Creative engineering solutions to alleviate poverty can be achieved when the engineering profession acts proactively to meet challenges posed by the developing world.

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Abstract

Poverty alleviation in the developing world will invariably involve a contribution from professional engineers. However, such initiatives are too often unsustainable. The sustained alleviation of poverty through the implementation of infrastructure solutions requires attention to the underlying social, economic and political influences. The engineering profession should not accept a role of supporting poor policy with ‘good’ engineering.

The role of the engineer is important – but the engineer must work in collaboration with other professionals if sustainable poverty alleviation is to occur. Engineering solutions to poverty situations must take account of the socio-political and economic framework that they face, if they are to achieve medium to long-term sustainability. Creative engineering solutions to alleviate poverty can be achieved when the engineering profession acts proactively to meet the challenges posed by the developing world.

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Introduction

The statistics on world poverty are frightening. Close to half of the world’s six billion people live on less than US$2 a day. One percent of the world’s population has an income equal to that of the entire bottom 57% (World Bank, 2000c). Poverty, however, is not only about lack of wealth in monetary terms; it also implies the “denial of various choices and opportunities basic to human development. These include the ability to lead a long, creative and healthy life, to acquire knowledge, to have freedom, dignity, self-respect and respect for others, and to have access to the resources needed for a decent standard of living” (UNDP 2002).

Community infrastructure is a key element in alleviating poverty – thus engineers have an essential role to play. Without ready access to clean water and sanitation, productivity is severely reduced through illness and time spent in water collection. Without roads, the poor are unable to sell their goods at market. Basic infrastructure is not a luxury that can wait for better economic times, but a precondition for creating them. The provision of basic infrastructure is an urgent and on-going requirement.

The Economist “observed over the past 50 years rich nations have given US$1 trillion in aid to poor ones. This stupendous sum has failed spectacularly to improve the lot of its intended beneficiaries. Poor countries that receive lots of aid do no better, on average, than those that receive very little” (The Economist, 1999). Poverty is not being ignored; however, the effectiveness of poverty alleviation strategies needs to be improved if world poverty alleviation is to be achieved.

The Origins of Poverty

In order that solutions to poverty may be implemented, the origins of poverty must be clearly understood. The basic causes of poverty and barriers to human development are:
- Lack of access to safe water and sanitation
- Lack of facilities for adequate health care
- Lack of access to educational opportunities
- Shortage of adequate nutrition
- Lack of adequately paid employment
- Inadequate or expensive transport facilities
- Limited or expensive power supplies

In general, poverty has different causes in urban and rural areas; many of these influences are not mutually exclusive. In urban areas, the predominant causes of poverty are likely to be:
- Lack of adequate income or no income, due to underemployment or unemployment
- Inadequate housing, sanitation and water supply
- Limited opportunities for education
- Inadequate or expensive transport facilities

Poor health and lack of access to education tend to minimise skills and, therefore, compound the problems of un- or underemployment and, therefore, reduction of income-earning capacity.

In rural areas, the predominant causes of poverty are likely to be:
- Lack of access to a range of facilities: healthcare, education
- Inadequate shelter, sanitation and water supply
- Lack of access to markets for agricultural products
- Limited opportunity to earn income
- Inadequate or expensive transport facilities
- Lack of access to power and telecommunications facilities

Poverty in rural areas tends to be more widespread and more intense than in urban areas; this is because:
- Employment opportunities are more limited
- Access to a range of key facilities is significantly reduced
- Many households are headed by women – often due to abandonment of the family by the males, with commensurate reduction in income
Sanitation and water supply deficiencies are more intense, leading to ill-health. The trend in developing countries worldwide - whereby male family members gravitate to urban areas in search of employment - often reduces the rural family's ability to survive in a subsistence economy.

**Poverty Alleviation Strategies**

Understanding the potential role for engineers in poverty alleviation is informed by past and current projects. Historically, poverty alleviation strategies have focused on direct intervention to provide facilities that are lacking. Investments by the international lending agencies over the past two to three decades have concentrated on solutions to deficiencies in infrastructure that are usually expensive, often with apparently limited thought to ongoing operation and maintenance. Local observers in a number of recipient countries and other stakeholders have commented on inadequacies in the implemented projects and programs:

- Lack of planning for on-going operation and maintenance of the facilities
- Limited attention to the development of a sense of ownership by the local community
- Political interference and intervention
- Allocation of funds to countries without a poverty alleviation strategy of their own
- Corruption, leading to ineffectiveness of investment

Over the last 20-30 years, experience with the implementation of large-scale infrastructure improvement projects has led to an improved understanding of the conditions that are necessary for sustainable reduction in poverty levels:

- The local community must be empowered by the decision-making process
- The local community must be involved in on-going operation and maintenance
- National and regional governments must also be involved in the project
- Project selection must favour those projects that lead to economic growth
- Strength of the market economy is a prerequisite to economic growth
- Close involvement of the local community will improve the chances of project success; the project needs to be 'owned'

Poverty alleviation requires interventions that involve considerable social and cultural change. Poverty has many aspects and solutions require more than a technical or engineering basis. Provision of infrastructure alone will not alleviate poverty, without access being provided to that infrastructure. We can ask the following questions: What good is a road, if there is no means of transport? What good is a latrine, if it is not being used? What good is a water supply system, if it is in disrepair? In developing strategies for the alleviation of poverty, we must take account of and address these wider issues.

At the recent Johannesburg Sustainability Summit, both the United Nations and the World Bank called for alleviation strategies involving “no more hardware”, pointing out that major investments over the last 20-30 years in water infrastructure schemes had often failed to benefit the people at whom they were aimed. This is because the majority of facilities involving technology are generally abandoned within two years, as revenue streams are insufficient to pay for repairs and maintenance and because of the lack of local skills to carry out repairs. Corruption is also often a barrier. In agreeing to a target to halve the number of people without sanitation globally by 2020, the Summit noted that the emphasis should be on smaller scale solutions suited to local capabilities, understanding and skills. The role of engineers in delivering infrastructure schemes needs to change significantly.

Figure 2: Grameen Bank micro-credit weekly meeting with the bank manager (Building and Social Housing Foundation)

Figure 3: Peri-urban drainage (WEDC Andrew Cotton)
Characteristics of Sound Engineering Solutions to Poverty Alleviation

Engineering solutions are integral to the mitigation of poverty; however, engineering is not the sole contributor to successful poverty alleviation programs. Sustained alleviation of poverty also entails attention to social, economic and political influences.

**Sustainable engineering** will be achieved when the engineering solutions adopted take into account their use of natural resources; optimum solutions will have a positive or neutral impact on natural resource consumption. Unsound engineering solutions, by comparison, may leave the environment depleted and society poorer over time.

**Life-cycle engineering** takes into account the operational and maintenance cost of the engineering solutions proposed, such that the completed projects have effective and affordable operational and maintenance regimes.

**Empowered engineering** will take into account the capabilities of the local community, in particular its engineering and technical professions. Where possible, the solutions developed will involve local professional and technical staff and will establish an on-going engineering and operational resource.

**Appropriate engineering** will consider various options that meet the engineering needs of the project and may adopt labour-based construction techniques. Labour-based construction has been shown to compare favourably with plant-based construction. In addition, it facilitates knowledge transfer, creates jobs, encourages private enterprise, creates ownership and may reduce cost.

The case studies that follow illustrate the application of engineering to poverty mitigation programs and identify the associated social, economic and political actions that have been put in place. Each case illustrates characteristics of sound and appropriate engineering.

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1 Labour-based construction differs significantly from labour-intensive construction. Labour-intensive construction is basically the substitution of men for machines eg the construction of a concrete framed building for which the concrete is mixed by hand, without the use of a mixer. Labour-based construction, however, aims to change the technology employed in the construction process so as to make it appropriate for manual labour eg eliminating the concrete frame and building the structure using load-bearing masonry. (Croswell 1993)
South African Roundabout HIV/AIDS Initiative

Project Background
The AIDS epidemic is tearing apart the social and economic fabric of many African nations. 70% of the world’s AIDS infected adults and 80% of infected children live in Sub-Saharan Africa. There are 11 million child AIDS orphans and grandparents are forced to assume the responsibility for childrearing (AVERT 2002). Affected families lose income-earning capacity, both through the unavailability of the income earner and the time and cost incurred in nursing the infected. The problem compounds itself: poverty is a key factor leading to the behaviour that exposes people to risk of HIV infections and the resulting HIV compounds the poverty.

Project Details
The scheme concept is simple: a child’s playground roundabout is bolted on top of an existing borehole. The energy of the children at play is harnessed to pump drinking water into an overhead storage tank. These tanks are screened with billboards promoting HIV/AIDS awareness to the children and communities. A communal tap is located at ground level.

The roundabouts/pumps cost US$5,000 each and are based on standard windmill equipment located below ground (BASD & UNDP 2002a). The above ground equipment includes a tank and galvanised sheet as advertising boards, available at any farm supply store. Project construction and replication is assisted by the use of standard and easily procurable materials.

Play power has advantages over conventional energy sources. It is clean, renewable and robust and the borehole recovers naturally during the night. There is no risk of pumping the hole dry or engine burnout if the pump is accidentally left on overnight.

At least 50% of the advertising space on the billboards is used to promote health-related information, in particular with regards to HIV and AIDS. This is an effective advertising medium in the absence of conventional first world media such as newspapers, magazines, television and the Internet. Revenue from commercial advertisers in the remaining space will provide a regular flow of income for the manufacture of new roundabouts and to cover maintenance costs.

Women and young girls benefit from the saving of time and energy previously spent fetching water for daily water needs from deep wells at long distances and are placed at less risk. In addition, they benefit from the HIV/AIDS awareness campaign.

Case Study

Progress Report
More than 300 roundabout pumps have been installed in South Africa, each serving a community of over 2,500 people. Various improvements to the standard of living have been noted, including the ready availability of clean drinking water that has resulted in the reduction of water-borne diseases such as cholera and the development of thriving vegetable farms that provide fresh produce for schools and for sale at market.
Micro-finance in Bangladesh

Project Background

Bangladesh is one of the poorest, most densely populated and least developed nations in the world. With a population in excess of 125 million, it is the eighth most populous country in the world. Per capita income is estimated to be around US$280 (BSHF 2002). Situated in a low-lying delta where four major river systems come together, the country is blessed with highly fertile soil, but also suffers regular and severe flooding.

Shelter is one of the most basic requirements, but many Bangladeshis cannot afford the cost of housing capable of withstanding the monsoon and winter periods.

Typical houses are made of jute sticks placed side-by-side and cost between US$25 and US$30. Such houses tend to collapse in moderately severe weather. Even houses constructed with bamboo walls and hay/thatch roofing, at a significantly higher cost, are not very durable. As a result, almost ever year, people replace or repair the roof of their house at a cost of up to US$40 per year. This cost is increasing as the price of bamboo and hay is constantly increasing. This on-going expenditure is a heavy burden on the poor. If they do not have access to cash, people are forced to borrow money from moneylenders at very high rates (10% per month) (BSHF 2002).

This situation could be avoided if more durable shelter could be constructed; this in turn is dependent on the availability of finance.

Project Details

The Grameen Bank, the largest rural credit institution in Bangladesh, with 2.4 million borrowers, 95% of whom are female, was established in 1976. The bank recognises that it is the lack of access to collateral, rather than an inability to make loan payments, that perpetuates poverty.

Regular micro-enterprise loans are typically disbursed to individuals for one year and are paid back in weekly installments at 2% of the loan amount, which is normally no more than $20 for the first loan. To participate in the loan program, a member must gather five people with similar economic and social backgrounds who will agree to apply for, and sign together on, loans (a group). A cluster of groups (between two and 10) constitutes a centre that is presided over by two officials (BSHF 2002). The borrower’s group and centre members must agree to stand behind the loan for the individual member. The collateral system, based on peer support, means that families help each other out with payment to ensure that all repayments are made on time.

Grameen Bank operates as a specialized bank for the poor, generating income from its investments; it is not reliant on donor funding. When the bank was formally incorporated in 1983, the original rural members provided 40% of the initial capital and the Bangladesh government contributed the rest. The bank has since become largely self-sufficient, with the government now holding less than 10% of the equity.

Housing Loans In 1984, the bank started to lend money for housing loans and to date 450,000 houses have been built using these loans. An average of 7,000 to 8,000 new loans are made every month.
Although exceptions are made for the poorest of poor in dire need of shelter, relatively strict rules govern these loans. To qualify for a housing loan, a member must fulfill the following:

- be an existing bank borrower, with a 100% repayment record and have completely repaid their first two loans from income generating activities;
- prove that they have an adequate income and have acquired savings;
- have a history of regularly attending weekly meetings;
- provide legal documentation of land ownership where the house will be built. If the member does not own land, he/she is encouraged to use the loan towards land purchase; and,
- must submit a proposal on the type of house planned and devise a repayment schedule.

The House Design

The Grameen Bank has developed house designs for borrowers. The houses, although varying in appearance, have the same basic structural components. There are four reinforced concrete pillars on brick foundations at the corners of the house and six intermediary bamboo posts, with bamboo tie beams, wooden rafters and purlins supporting corrugated iron roofing sheets. This design provides stability in flood and strong monsoon winds and protection from rain.

Although the borrower is responsible for the construction of the house, the bank ensures that it meets basic health and safety requirements and achieves minimum Grameen standards. Since mid-1998, the bank has required members to install a sanitary latrine with each house.

Progress Report

The bank is operating efficiently and is widely considered innovative, progressive and corruption free. The rate of repayment for all loans is 98%, and for housing loans it is close to 100%, compared to a 25-30% for other banks. Loans are currently available at 8% interest, which compares very favorably with the 20% interest charged for regular or short-term loans from other banks (BSHF 2002). The bank provides employment for 12,600 people.

To date, the Grameen Bank Housing Program has assisted hundreds of thousands of Bangladeshi families to break out of the downward spiral of poverty. A sturdy, well-built house is a symbol of social status and so borrowers experience an improvement in their dignity and standing within the community.

The larger houses are providing improved environments for work and study, and hence they have directly contributed to higher income generation. It is estimated that 95% of borrowers’ children attend school, well above the nationwide average. By demanding standardised construction practices, such as the use of cement pillars and installation of sanitary latrines, Grameen Bank assists in improving the health and safety of borrowers. In one survey, the general health of those with the new Grameen houses compared well with those in pre-existing or more traditional houses. Fever, influenza, and typhoid (among other diseases) were down by almost 50% (BSHF 2002). Micro-credit programs based on the Grameen experience have been established in 56 other countries.

Figure 9: House after the Grameen Program
(Building and Social Housing Foundation)
BP Solar Energy Project, Philippines

Project Background
The Philippine archipelago is made up of around 7,100 islands, 1,000 of which are inhabited. Less than one-half exceed 2.5 sq km in area. Many of the villages (barangays) dotted over the country are remote and difficult to access by both land and sea. For many villages, connection to a national power grid is not feasible. Most district hospitals and regional health units have little or no electricity. Lack of lighting in community halls limits opportunities for further education and involvement in community affairs. Many villages rely on shallow wells or surface springs for their water, hence water-borne disease is endemic. Latrines are unsanitary, if in existence at all.

Solar power can provide a highly effective, low-cost and environmentally friendly alternative to extending power lines and/or transporting generator fuel to these areas.

Project Details
After the success of a solar power project completed in Sri Lanka in 1993/94, BP Solar Australia approached the Philippine government with a concept for large-scale implementation of solar power across rural communities. The idea was well accepted by the Philippine government. The initial objective of the project was to install about 1,000 stand-alone solar powered equipment packages in 400 villages in remote areas of Mindanao and Visayas provinces. At its time, this was the largest solar contract in the world at a total project cost of US$27 million.

Simplicity in funding arrangements for this project was fundamental to its success. Funding was provided by a single loan recipient, the Department of Interior and Local Government (DILG), by way of a grant of 33% from the Australian government plus a soft loan from the Australian government for the remaining 67%.

Community Mobilisation Phase
Community involvement throughout the entire duration of a project is essential to project success. Involvement fosters a sense of ownership and responsibility. The MSIP project was implemented with help of two full-time BP staff from Australia. The other 500 staff involved in the project were Philippino, selected from the communities in which they were to work to enable communication in local dialects.

Prior to project finalisation, officials used community assemblies to introduce the project, discuss the benefits both to the individual and to the entire community and to explain the basics of solar electricity.

If the community, and in particular the mayor, were interested, agreements were made to proceed. Site and social surveys were used to determine the development needs of each individual community and to identify the means by which solar energy could be best used as the enabling technology to meet these needs. BP also spent time with each barangay exploring revenue-generating activities that would enable them to pay for the services provided by the solar-powered systems.

Provision of Systems
Solar systems were supplied and installed in the specified areas. The logistics were challenging, due to the difficulty in getting construction materials, equipment and systems into the communities. As this was a ‘tied-aid’ project funded by the Australian government, BP Australia was obliged to source a minimum of 87% of components from Australia. However, some construction items, videos and televisions were sourced locally/nationally (BASD & UNDP 2002b).

Training and Capacity Building
In each barangay, two people were elected to form the Barangay Technical Team (BTT). The BTT was trained on simple system maintenance: cleaning the modules, topping up the battery electrolyte etc. Municipal engineers and operatives were trained on the more technical repairs and maintenance of the system’s components. Spare parts were distributed to the municipality in order that the communities could have easy access to replacement parts. High-level training was given to the universities, and university staff and students were able to fully dismantle, repair and reassemble the components. After
the commissioning and handover of each system, BP Solar carried out three separate follow-up visits with the groups that had been formed.

Over 2,000 people have been trained (including ‘training of trainers’) on both the governance of the project (how to, organise meetings, accounting and reporting; how to collect fees/local revenues for sustaining services/maintenance, etc) as well as on the technical aspects (maintenance, including local repair and replacement of parts). Experience has clearly shown that without such training, systems fall into disuse and disrepair and communities are then left disillusioned.

**Progress Report**

MSIP commenced in November 1997 and was completed in May 2001. In total 1,145 packaged solar systems were installed in 11 provinces, 53 municipalities and 435 barangays. The quality of life for over 720,000 people in some of the most remote and poorest provinces of the Philippines has been improved (WBCSD 2002b). Improved health, safety, education, governance and easier access to potable water will bring about poverty alleviation.

The project improved local governance. The project enhanced the Local Government Units (LGU) to deliver essential social services and elicit the participation of community organisations and individuals in improved governance. Although it was necessary for BP Solar to pull out of several areas over the life of the project due to political uncertainty, an impressive list of community facilities have been upgraded:

- **Four District Hospitals, 11 Rural Health Centres & 104 Barangay Health Centres**: more than half a million people will directly benefit from improved services. Improved capacity to store and utilise vaccines, and other medicines will reduce infant of maternal mortality rates, assist in tetanus prevention and improve general illness treatment.

- **289 Communal Area Lighting for Markets and Fishermen’s Wharves**: facilitating safer night vessel navigation and reducing night fishing wharf accidents.

- **260 Barangay Potable Water Supply Systems**: will lead to substantial reductions in water-borne disease. Women in particular will benefit from time savings in water collection and caring for ill family members.

- **266 Schools, Six Municipal Halls and 201 Barangay Halls**: access to school facilities at night for adult education or entertainment will further improve quality of life.
Communal Sanitation, Myanmar

Project Background
Access to clean water and adequate sanitation is essential to the development of a sustainable community. Access for the poor is a key factor in improving health and economic productivity and is, therefore, an essential component in any effort to alleviate poverty.

In 2001, 16% of the world was without water supply and 40% without access to adequate sanitation. Water-borne diseases are responsible for more than 80% of all sicknesses in the world, resulting in the death of more than four million children annually. Diarrhoeal diseases are the third most significant child killer (after respiratory infections and malaria), accounting for 15% of the under five years mortality rate, especially in rural areas. Substantial decreases in the frequency of contagious disease that is caused by inadequate sanitation and water supply would result in substantial savings in healthcare costs. These savings could be invested in national development, thus further increasing national productivity.

In 1997, Myanmar was crippled by diarrhoeal disease, killing 30,000 children. Sanitation coverage stood at only 39% of the population and personal and domestic hygiene was poor (Yango 2001). Myanmar ranked 190 out of 191 in the World Health Report 2000 (WHO 2000).

Project Details
Over the past decade, significant attempts have been made to improve sanitation in Myanmar. In the mid-1990s the government, in a bid to promote community participation, adopted a strategy in which families were provided with free latrine pans. However this proved too costly, failed to achieve community support and was phased out.

The government then recognised that they could no longer be the sole provider of sanitation services. They recognised that the key role of government should be to facilitate and stimulate local communities to recognise and meet their own needs. This was to be carried out through organising and financing community mobilisation and household motivation and running an awareness campaign, known as the National Sanitation Week. For the past five years, UNICEF has supported this program.

National Sanitation Week activities are carried out under the guidance of the National Health Committee and with the active involvement of the entire nation. The week has three key objectives:

- educating the general public in the values of sanitation
- assisting the people in the actual implementation of sanitary work
- reducing the spread of communicable disease

Community Mobilisation
As individual users are the ultimate decision makers in the acceptance or rejection of new technology, community involvement is widely accepted as a key ingredient in the success of any aid project. Participation of local people in all stages of a project, from design, construction, operation and maintenance, is paramount in fostering a sense of ownership and to ensure that facilities are properly used and maintained.

Sanitation cannot be imposed; use had to be created, by demand. In the past, supply-driven approaches to the provision of sanitation have led to widespread disuse of latrines, leaving latrine slabs as a health hazard and a negative influence on any future sanitation attempts.

Demand for use of sanitation systems is not something that is easily generated, as rural populations do not often perceive the health benefits arising from sanitation. It is therefore fundamentally important that sanitation be effectively promoted, as part of health education, to create demand.

Promotional Campaign
The campaign treated sanitation as a product to be marketed to individual
Case Study

households, using all the skills of the advertising and marketing industry. All available and affordable media and communication channels were used to promote sanitation messages. A broad-based approach was adopted that emphasised not only potential health improvements but also benefits such as privacy and convenience, elevation of household status, respect and dignity (especially for women), environmental awareness and the potential economic benefits of generating resources out of waste.

Social mobilisation was intensified through community meetings organised at various levels, supported by visiting health teams and input NGO’s, school teachers and local leaders. A range of information and communication materials, such as posters and pamphlets, and models of affordable latrines was produced. National television and media played a significant communication role. UNICEF contributed about US$100,000 per year to these promotional activities (Sanda 1998).

The communication and social mobilisation package has been improved each year, to give greater attention to the upgrading of unsanitary latrines and the integration of washing of hands into the sanitation cycle. Interested households form a village sanitation committee, which plays a fundamental role in coordinating activities.

**Implementation** Construction activities commenced only after the awareness campaign had been launched and hygiene and sanitation education provided. Construction occurred only in motivated communities and with the cooperation of the end user.

A do-it-yourself construction program was promoted. Families were responsible for the installation and financing of their own sanitation facilities; subsidies were only available for schools and for the communities that could not afford self-finance.

Households were subsidised during the floods of 1997 but an element of self-help was expected. A low-cost (Kyat 900 or US$2.75) locally-manufactured plastic pan and pipe set was made available to each household that had excavated (and lined where necessary) a pit and then built as good a superstructure as they could afford (UNICEF 1999).

A wide range of low-cost and appropriate latrine designs was developed, suited to individual family preference and affordability. Every effort has been made to promote capacity and income generation activities among community members, in order to allow them to participate by contribution of labour, cash and/or materials towards construction of the project.

The private sector responded to meet the rising demand for parts. Local production of plastic latrine pans has increased by a factor of six in the last five years, from about 40,000 in 1995 to more than 250,000 annually today (UNICEF 1999). To reduce costs, locally available materials were widely used and some village leaders organised the bulk purchase of bamboo.

**Progress Report**

In 1997, prior to the launching of the national campaign, the sanitation coverage throughout rural areas stood at 39% (Yango 2001). In 2001, sanitation coverage stands at 57% (WHO 2001). Hand-washing with soap and water after latrine use has also increased, from 18% in 1996 to 43% in 2001 (Bajracharya 2002).

Too frequently, the success of sanitation programs is measured by the total number of latrines constructed, with little attention to actual operation, maintenance, or usage. Long-term success of these systems depends on the availability of supplies, parts, equipment and the availability of trained people needed to monitor, maintain and repair the systems, as well as continued community demand for their use.

As sanitation coverage in Myanmar grows, campaigning continues. Programmed follow-up to National Sanitation Week is being provided in selected townships through more intensive social mobilisation targeted at hard to reach households and communities and activity-based sanitation and hygiene education in selected schools. This approach recognises that schools create an excellent participatory and enabling learning environment in which to promote sanitary habits and hygienic practices. General training of decision-makers, planners and trainers in social mobilisation programs for hygiene also continues to be widely undertaken.

The 2002 National Sanitation Week accordingly gave special emphasis to activities to be carried out in 73 of a total of 324 townships, where 50% or more of the households still do not have access to a sanitary latrine (Bajracharya 2002).

Myanmar’s success is a model to other countries and has been internationally recognised by South-East Asian region countries. Government delegates from Indonesia, Pakistan, Bhutan, China, Vietnam and Laos have come to Myanmar to observe their activities and learn from their experiences. Nepal launched its own National Sanitation Action Week in March 2001.
Conclusions

Each of the case studies illustrates the application of relatively low technology engineering in small-scale investments that enjoys high levels of community engagement. The success of these programs is due in significant measure to this level of community commitment and to the extent of understanding of social, economic and political influences in that local community.

In each of the case studies and in many similar scenarios, the solutions developed have not been primarily engineering solutions, although engineering plays a key part in the outcome adopted. It is not known which profession took the lead in which scenario, but it is clear that engineers with appropriate sensitivity could have lead in all of the case studies.

The case studies illustrate the application of sound engineering solutions to poverty alleviation.

Sustainable engineering has been achieved, as the solutions adopted will have a positive or neutral impact on natural resources.

Life-cycle engineering has taken into account the operational and maintenance cost of the engineering solutions. The completed projects have effective and affordable operational and maintenance regimes.

Empowered engineering has taken into account the capabilities of the local community, in particular its engineering and technical professions. The solutions developed involve local professional and technical staff and will establish an on-going engineering and operational resource.

Appropriate engineering has considered various options that meet the engineering needs of the project and adopted labour intensive construction where relevant, in order to create community involvement and knowledge of the project’s operations and to stimulate community income.

The challenge for the engineering profession is to revisit our Brunel roots and to develop a suite of solutions to the issues raised in this paper. These should include solutions not only to the alleviation of poverty when it occurs but also to the development of sustainable urban infrastructure, that recognises rather than resists the inevitability of migration to urban centres and then makes provision for these rapidly growing populations.

As engineers, we can work effectively with other professions and community leaders to develop sustainable solutions to poverty. As engineers, we can take the lead in developing sustainable concepts for the urban areas of the future, concepts in which:

- access to and opportunities for employment are enhanced
- housing, sanitation and water supply are provided at affordable prices
- access to and opportunities for education are enhanced
- affordable transport facilities are available.

This is our Brunel challenge; it is worthy of our commitment.


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