineers who would lead the decision making process about the use of materials, energy and water resources, development of infrastructure etc. Civil Engineers must therefore be key players in Sustainable Development and in fact we have an obligation as citizens to not just to act as isolated technocrats. One implication is that the engineer may face the dilemma of their responsibility their responsibility to his immediate client or customer and the society at large, which may be in conflict sometimes. At such situations, the engineer's strength will be a sound knowledge and understanding of the guiding principles of sustainable development and alternatives available to him to satisfy the client's needs in a sustainable manner.

Even though the awareness of the importance of sustainable development is growing in the world, engineers will still be called upon to design, construct and manage complex systems or simple systems to manage complex demands. However, the context within which the engineer has to operate is redefined by the need for sustainable development. It is a new integrative principle, not a set of tools that can be added on to the existing engineering skills. For sustainable development to be achieved, professional practice in engineering needs to have a wider scope than the development of elegant solutions to narrowly specified technical problems.

The challenge faced by Civil engineers in sustainable development is to make their contribution to society to

- Reduce the adverse environmental and social aspects of developments
- Improve their environmental performance
- Improve their contribution to a high quality of life
- Help society to move towards a more sustainable lifestyle, and
- Ensure that products, services and infrastructure meeting these criteria are competitive in the market place, and ideally the most competitive

This task is vital and urgent, and demands innovation, creativity and other traditional engineering skills, alongside an ability to work with the many other disciplines involved. It also requires a new view of the world, and a preparedness to adopt new ways of working and thinking about the impacts into the future – negative as well as positive, of their actions. It needs much more planning before a project can be implemented, as every material used, every process employed, has to be considered in the light of resource, energy and water conservation, enhancement of the environment and the quality of life of the local community, pollution control and waste reduction, transportation reduction etc.

Ecological Foot Print, Carbon Foot Print, Green Buildings and LEED Certification

These are some terms that are used often in the sustainability jargon. It is important to understand what they really mean.

The ecological foot print is a measure of human demand on the earth's ecosystems. As I mentioned earlier, while humans use or consume the natural resources and also discharge wastes into the environment, the earth's ecosystems have a capacity to regenerate the resources and absorb the waste products, as long as the demand is not excessive. It is possible to calculate the total capacity of the earth's ecosystems available for this function, and the amount of biologically active land and water area needed to regenerate the resources consumed and absorb the wastes produced by the human population, if everyone lived a certain lifestyle. The 'ecological foot print' is a comparison of the human demand with planet earth's capacity for these functions, and is expressed as the number of planet earths required. The ecological foot print for the total world population in 2005 has been calculated as 1.3 planet earths, in other words, humanity uses ecological services 1.3 times as fast as Earth can renew them. (This will be updated every year with a 3-year lag period, which is needed to get all the required data.) While this is the average for the whole world population, the same technique can be used for calculation of the ecological foot print for a person, household, community, town or country, considering the particular lifestyle is being led by the total world population. Usually, the more affluent communities have a much larger ecological foot print than the poorer communities, but it is more to do with the wasteful resource use than how wealthy a person is.

A carbon footprint is defined as the total amount of greenhouse gases produced to directly and indirectly support human activities, usually expressed in equivalent tons of carbon dioxide (CO_2). It can be calculated by adding the emissions of carbon dioxide and equivalents of other green house gases which were produced in a given time frame, usually one year. Carbon foot print also can be calculated for a person, building, organization, community or the whole population, by estimating carbon dioxide emissions from non-renewable energy sources directly or indirectly produced during transportation, cooking and heating, cooling, etc. as well as for processing of food, production of plastics, other goods, packaging, building materials etc. The carbon foot print can be reduced by using more renewable energy and less energy from fossil fuels, and the ultimate aim would be to become zero-carbon or carbon neutral, which means that all energy used is from renewable sources like solar, dendro, biogas and bio diesel.

A **green building** is an outcome of a design philosophy which focuses on increasing the efficiency of resource use — energy, water and materials, while reducing building impacts on human health and the environment during the building's lifecycle, through better siting, design, construction, operation, maintenance, and removal.

Effective green building can lead to 1) reduced operating costs by increasing productivity and using less energy and water, 2) improved public and occupant health due to improved indoor air quality, and 3) reduced environmental impacts by, for example, lessening storm water runoff and the heat island effect. Designers using the green building concept often seek to achieve not only ecological but aesthetic harmony between a structure and its surrounding natural and built environment, although the appearance and style of sustainable buildings is not necessarily distinguishable from their less sustainable counterparts.

LEED, which is a shortened term for Leadership in Energy and Environmental Design, Certification is a Green Building Rating System, developed by the U.S. Green Building Council (USGBC), which provides a set of standards for environmentally sustainable construction.

LEED certification provides independent, third-party verification that a building project meets the highest green building and performance measures. If a developer is interested in obtaining LEED certification, sustainable building strategies should be considered early in the development cycle. There is a checklist which ensures that all aspects of sustainability are covered in the design and implementation of the project. There are both environmental and financial benefits to earning LEED certification. Certain clients in the developed market insist on purchasing only from LEED certified suppliers. However, there is a debate going on whether aiming at LEED Certification distracts the designers from the main objective of sustainability and miss opportunities for innovation that each project presents, by chasing certification points according to the LEED Checklist.

Examples of Sustainable Civil Engineering

Sustainable Civil Engineering requires much more planning, working in multi-disciplinary teams, flexibility and adjustments and innovation than traditional civl engineering. However, the positive side of this is that if carried out well, the payback period for increased investments on a Project can be very short, because all these measures used for conservation can really have significant reductions in operational costs, as can be seen by many successfully implemented projects, in Sri Lanka as well as in other countries.

The UK Government has set out to become carbon- neutral by 2012. Some of the examples of Sustainable Civil Engineering Projects from the United Kingdom are:

The Manchester Civil Justice Centre

This building, which is the Northwest England Headquarters for the Department of Constitutional Affairs has been officially opened by the Queen in March 2008. The main Sustainability Features in this building have been recorded as:

- Natural ventilation
- An 'environmental veil' on the east façade to control solar gain but also maximise natural daylight, and
- Groundwater cooling, which alone reduces cooling load energy consumption by around 15-20%.

Vulcan House, Sheffield

This building is the new base of the Home Office, and it is said to be a building that's well insulated, protected from solar gain and airtight, thus creating an internal environment that's stable and passive and needs less energy for heating and cooling than a conventional building.

Sustainable design elements include:

- Heat reclaim and circulation systems
- HFC free cooling and heating plant
- Audited subcontractors supplying only approved materials
- Prefabrication of plant and minimal packaging (which is then reused or recycled)
- Grey and rain water recycling for toilets

In addition, all staff has been provided with a guide on how to use their new office. The guide helps them understand the design principles and helps them conserve energy.

Cathodic Protection on M4 Motorway

In the UK it used to be a common practice in the winter, to use salt to prevent ice forming on the roads. Salt used to prevent ice forming on the M4 during winter had seeped through joints in the road deck into the concrete of the beams, causing near surface steel reinforcement to corrode. It was necessary to install cathodic protection on the reinforcement in order to prevent further deterioration of the concrete, which would endanger the users of M4. However, the usual method of drilling holes vertically to reach the reinforcement, which would have meant stopping the traffic on M4 for several days, which would have created havoc. Instead of drilling multiple holes, a single hole was cored from end to end of the beam, right through its centre, thus completely avoiding working beneath it.

Rethinking how to install cathodic protection on the M4 motorway viaduct has reduced traffic disruption and environmental impacts, and slashed costs.

Key sustainability facts of this operation are:

- Energy demand cut by 60%
- Cost cut by 20%
- Time cut by 90%
- No major traffic disruption
- Reduced noise pollution
- Reduced work at height

Chineham Energy Recovery Facility, Hampshire

This facility, which is operating on waste, produces up to 8MW of power of which 1.25MW is used to operate the plant. The remaining 6.75MW is sufficient to supply 10,000 homes with electricity each year. The building is partly clad in light-reactive coated aluminium that changes colour depending on light levels and weather to appear grey, blue or purple. Semi-opaque polycarbonate cladding allows natural light into the building and reduces electricity use. The 'tipping hall' has a 'living roof' covered with plants that change colour seasonally and require no maintenance

Kingsmead Primary School, Cheshire

This primary school in Northwich was constructed as a template for new school design using innovative engineering, sustainable principles and collaborative working. As well as being a futuristic learning and teaching environment the school delivers environmental, economic and social benefits. The school's location maximises natural daylight and ventilation and exploits passive solar energy while its wood and glued laminated timber-frame construction reduced the amount of concrete, plaster, metal and PVC required. Energy for lighting is reduced using daylight sensor controls and low-energy high-efficiency lamps. Recycled and recyclable materials are used wherever possible and rainwater is used for toilet flushing. Engineers increased insulation and thermal mass (heat storage capacity) to reduce the energy needed for heating. Heating is provided by a gas boiler and by burning biomass (plant or animal matter). Solar thermal power is used to assist water heating. The building is also a teaching resource where pupils learn about their environment by remotely accessing the building management system to monitor classroom temperatures, rainwater volume and the amount of energy consumed.

Masdar Initiative, Abu Dhabi, UAE

Sustainable Development has not only been applied to individual projects. I am sure some of you have heard or read about the Masdar Initiative in Abu Dhabi, UAE, where the whole new City of Masdar is being built as the world’s first carbon-neutral, zero waste City.

Some of the salient features of the initiative are:

- With respect to Power, generation of electricity is through renewable resources, or by using natural methods to bypass the need for power use. While a standard city would draw power from a distant power station, fired by coal, oil, gas or nuclear fuel, they use
    - Photovotaic Technology
    - Solar thermal evacuated tube collectors
    - Concentrated Solar Power
    - Waste to Energy
    - Geothermal Energy

- As to Water Conservation
    - Their Houses and offices will have three separate water lines for drinking water, grey water (wastewater from cooking and bathing) and black water (sewage)
    - Grey water will be lightly filtered and reused or used for irrigation of indigenous plants

- As for Transport, the city is designed as a 'Walkable' City, and motorized transport will be by
    - Personal Rapid Transit (PRT) – A fleet of 3000 automated electric taxis, the service to be operated 24/7
    - Freight Rapid Transit
    - Light Rail System

  The transportation system will be designed for Multilevel, barrier-free transport. And for long distance travel, it is proposed to have Metro and high speed rail services

Over 90 sustainable programs have been identified for development over the next few years.

(Ref: http://www.masdarcity.ae)

Clothing Factory in Sri Lanka, MAS Fabric Park – 'Thurulie', Thulhiriya

In Sri Lanka too, there are a few Projects that have been successful in moving towards Sustainable Construction. The Clothing factory of MAS Intimates at Thulhiriya, Thurulie, is one such successful Project.

Let me discuss some of the Salient features of Sustainable Design and Construction in this Project.

1. As for the Site Design, the guiding principle was to **accommodate the building while respecting nature.** Several sustainability features have gone into the site design, like

- Having a compact building with a foot print of only 6780 sq.m. covering only 15% of the site, leaving a maximum of open space;
- Open space left undisturbed or improved with erosion control and new planting;
- Lake and wood left as protected areas, and most large trees on the site preserved
- Preserving natural topography and drainage patterns as much as possible, in fact one building is constructed on stilts in order to accommodate the drainage
- Internal roads, walkways and terraces are paved with cement stabilized earth instead of sealed pavements, and paving covers only about 10% of site, thus leaving 75% of the total land area to nature
- Water use for landscaping is reduced by 50% due to drip irrigation, and selection of endemic and adapted species
- Innovative 'cascade' water management system for drainage- terraced slope built with cement stabilized rammed earth, draining all runoff to the retention pond.

- And the facility is planned for such a capacity that it can supply the demand by only working during daylight hours – at night it is left to nature.

2. As for the Building,
   - it is designed as a 2 storey building to reduce the impact on land, whereas usually clothing factories are designed as single storey buildings,
   - the Production floors are column free, for flexibility
   - and overhead electrical receptacles and lighting fixtures are provided so the machine arrangements can be changed to suit the garments being made
   - Passive cooling measures are introduced to reduce the thermal load to a level that can be handled by environmentally efficient cooling systems, and
   - Wastewater is treated using an anaerobic system, and biogas produced is planned to be used in the kitchen, while the solids are used for composting

3. Factory is Designed for Lean production, by

   - Efficient Factory layout Planning
   - Operating a 'Just-in Time' Manufacturing Process, thus reducing material storage requirement and getting more space for value addition
   - Having a Wireless network enabled building with laptops and mobile phones linked to the company phone system, so that anyone can go on line anywhere within the factory, and everyone can be contacted.

2\. Employee Wellbeing is looked after by providing

   - An Attractive environment with Pleasant outdoor views
   - Thermal comfort
   - Fresh air
   - Just enough Illumination, by a mix of natural lighting and task lighting
   - Comfort at work- T-shirt and bare foot working allowed
   - And many other benefits to the employees

3\. One of the most important aspects of sustainable construction is selection of the right materials. Construction Materials used in this factory are:

   - Compressed stabilized earth blocks for Main Exterior walls
   - Concrete and steel with high recycling content is used for the frame
   - Zinc Aluminium for the Roofing

- Metal framed windows
- Several types of Floor finishes including polished concrete tile, rendered and cut cement, tile and wood
- Bamboo for window blinds and sunscreens, and
- Non-hazardous and the greenest viable alternatives in Sri Lanka for finishes
- Construction waste has also been recycled as much as possible

4. As for the Energy Efficiency, their motto is

‘We put all our energy into designing a plant that will save energy’

- For Air Conditioning, by using passive cooling and efficient evaporative cooling equipment, an indoor temperature of 27-29^{0}C is maintained, which is as comfortable as 25 -26^{0}C in a normal factory, while only 25% of electricity required
- Natural lighting is used in all areas other than work areas, while efficient task lighting complements the low level of room lighting provided by overhead fluorescent lights in work areas. The restriction of artificial lighting gives an added benefit of minimizing heat gain inside the factory.
- Energy efficient sewing machines and laptop computers are chosen to reduce electricity use

5. As for Water Management

- Consumption of potable water has been brought down to about 50% of comparable plants, due to water management
- Potable water is used only for cooking, washing, drinking (after filtration), for the evaporative cooling system and as back up for toilet flushing.
- Rainwater from cool roof is harvested for toilet flushing, which is sufficient for 90% of the time
- Rainwater from the green roof is filtered through gravel and sand and fed to the pond
- Treated sewage is discharged into the retention pond and groundwater recharge.

6. Only renewable energy is used in the factory, hence it is a carbon neutral facility.

- Rooftop photovoltaic system provides 10% of total electricity requirement, while the Balance 90% is obtained from a small hydro electric plant in Deniyaya, which is sponsored by the company and is connected to the national grid.

- This is said to be the first facility in Sri Lanka where Net metering is practiced – the consumer is credited for the power fed to the national grid, and billed only for the difference.
- Boiler feed water is pre-heated in Solar water heaters before boiling in conventional boilers, thus reducing the energy requirement.
- Methane produced in the waste treatment plant is planned to be used for stoves and ovens in kitchen

As for the Economic Performance of the factory, it has cost USD 7 million, which is 25% more than an equivalent conventional clothing factory

- The payback period on additional construction cost is expected to be 5 years, due to energy savings and higher operational efficiencies
- M & S contributed USD 400,000 for sustainable energy (photovoltaic panels etc.)
- Added intangible benefits of good will, image enhancement and reputation resulting from this can be considered as long term benefts for the Factory.

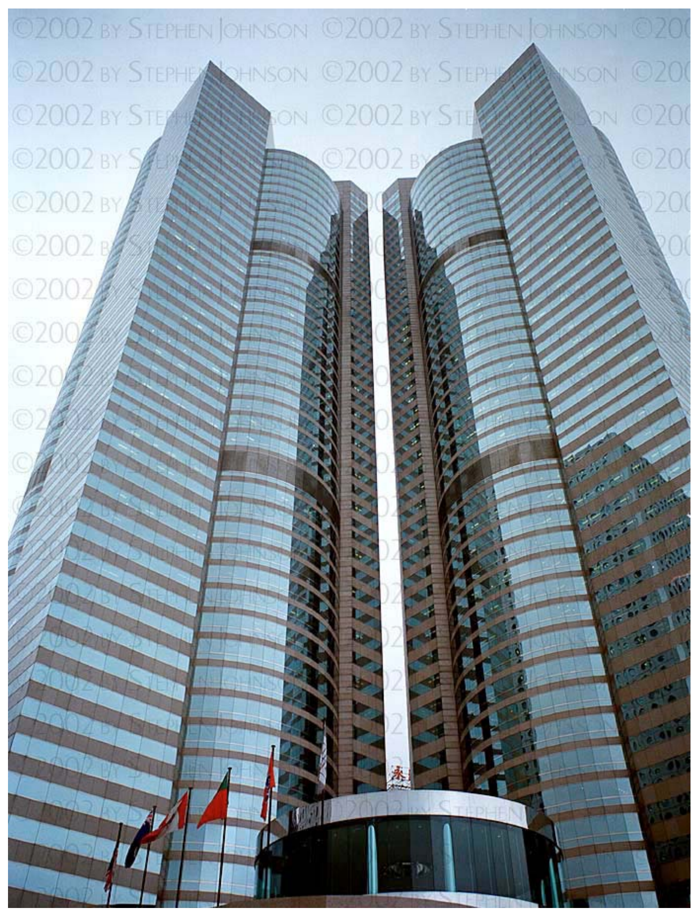
(Ref: Holcim (Lanka) Ltd, 2008 “Clothing factory in Sri Lanka”)

I have given rather extensive details about the MAS Intimates Clothing factory at Thulhiriya, just to impress upon you that Sustainable Civil Engineering can be actually implemented in Sri Lanka, and if you look at the Multidisciplinary Design Team, you can see that they are all Sri Lankans, and I am proud to say that the Architect, Civil Engineer, Materials Specialist, Energy and Cooling system specialist and the Chemical Engineer are all senior academics from University of Moratuwa.

So dear colleagues and friends, I hope that I was able convince you that we have to commit ourselves to sustainable civil engineering, or construction without destruction, as we have only one earth, and although it involves a change in our mindset and a lot of preparatory work, that, with determination, commitment, and innovation, it is possible to do it.

We can see that this **tree house** must be having a very small ecological foot print, but in this day and age, we cannot expect people to be living in tree houses.

As Civil Engineers, our job is to construct more and more **structures like this**, to accommodate the needs of the growing world population.



The Challenge of Sustainable Civil Engineering is **to try and make the ecological foot print of this structure as small as that of the tree house**!

Thank you.