DEVELOPING AND FOCUSSING CEMENT & CONCRETE TECHNOLOGIES TO ACCELERATED, SUSTAINABLE DEVELOPMENT IN SUB-SAHARAN AFRICA

Dr. Stephen Ekolu[1] and Dr. Eng. Jean-Bosco Kazurikanyo[2]

[1]*School of Civil and Environmental Engineering, University of the Witwatersrand*
[2]*Advanced Cement Training & Projects cc, Johannesburg, South Africa*
[1, 2]*Spearhead Network for Innovative, Clean and Safe Cement & Concrete Technologies (SPIN), European Union-AFRICA*

ABSTRACT

Problems of lack of rural development, low-cost housing and the urban poor are recognised features of endemic complex limitations of modern construction technologies, government policies and market forces to achieve balances of sustainable societal development. There is however a continuous struggle through science and technologies to improve the human conditions of living. Along these efforts, the cross-cutting issues arising from industrial exploitation of cement and concrete are espoused delving into their sources, with suggestions for a multidisciplinary, multi-faceted network approach as an effective channel for innovative progress.

Advanced technologies, while valuable, are not in themselves the ultimate solution to rural development but selective intermediate technologies could significantly be effective for development. It is argued that, the concept of sustainable development in Sub-Saharan Africa (SSA), and other developing economies, require a unique definition and focussed approach which may need daring policy decisions. China's experience with 'walking on two legs' is highlighted for lessons of interest to achieving acceleration of rural development. A broad spectrum of cross-cutting issues discusses - the environment, health, energy, employment creation, and domestic innovation in cement concrete technologies as mainstream technical channels for socio-economic contribution to development at large.

SUSTANINABLE DEVELOPMENT IN CONTEXT OF THE POOR

The concept of sustainability in development appears to have been awakened by the enormous adverse impact, both realized and envisaged, of human exploitation of natural resources in the race to achieve better living standards primarily through industrialization which has been the main engine of modern civilization. This has been helped by large-scale production, consumerism and remarkable increase in population. These effects not only forecast fast depletion of natural resources but the impact of human activity on the environment and ecological system could threaten existence of life on the planet. Accordingly, different definitions of sustainable development have been given but an early generally accepted conventional definition was stated by the World Commission on Environment and Development, 1987[1] as *Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*. Another commonly cited definition is *Economic activity that is in harmony with the earth's ecosystem*, given by the 1992 Earth Summit of Rio de Janeiro[2]. It is often protracted that the concept of sustainability should achieve environmental protection, health and better economic conditions for all including the developing world.

This kind of thinking, however, may be far fetched considering that its understanding is based on concepts of large-scale world-wide technologies and developed economies. It assumes that similar concepts govern development in all circumstances and value systems, an assumption which has been proved to be incorrect[3]. This is of particular concern with technologies for development. Modern strategies from the developed economies have been found to create few rich elite in developing countries while widening the gap between the poor and the rich. All over the African continent, there are numerous instances of inhabitants with natural and cultural inheritance to rich resources, who have been disowned of land, mineral resources and other assets only to be left without means of sustainable living in a money market economy. This set of economically driven forces can be seen as negative development against the poor though it may augment national foreign exchange and elitism. Ironically, this is the plight of a majority of the population in Sub-Saharan Africa. A sustainable future cannot be expected while large-scale economic schemes have this effect of relegating a majority of the population to more poverty. There needs to be a reversible of this trend for definition of sustainable development to have meaningful application to the poor of the developing world. It becomes clear that some principles of sustainable development as known in the developed world may turn out to be ineffective or inappropriate for application to Africa, if done without modifications.

HIGHLIGHTING COMMONALITY OF PROBLEMS IN SUB-SAHARAN AFRICA

The Sub-Saharan region, an extensive geographical block consisting of 49 countries south of the Sahara desert, out of Africa's 54 countries has an estimated population of over 800 million (2007) and face major common issues associated with underdevelopment. These countries also have had similar or shared historical difficulties including ravaging conflicts, diseases (such as malaria and wars), colonialism and pandemics, issues that are complex and have undermined potential scientific progress, technologies and development. Poverty and mortality rates are high while HIV/AIDS is endemic in nearly all the countries. High population growth is promoting strong urbanization resulting in the rise of informal settlements and aggravation of poor housing conditions. However, the existing shared cultural heritage and regional economic structures viz: the East African Community (EAC), Southern African Development Co-operation (SADC) and the Common Market for East and Southern Africa (COMESA), Economic Community of West African States (ECOWAS) foster regional levels of co-operation which resonate to lower institutional inter-linkages among different countries. The African Union's initiative, the New Partnership for African Development (NEPAD) is intended to facilitate countries towards sustainable development and growth.

Sub-Saharan Africa lags behind all other world regions (East Asia & Pacific, Europe & Central Asia, Latin America & Caribbean, Middle East & North Africa, South Asia) in nearly all indicators of development. On average, poverty is extreme (living less than $1.25 a day) life expectancy is the shortest (51 years) while population growth rate is high, approximately 1.9% and 4% annual increase in rural and urban areas respectively[4].

THE CHINESE CONCEPT OF 'WALKING ON TWO LEGS'

'Walking on two legs' concept[4] implemented by China's political authorities to promote rural development since 1950's is noted to have been an innovative and powerful contributor to the performance of modern Chinese economy. The concept is China's policy of technological dualism, promoting complementary co-existence of, both:

1. Modern, conventional large-scale technologies as the backbone of the industry
2. Intermediate or small-scale technologies for rural development

As a policy requirement, the small-scale industry does not compete with the modern industry for factors of production but rather fill gaps in the economy left by the conventional industry. These small-scale industries, dubbed the '5 small industries', and implemented at county level are: Iron and Steel, Cement, Chemical fertilizers, Machinery, and Electricity production. Small-scale cement production has been one of the most successful rural industries in China and is of interest to this article. The viability of investment in rural small-scale cement production can be sustained by public works program, local housing construction and open market demand within the local areas.

RELEVANCE OF INTERMEDIATE TECHNOLOGIES TO DEVELOPMENT

Among most African countries, there exist small-scale industries indeed making some contribution in the modern economy. These are confined mainly to sectors of iron and steel (producing small tools and household utensils etc.), and handicrafts (including pottery, weaving etc., and cultural outfits). It should be noted that most of the small-scale industries in African countries came about naturally as a means of living for individual humans struggling for survival. But some of these industries have been promoted as community programs typically encouraged by non-governmental organizations. Most are sporadic and not in any organized form of associations. For example, the iron and steel industry is located mainly in the suburbs of major cities as an alternative for low income earners. In China, government initiated policies and deliberately took strides in promoting implementation of indigenous and intermediate technologies in rural areas. In the absence of deliberate government drive, the value of small-scale industries in African economies does not receive significant attention essential for necessary adjustment to the needs of local communities. While there may be several complex factors which may determine the success of small-scale industries, the following functions of these technologies are undisputedly important[5]:

1. Employment creation
2. Social costs and urbanization
3. Self-reliance

Employment Creation

Sub-Saharan African countries have perhaps the highest unemployment rates in the world. In such circumstances of underdevelopment and high population densities, intermediate technologies will allow more employment of existing labour than modern large-scale, semi-automatic processes. In South Africa, initiatives in labour intensive construction methods have for long been researched and applied with some success[11]. It should be considered an achievement for any ability to locally absorb rural labour into an industrial activity.

Social Costs and Urbanization

The current statistics indicate that more cities are likely to form in developing countries[12] while existing urban centres continue to increase to mega-size levels, primarily resulting from movement of people from villages to urban centres in search of employment and better living standards. In cities, however, living costs are high compared to rural life. The social costs of transferring an individual from village to city locations requires provision of expensive infrastructure involving housing, transport, water and sanitation etc., done within the confined urban space of high population density. In the rural areas, workers will often continue to live in their villages without any need for additional infrastructure costs. It cannot be neglected that while labour may be cheap in the rural areas, other factors of production can be costly due to scarcity or underdeveloped electricity supply, equipment and transport systems. However, rural industrialization projects are probably one valuable re-course to minimizing extensive future urbanization.

Self-Reliance

Rural small-scale industries utilize locally available resources only for production, ensuring that affordable products are available locally for consumption. And when there is sufficiency in production, the price factor can be reduced to affordable levels. In addition, unjustifiable exploitation of local resources by external entrepreneurs can be avoided or controlled. Other spin-offs from such rural industrialization are: planning is conducted at community and county levels minimizing the hindrances of centralized bureaucracies to local development, while most of the profits will remain with the local communities.

In all the potential valuable contributions of intermediate technology to development, the role of central and provincial governments is key to its success, providing ideological education, promotions, financial, and technological support.

SUSTAINABILITY AND DEVELOPMENT IN CEMENT AND CONCRETE TECHNOLOGIES

In most African countries, the adverse impacts of cement and concrete industries on environment, health and energy consumption are often overlooked or sidelined in the interest of achieving maximum economic gains. It is important to realize that concrete in developing countries is also called upon to serve three essential societal needs to: (i) protect environment through use of alternative waste materials and reduction of green house gas emissions from cement production, (ii) meet the demand for physical infrastructure due to industrialization and urbanization growth from strong population increase, (iii) alleviate acute shortage of energy through re-use of wastes and alternative sources of energy to generate own electricity.

It is well known that cement production generates and ejects into the atmosphere, a significant amount of carbon-dioxide (CO_2). Approximately one ton of CO_2 results from every one ton of clinker cement produced, contributing about 5% of all carbon-dioxide emissions released into the atmosphere worldwide[13,14], and impacting climate change globally. Unprotected use of cement material can be carcinogenic and with lack of regulation in most African countries, safety and health issues in construction are crucial concerns. Also, cement in Africa is produced on large scale requiring high capital levels which small and medium enterprises cannot afford to raise. Besides, the technology for small-scale cement production doesn't exist in most African countries. But, small-scale cement production plays a key role in development. For example, small-scale cement production has for long been the backbone of cement and concrete industry in China and India. There have been 2800 active small-scale plants in China, 200 in Europe, and in 2005/2006, there were 206 mini-cement plants in operation in India[6,7]. Accordingly, there is no wealth distribution from the cement industry to directly fight poverty in African countries. Despite the abundant resources, energy shortage in Africa is acute with most of the population having no access to electricity. Cement manufacture is itself energy intensive, and techniques of conserving energy in its production are needed along with alternative forms of energy. Cement in most African countries is very expensive and consequently most people are unable to afford construction of proper housing. Most of the population therefore relies on indigenous forms of construction requiring wood obtained from felling of forest trees and ultimately contributing to de-forestation. Informal settlements in South Africa are literal evidence where originally green natural vegetation has been turned into artificial desert-like landscapes. Further still, disposal of construction waste in most African countries is largely not regulated and is often damped in landfills or near wet lands, not only contaminating water reserves but also becoming health

hazards by turning into breeding grounds for various diseases. Sustainable options require recycling of these construction wastes as well as proper regulation of its disposal.

The limited, and even lack of capacity focussed on conducting research activities and contributing to regulation of undesirable practices are a major problem in construction and concrete industry. The SSA region has no established regional networks among researchers in cement and concrete technology with exception of South Africa. The absence of focussed conferences, workshops and journals or handbooks for use in this field is also indicator of the existing lags. Consequently, generation of scientific knowledge and cross-exchange of ideas necessary to promote social and regulatory actions to bring about essential improvements are currently severely undermined.

By focussing on improved /novel strategies and regulation of industrial practices for developing countries (e.g. massive waste utilization in concrete, affordable cement alternatives for low cost housing, technologies for small-scale cement production, economic concrete, concrete quality improvement, regulation of heavy metals and other hazardous chemicals like the carcinogenic chromium (VI) in cement production), acute societal needs in Africa can be addressed, such as sustainable and economic concrete for infrastructure development, poverty alleviation by employment creation through involvement of small and medium-scale enterprises, mitigation of de-forestation through use of affordable concrete construction in place of indigenous wood and alternative fuels for industrial processes. Concomitantly, these efforts may enormously contribute to reduction of CO_2 gas emissions resulting from cement manufacture, and are likely to positively impact sustainability and development. These following specific problems are considerable priority areas[8] for sustainability:

- **Health improvement**: This concerns reduction of heavy metals such as carcinogenic chromium (VI) in cements produced in Africa to preserve or improve the health of the building industry employees and the population in general. There is generally no regulation on Cr(VI) content in cement in most of the African countries. The objective would be to create awareness and assist in the implementation of Cr(VI) regulation in Africa, for example.

- **Environment protection and climate change**: The reduction of CO_2 emissions and its global effect on climate changes can be addressed resulting in preservation of naturals resources and a more cleaner environment (health) in Africa through partial but maximum replacement of pure Portland cement used in mortars, bricks and blocks, concrete, by industrial wastes such as fly ash, agricultural waste more especially sugar bagasse, coffee husks, rice husk, etc. or natural pozzolans and limestone abundantly present in most of the African countries of the Sub-Saharan region.

- **Energy and alternative fuels**: The use of the huge agricultural waste available in African countries (e.g. cotton, coffee husk/shells, rice husk, bagasse, etc.) as alternative source of energy for the Portland cement clinker production can be promoted especially in consideration of alternative technologies for small-scale cement production. At the same time, this action would reduce CO_2 and other harmful emissions from coal and heavy oil fuel.

- **Development in the rural private sector and poverty reduction**: Cement production with small /medium-scale technologies has significant implications for wealth distribution, reduced cost of cement, and other functions as previously discussed. Problems of physical infrastructure especially poor housing, roads and bridges, dams etc. that are important for

economic development will be impacted while emerging technologies from other economies can be assessed for incorporation with a view of helping to fight poverty in Africa.

Within the SSA region there are few existing activities addressing some of these issues among scientists and researchers, and there are also some attempts to create network links[9,10]. But at present, most of the efforts appear to be isolated and not intensive enough to generate technology transfer and major impact in the region.

A REGIONAL INITIATIVE FOR SUSTAINABILITY AND DEVELOPMENT: SPIN

Cement and concrete technologies can be seen as crucial for SSA's development (and developing countries generally), considering their enormous societal and economic contributions often reflected in the gross domestic product. These technologies have strong potential for employment creation and poverty alleviation, if innovatively applied as an economic product for development. But research in the field is severely inadequate while poor construction practices are rampant, usually causing failures. These issues, along with sustainability problems in the cement and concrete industry, should be major concerns in addressing development.

Recently, the European Union (through the ACP S&T call of 2008) offered a grant to a consortium of institutions from seven African and three European countries to start working on establishment of innovative cement and concrete technologies for sustainable development. The program initially focuses on the East, Central and Southern Africa (ECS) Africa block. So called, the "Spearhead Network for Innovative, Clean and Safe Cement & Concrete Technologies (SPIN), the program comprises participation of Burundi, Croatia, DR Congo, Germany, Mozambique, Netherlands, Rwanda, South Africa, Tanzania, and Uganda. Considering the cross-cutting nature of issues that undermine sustainable and innovative development in Africa, a multidisciplinary approach has been adopted with the experts being of diverse backgrounds of geologists, material scientists, civil engineers, mineralogists, processing engineers, chemists, educators. These experts will contribute in different forms, the potential sustainable solutions to problems of development in Africa as addressed within the confines of cement and concrete technologies[8].

It is understood that the initial phase of SPIN intends to strengthen institutional research links and lay a foundation for innovative domestic solutions in the cement and concrete industry. Such initiatives are healthy efforts for future projects, research activities, and expansion of links for the rest of Sub-Saharan Africa.

CONCLUSIONS

It will be distinguished that technologies that apply to sustainability in developed countries may not accurately reflect the requirements for sustainable development in developing countries. The Sub-Saharan Africa, being one of the most underprivileged and poor regions in the world may need domestic innovations and intermediate technologies to engage rural communities towards industrialization, which in turn may bolster national economies, reduce urbanization and reduce social costs. China's successful concept of 'walking on two legs' does find resonance with the current needs of SSA for development, albeit considering the existing factors of production.

Cement and concrete technologies affect cross-cutting fields of the environment, health, energy, employment creation, and domestic innovation which are of essential concern to sustainable development in the mainstream industry.

Networks and scientific research initiatives of multidisciplinary, multi-faceted approach such as the SPIN network within the region, in collaboration with the cement, concrete industries and related organizations, have the potential to appropriately influence sustainability and development in the SSA, within the confines of cement and concrete technologies.

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