LINKING ACADEMIA TO INDUSTRY: A CASE STUDY OF THE BUILDING AND CONSTRUCTION INDUSTRY

By

Danladi Slim MATAWAL, DIC, PhD, CEng, FNSE, RE(coren)
(Professor of Civil Engineering)
Director-General/Chief Executive Officer
Nigerian Building and Road Research Institute, NBRRI

1. INTRODUCTION

1.1 PREAMBLE

The world population more than doubled in the last half-century and is ever increasing, especially where no controls are in place, like in Nigeria. Most of this growth has taken place in the developing world. As we progress into the decade, around 98% of world population growth will occur in developing countries; around half of this mushrooming population will live in urban areas. Three-quarters of the people in developed countries already live in urban settlements. In developing countries the share of the population living in cities reached 40% by 2010, compared with less than 20% half a century back. Some 60% of the world’s fastest growing larger cities (750,000-plus) are in low income countries. In terms of farmland alone, urbanization claims as much as 40,000 km$^2$ per year. These demographic trends translate into increased demand for buildings and infrastructure. In Nigeria, the housing needs have been projected at unsubstantiated figures of 16million home for workers and also there will be a large volume of roads and infrastructure that will need construction for many years to come. World infrastructure needs, as example, have been estimated at over US$ 2 trillion over the next decade and a half or so as revealed from table 1 below.

Table 1: World Infrastructure Needs

<table>
<thead>
<tr>
<th>Type of Country by Income Level</th>
<th>% of total world population</th>
<th>Unpaved Roads (%)</th>
<th>% of urban population without sanitation</th>
<th>GDP per capita (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-non OECD</td>
<td>0.5</td>
<td>15.6</td>
<td>1.1</td>
<td>16,664</td>
</tr>
<tr>
<td>High OECD</td>
<td>14.9</td>
<td>18.7</td>
<td>2.4</td>
<td>27,305</td>
</tr>
<tr>
<td>Upper Middle</td>
<td>8.2</td>
<td>44.8</td>
<td>7.5</td>
<td>4,670</td>
</tr>
<tr>
<td>Lower Middle</td>
<td>35.5</td>
<td>52.8</td>
<td>9.5</td>
<td>1,195</td>
</tr>
<tr>
<td>Low</td>
<td>40.9</td>
<td>71.0</td>
<td>25.4</td>
<td>408</td>
</tr>
</tbody>
</table>
Developing countries are expected to account for only slightly more of this amount than developed ones.

The demand for shelter is so pressing in less developed countries that it can only be met by “informal” housing – often self-built, usually illegal, and almost always lacking basic infrastructure. Such housing is estimated to account for 20-30% of urban growth in the largest cities in developing countries. As high as 60-70% of the population of most Nigerian cities, except Abuja, live in informal housing. Estimates of the amount of time we spend in the built environment – and on it, in vehicles on our road networks – range from 80 to 90%. Therefore besides the resource (materials, construction costs, equipment and technology) and pollution issues surrounding the construction sector, ensuring that the built environment is healthy and pleasant for humans is beginning to be perceived as a crucial productivity issue. If current patterns do not change, expansion of the built environment will destroy or disturb natural habitats and wildlife on over 70% of the Earth’s land surface by 2032, driven mainly by increases in population, economic activity and urbanization.

1.2 IMPACTS OF THE BUILDING AND CONSTRUCTION SECTOR
Both the existing built environment and the process of adding to it have numerous environmental and social impacts. While most available statistics related to these impacts are for developed countries, experts believe on the whole that these impacts are worse in developing than in developed countries. The developing world’s share of world construction activities was 10% in 1965, 29% in 1998, 32% in 2010 and still growing. Compared with other industrial products, buildings and infrastructure present an unusual case in that they are long-lasting, that is they don’t decay-out like that. Steel and concrete structures being built today in Nigeria and many other countries will have an average life of 80 years. In many countries there are buildings, bridges and other structures hundreds of years old. This means the design of, say, an office building or tunnel or duct will have long-term repercussions on a structure’s performance and environmental impacts. To end up with a high-performance, low impact structure, it is vital to also incorporate sustainability principles beginning at a project’s earliest stages. Of course, the impacts of buildings and construction are not all negative. Well planned structures built with sustainable methods and materials can be highly beneficial to both communities and workers. The most notable social benefit is the provision of construction jobs, especially for low-skilled and/or entry-level workers. The overall economic contributions of the construction sector are considerable. Its worldwide market volume amounts to over US$ 3 trillion and accounts for as much as 10% of world GDP, depending on how the sector is defined. Construction is the
largest industrial sector in Europe (10-11% of GDP) and in the United States (12%). In the developing world it represents 2-3% of GDP. Construction also accounts for over 50% of national capital investment in most countries. It provides around 7% of world employment (28% of industrial employment) with a workforce of about 111 million, 74% of which is in low-income countries. Developing countries account for 23% of global construction activity – in other words, the construction industry is more labor-intensive in poorer countries. In most countries, the building and construction sector is the largest single employer. It is probably the world’s largest industrial employer. Its activities involve a very high multiplier effect: It is estimated that a dollar spent on construction may generate up to three dollars of economic activity in other sectors.

The implication of all the discussion is that the Building and construction sectors of the Nigerian economy play real significant roles as major drivers of government and governance, trade and commerce, agriculture and education and major research and development interventions must be made to drive the economy forward. To achieve the nation’s driving visions such as the MDGs, NV20:2020, the agendas (4-point, 7-point, 10-point, 12-point, etc), there must be strong link between the academia and industry. There is need to synchronize programmes of the academia with the needs of the industry; to initiate research in academia that addresses problems of industry and society. There is need to translate results of research into industrial processes, innovations and processes in industry.

The paper therefore takes a close scrutiny of the building and construction industry. In particular, the relevancies of researches being conducted in our Universities and tertiary education sectors in relation to the needs of industry. The pioneering contributions (designs and fabrications) of the Nigerian Building and Road Research Institute, NBRRI, and their expected impacts upon the economy are highlighted. The roles of construction industries, manufacturing companies, consultants, professional bodies, related agencies and all stakeholders are discussed.

2. TYPES OF CONSTRUCTION MATERIALS

For a clear understanding of the building and construction sector, one of the most important assignments that must be done is to identify the different types of construction materials available to harness and process because this will give an insight into the possible areas of emphasis in research. For the benefit of doubt, almost any material can be harnessed for one type of building and construction activity or another. However there are guiding principles that will warrant the choice of one material in preference to another and these include material and structural stability, strength, economy, stress-strain characteristics, etc. The
following, without recourse to details, are many of the materials universally applied in construction industry today from one country to another.

2.1 SOILS
Soils used as construction and/or foundation materials are the most common materials in building and construction all over the world. Their applications are varied and complex from mere backfills to selected materials for special purposes beneath road-works, behind retaining wall structures, as surrounds for culverts, wing-walls for bridges, in tunnels; to actual foundation materials (improved or as found in-situ). They do form special considerations as porous and semi-porous media for ground water flow and seepage. Where the properties of soils are of concern, special ground improvement techniques can be applied to strengthen them and make them less compressible or expansive. Large haulages of selected fill/soil material are always necessary for road and dam infrastructure and the mathematics, physics and chemistry of soils vary from introductory to very complex. The properties, parametric quantities of soils are measured via field and laboratory tests.

2.2 PORTLAND CEMENT
Portland Cements are produced by blending a mixture of calcareous (lime-containing) materials and argillaceous (clayey) materials. The raw materials are carefully proportioned to provide the desired amounts of lime, silica, aluminium oxide, and iron oxide. After grinding to facilitate burning, the raw materials are fed into a long rotary kiln, which is maintained at a temperature around 1000°C. The raw materials, burned together, react together chemically to form hard pellets of a material called clinker. The clinker, after discharge from the kiln and cooled, is grounded into fine powder and gypsum added as retarder to avert flash set during use. Depending on the proportions of the various constituents, the resulting product can be General Purpose (Type I), Modified General Purpose (type II), Rapid Hardening (Type III), Low Heat (Type IV), and Sulfate Resisting (Type V) Portland cement types. The relevant laboratory tests for ascertaining the quality of cements are many but consistency, soundness and setting times (initial and final) are common for direct engineering purposes.

2.3 AGGREGATES
The coarse aggregates are the strength taking components in application while fine aggregates act as Fillers in concrete production. Aggregates must satisfy a certain gradation to be suitable and may have to meet with test specifications and desirable characteristics (AIV and ACV). Lightweight and Heavy aggregates exist.
2.4 **CONCRETE**
Concrete is a mixture of Portland cement, fine aggregate, and coarse aggregate and water. It is temporarily plastic, which can be cast or molded, but transforms to a solid strong mass with time through a chemical process known as hydration. The use of concrete desires adequate strength, workability, and durability at minimum costs. A concrete mix design is generally performed to meet desired grades for given design specifications. Admixtures are frequently added to meet desired special effects like workability and imperviousness. Many factors affect concrete strength and these include Initial water to cement ratio, Method of curing, Mix ratio, Age, Types of aggregates, etc.

2.5 **POZZOLANS AND OTHER CEMENTATIOUS MATERIALS**
Hydraulic cements, Hydraulic limes (Quicklime, Hydrated limes), Gypsum cements and Oxychloride cements exist but the greatest potential is in Pozzolanic cements which are used in partial replacements of Cements in concrete and cement products.

2.6 **REINFORCEMENT AND STRUCTURAL STEEL**
Reinforcements are introduced strategically into concrete and concrete products, through precision designs, to resist forces and stresses due to tension (direct or flexural) from bending, shear and torsion. Structural steelworks are actually industrially formed UBs, UCs, angles, channels, tees, tubular sections, etc, joined by bolting or welding.

2.7 **TIMBER**
Timber is an organic material specially cut, processed and seasoned.

2.8 **COAL TARS AND BITUMINOUS OILS**
These are used as binders like concrete and for surface dressing and asphalt concrete for roadworks.

2.9 **PLASTICS AND OTHERS**
These are applied in varied formats and numerous new materials, especially composites, in application currently.
3. NBRRI’S CONTRIBUTIONS TO BUILDING AND CONSTRUCTION SECTOR

In this chapter, some of the areas of present and past endeavors of the Nigerian Building and Roads research Institute, NBRRI that are milestone contributions in building and construction are presented.

3.1 EARLY TECHNOLOGICAL THRUSTS

From establishment to 1996, some of the achievements in the area of Research and Development (R & D) include:

- Development of cheaper alternative building materials from locally abundant raw materials for housing
- Sun-dried, cement-stabilised and burnt clay bricks
- Lime from limestone
- Pozzolana from agro-industrial wastes such as rice husk
- Roofing sheets from coir fibre
- Road materials
- Building physics—thermal comfort studies, lighting, ventilation, acoustics and solar energy

Some of these early achievements that are well catalogued include the following

i) Alternative Building Materials from Local Raw Materials.
- sun-dried bricks, cement-stabilised bricks and burnt clay blocks from laterites and lateritic soils which were abundantly available in the country
- lime from poor grade limestone at laboratory stage
- pozzolana from rice husks at laboratory stage

ii) Production of Fibre Concrete Roofing (FCR) Sheets

The FCR Sheets were developed from coir fibre (derived from coconut fibre which occurs commonly in coastal areas), sand and cement. Other fibres such as sisal fibre (from the savannah region of Northern Nigeria) and palm fibre (common in the Rain forest areas of Nigeria) can also be used to produce quality FCR sheets.

iii) Production of FCR Tiles

iv) Development and Construction of a Prototype Small Scale Burnt Clay Brick Production Plant

v) Manual Brickmaking Machine

Raw materials: Laterite/Cement/Water
Compression: Not less than 4N/mm²
Cement Stabilization: 4 – 5%
Strength of Brick: Not less than 1.7N/ mm²
Dimension of Brick: 290mm x 140mm x 100mm (L x B x H)
Production Capacity: 600 – 700 bricks per 8 hour-working day.
vi) Single-Mould FCR Tile Making Machine. Which produces one Tile per operation and has a daily production capacity of 150-200 Tiles per day.

vii) Prototype Lime Production Plant


ix) Subgrade Soils Maps of Nigeria.

x) Construction Tools for Bricklaying and Plastering. NBRRI developed three construction tools, namely ENDFRAMES, STRING HOLDERS AND MORTAR GUIDE BOARDS.

xi) Stonecrete Block Technology.

xii) Study of the Environment within the Home: Generation of Building and Road Services Information and Data.

xiii) Housing Studies: Conceptual Study of Housing Needs in Different Nigerian Environment

xiv) Road Traffic Accident (RTA) Data Generation on Nigerian Roads

xv) Investigation of Failures on Major Nigerian Roads mention a few.


xvii) Collaboration with Nigerian Universities, Stakeholder Organisations, Notable Seminars, Conferences and Workshops.

xviii) Technology promotion

xix) Technical reports

3.2 THE PERIOD UP TO 2010

A. HARD TECHNOLOGIES

i) Electrohydraulic Brickmaking Machine (with double mould)

In order to automate the manual NBRRI Brickmaking Machine, NBRRI developed an Electrohydraulic Brickmaking Machine. The machine is robust, compact, equipped with double moulds and is driven by a 7.5KW Electric Motor. It has electrohydraulic system to compress and extrude cement-stabilized Laterite Bricks with enhanced production capacity. The machine has the following attributes

- Automates process of brick production
- Produces 3,000 bricks per 8-hr work day
- Produces two quality bricks per operation
- Improvement over the manual brickmaking machine
- Can be deployed for mass housing scheme
- Can support small and medium scale entrepreneurship
• Consistency in the size and high quality of bricks produced.
• Can be fitted with special moulds to produce interlocking blocks.
• Leg pedal extrudes compressed blocks
• Ideal for rural areas and small scale construction jobs

ii) INTERLOCKING BLOCKMAKING MACHINE—Manual Type

The specifications for the machine are presented below

**Dimension** : (400 x 350 x 900) mm (L x B x H)

**Operational Systems** : Manual compression/ejection mechanism linked up to two down pressers.

**Production Capacity** : 1000 interlocking blocks per 8-hour work day.

iii) Interlocking Block-making Machine --- powered by Diesel Engine

The attribute of this machine are as follows

• Produces 3000 interlocking blocks per 8-hour work day
• Produces two interlocking blocks per operation
• Electro-hydraulically operated
• Powered by electric motor
• Ideal for mass housing delivery

iv) Interlocking Block-making machine—diesel engine model with specification:

**Engine** : 10kW diesel engine

**Weight** : 920Kg (Average)

**Dimension** : (2.0x1.0x1.5)m (Lx W x H)

**Production Capacity** : 350 to 400 blocks per hr

**Hydraulic Tank** : 75 litres capacity

v) New Interlocking Block-making Machine With Diesel Engine (Improved Version)

vi) new interlocking block-making machine with diesel engine (improved version): **Engine** : 10kW diesel engine

**Weight** : 920Kg (Average)

**Dimension** : (2.0x1.0x1.5)m (Lx W x H)

**Production Capacity** : 350 to 400 blocks per hr

**Hydraulic Tank** : 75 litres capacity

The machine uses the same principle of electro-hydraulically compressing and extruding interlocking blocks for use in walling.

vii) Interlocking Block-making Machine--powered by Electric Motor:

• Produces 3000 interlocking blocks per 8-hour work day
• Produces two interlocking blocks per operation
• Electro-hydraulically operated
• Powered by electric motor
• Ideal for mass housing delivery

viii) Interlocking block-making m/c—electric motor model:

**Engine** : 15HP,3-Phase electric motor
Weight: 920Kg (Average)
Dimension: 2m x 1m x 1.5m (LxWxH)
Production Capacity: 350 to 400 blocks per hour
Hydraulic Tank: 75 litres capacity

ix) Laterite grinding machine:
Engine: 7.5HP, 380V, 3-Phase Electric Motor
Vibrator: 0.37KW, 990.5rpm, 50Hz
Dimension: (1.2 x 1.0 x 1.5)m (LxWxH)
Capacity of Hopper: 15 litres

x) Laterite Mixing machine
xi) Development of NBRII paving stone machines (manual and electro-hydraulic types)

xii) Pedestrian roller compactor (Single and Double drum types)
The Single drum has:
Machine Dimension: (1900x1100x700)mm (LxHxW)
Weight: 650Kg
Roller Dimension: (680x500)mm (LxDia.)
Roller Type: Single Drum
Engine: 8HP diesel engine with gear box
Operating Speed: 4km/hr (max)

xiii) Multi-chamber fibre concrete roof (fcr) tile making machine
xiv) Clay roofing tile making machine with:
Roof Tile: (210x300x10)mm
Ridge Cap: (210x440x20)mm

xv) Semi-sheet roofing technology with specifications:
Dimension: (1120 x 610 x 4)mm
Net weight: 75kg
End Lap: 130mm
Side Lap: 120mm
Slope: 15-25 degrees
No. of Sheet/m²: 2Nos
Dimension: (1170 x 725 x 745)mm
Vibrator capacity: 1.5HP

- effective and innovative construction tools for Bricklaying and Plastering
  xvi) Design And Fabrication Of Interlocking Block Moulds With Grooves For Conduit Pipes (9" And 6" Size)

B. SOFT TECHNOLOGIES
i) Economic Pavement Design And Construction Through The Use Of Digitized Subgrade Soils Maps
Community-Based Technology For The Construction & Maintenance Of Access/Feeder Roads

C. GENERAL BENEFITS OF NBRRI TECHNOLOGIES

The Specific Benefits arising from the use of NBRRI Technologies presented above include the following:

i) **For Building**
- Reduction in the price of machines through local fabrication as compared to imported ones
- Employment generation through the use of local labour
- Reduction in the cost of Building materials
- Has high thermal conductivity as compared to conventional materials
- Requires the use of unskilled labour with minimum skilled supervision
- Technologies are simple and the skill easily acquired

ii) **For Roads**
The summarized benefits are presented below:
- Employment generation for the immediate communities
- Skills transfer and capacity building to replicate and maintain similar road networks
- Facilitating easy evacuation of perishable farm produce from farmland to ready market outlets
- Provision of ready access for the movement of goods and services
- Encouragement of inter-communal interaction and promotion of socio-economic integration of communities
- Facilitating access to emergency relief services in the event of natural disaster such as floods, bush fires, epidemics, etc.
- Facilitating the provision of other social infrastructures such as electricity, pipe borne water, water management facilities, rural telephony, etc.

iii) **General**
The general Benefits derivable from NBRRI technologies include but are not limited to the following:
- Poverty reduction
- Employment Generation
- Wealth Creation
- Improved Accessibility
- Development of SMEs
- Increased S&T consciousness of Federal, State and Local governments
- Reduction in rural-urban migration
- Improved housing and environmental conditions
• Beautification of rural landscape

D. ON-GOING PROGRAMMES/PROJECTS

Some of the notable on-going projects at the Institute which are at various stages of completion include the following:

i) Development of Sandlime Bricks for use in Riverine Areas
ii) Investigation of Building Collapse
iii) Development of Particle Board from Agro-Industrial Wastes
iv) Energy Efficient Kiln for Firing Green Clay Tile to Produce Burnt Clay Tile for Roofing
v) Design and Fabrication of Water/Bitumen Spraying Machine for Rural Road Construction
vi) Survey of Clay Deposits in Nigeria and their Suitability For Block/Roof Tile Making
vii) Design and Fabrication of Vibrating Table for the Production of Paving Stones Using Plastic Mould)
ix) Design and Production of Gear Box for Use in the Fabrication of NBRRI Roller Compactor
x) Production of Blended Cement
xi) Beam Mould, Cube Mould and Mortar Mould
xii) Some other Research works by NBRRI in previous years are in the table below.

Table 2: Previous Research publication list from NBRRI

<table>
<thead>
<tr>
<th>s/n</th>
<th>TITLE OF PUBLICATION</th>
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<tbody>
<tr>
<td>1</td>
<td>Engineering Properties of Black Cotton Soils of Nigeria and related Pavement Design</td>
</tr>
<tr>
<td>2</td>
<td>Periwinkle Shells as Concrete Aggregates</td>
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<tr>
<td>3</td>
<td>Simplified Spiral Transition</td>
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<tr>
<td>4</td>
<td>Nigerian Climatic Zones and Building Design Guidelines</td>
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<tr>
<td>5</td>
<td>Solar Water Heaters for Domestic Use in Urban and Rural Nigeria</td>
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<tr>
<td>6</td>
<td>Solar Data for Buildings in Nigeria</td>
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<tr>
<td>7</td>
<td>Measurement of Global Solar Radiation in Nigeria</td>
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<tr>
<td>8</td>
<td>Development of Solar Radiation Models for Nigeria</td>
</tr>
<tr>
<td>9</td>
<td>Determination of Acoustic Properties of some Building Materials for Building Design</td>
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<tr>
<td>10</td>
<td>The Use of Space in Nigerian Home</td>
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<tr>
<td>11</td>
<td>Solar Radiation Distribution Maps of Nigeria</td>
</tr>
<tr>
<td>12</td>
<td>Climatological &amp; Solar Data for Nigeria (for Design of Thermal Comfort in Buildings)</td>
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3. ROLE OF ACADEMIA

3.1 RESEARCH AND DEVELOPMENT CULTURE: The way in which research and technology development is conducted in most countries is changing dramatically. Every year in and out of Nigerian Universities, Research Institutes, even Polytechnics and colleges of Education, numerous researches and student projects are conducted and churned out. One only needs to visit exhibition stands during convocation ceremonies to observe how many models and designs are displayed to convince sceptics of how much initiative is put into new innovations. In Building and construction, there are displays and researches into new techniques, processes, products, etc, and the example of the long list from the Nigerian building and road research Institute is just an example. Therefore, fundamentally important in our discussion is to define the platform for the development of a partnership between the industry and the research community, internationalization, the stronger emphasis on integrated topics and approaches as opposed to the traditional emphasis on technical research, and the dominant role of electronic communication. There could be need for an ever growing emphasis on building and construction research and development (R&D) programs on topics related to information technology (IT) and sustainable construction. Unfortunately in Nigerian research institutes, companies, and universities active in the field of building and construction R&D, none is striving for active roles and more innovative attitudes concerning the development of a partnership between industry and the research community, and the development of international collaboration. That is why the support for many active theoretical suggestions of NBRRRI in this direction need to be given prominence and support. Decisions such as active collaborations between academia and industry through the platform of NBRRRI coordination are on the suggestion card. There are numerous avenues of collaboration in the areas of product accreditation and certification, licensing, etc,
which can be advanced in addition to annual product competitions, displays, fairs and exhibitions.

### 3.2 IMPLEMENTING RESEARCH WISDOM TO CHANGE CONSTRUCTION INDUSTRY:
Whether one is working in the construction industry or teaching at the university level, transferring new knowledge to a diverse group of people is the ultimate challenge. It is imperative that we learn how to implement this new knowledge to the academic student or the industry professional. An example of how to achieve educational success through academia to industry transfer is through short courses and continuous professional development where conventional classroom procedures are circumvented and some of the educational barriers by-passed. When companies are driven by competitive markets to keep cost down and investment low, only a few of the new research products are implemented. The incentives to implement and to make changes are not generally part of the company culture. Some school of thoughts have also been taking snipes at perceived difficulties caused by Codes and Standards. The systemic view of governmental regulatory organizations is to protect and the drive to protect has built-in barriers to not accepting change. The proof that something will work usually rests with the designer or builder who is attempting to implement. The buyer of the new construction is the funding agent. The beneficiary of most changes is the user. This divided responsibilities and coordination of cost, benefits, and funding between players makes standardization a significant coordination barrier that the academia needs to take into consideration.

### 3.3 INFORMATION OVERLOAD:
The wide range of information concerning the Building and construction industry that are available make identification, collection, distribution, and assimilation of new information almost an impossible task. The e-mail and web have added to the overload of data received from employees, customers, professional societies, the phone, and printed hard copy. How to locate, screen, and select the appropriate information challenges industry and how to streamline information to the basics is an important area of attention for the academia especially in Nigeria where hardly much is available through local initiative. Most of our information and standards are actually from a collation of sources from different countries; in particular Britain, USA, Japan, Germany, Italy, etc. We have so much data that we cannot find what we need. The recognition that a local champion is needed to implement change may be the first organizational barrier. It appears that few companies have a formal system to introduce innovation into their company. Many company cultures operate in a competitive market with a lean management style and under a compressed schedule. Changes are not promoted and may be resisted. An implementation program allows the introduction of new information and changes.
3.4 OTHER ISSUES:

i) Can’t quantify benefits of education: The manager who is concerned about return on investment may attempt to have education measured as a dollar investment. Many agree that indeed continuing education is a good investment, but recognize the difficulty in measuring the benefits. Most professionals will intuitively agree that education is worthwhile and the benefits of education will have to be accepted on faith. Some real challenges may be how to quantify the benefit of education or how to build fate in education.

ii) Building and Construction Industry Research and Education: In the 21st century whose first decade we have already squandered, some issues to ponder in academia industry synchrony have to do with defining a construction education research agenda as follows:

1. What will be the impact of the continuing globalization of construction? Will there be pressure to internationalize codes, standards, or contracting methods?
2. How will construction research be funded? The funds for applied research must be found. Is the construction industry prepared to begin funding research in a meaningful way? Today’s students need to be prepared for work at the site.
3. High School graduates and University students are not generally motivated to enter the construction industry. Where are tomorrow’s construction industry leaders going to come from if there is no increase in the level of effort to advertise and recruit students for the industry?
4. The construction industry needs to improve its image. Nigerians in general do not have a good impression of the integrity or quality of the construction industry unless it has to do with the giant companies like Julius Berger, Dantata Sawoe, etc.
5. There is a growing opportunity for international work. Graduates need to be more aware of other cultures, other societies, and the laws that govern construction practice in other countries.
6. The greatest changes in the industry may be in the technology of the contract delivery systems. Changes such as design-build and performance-based procurement have the potential to completely change construction procurement methods.

Of the six points above, five relate directly to the content of future university construction education programs. Those five points are Globalization, Research funding sources, Preparing students for leadership roles, International construction opportunities, and Changing contract delivery systems.

In addition to these points, there are additional issues that must be pondered in relation to construction research in the academia as it relates to expected growth in number of Students. These are:
Globalization: Tomorrow’s construction graduates will do business in a global economy, even a global cyber economy. How can we best determine what curriculum changes will best suit their needs? The courses taught and the teaching methods used in construction programs need to be reviewed. Are the courses offered in today’s accredited construction programs the courses that will be needed in the next century? What areas may not be needed, and what should be added? What will the effect of globalization of construction be?

Research Funding Sources: The trend in research has historically been toward pure research. Construction graduates will operate in the field. They will earn their livings on construction sites or in offices that support construction sites. Construction research needs to be applied, directed toward field operations. Who will fund applied research in construction?

Preparing Students for Leadership Roles: There is no question that the construction industry needs leaders. Its greatest need is leadership, and its greatest need in the 21st century will continue to be leadership. Where are the leaders going to come from, if not from the university construction programs? How are the university construction programs of the future going to prepare students for leadership in the industry? Do today’s education systems instil the leadership qualities that will be required in the future? How do we measure what ought to be done to prepare for future leadership?

International Construction Opportunities: The internationalization of construction will continue. More companies will operate internationally. The construction curriculum must prepare students for international opportunities. This issue is related to globalization, but is not the same issue. This issue addresses the preparation of the individual for work in another country, in another culture, or in a firm from another country. How should international influences, and their accompanying intermix of cultures, be addressed at the university level? How will universities respond to a need for increased international certification of construction managers? Should international codes and standards have a place in Nigerian construction education? What social and cultural courses will be needed?

Changing Contract Delivery Systems: Today’s constructors make changes in a matter of minutes, even seconds. The contract delivery systems are changing. Technology is forcing change. The trends are away from low bid selection processes. How long will it take construction education to change? How can construction education be as responsive to change as the industry itself? What is the role of accreditation bodies in effecting change?

Teaching a Larger Number of Students and Practitioners: Construction management education must be made available to a larger audience, including full- and part-time students, on- and off-campus students, and constructors who may not
have direct access to a university campus. What are the best ways to use the internet, television, off-campus sites, and cable access to support construction education?

**My Vision of Future Construction**
What will the future construction industry be like? First, the industry will be basically the same as it is now. Engineers and architect will design projects, and contractors will build them; however, they will probably work for the same company. The projects will still be the same types - houses, utilities, commercial buildings, highways, bridges, airports, and all the other projects we see today. Second, it will be very different than it is today. The design process, contractor selection process, contract administration, materials, and contractual relationships will all be different.

a. **The Built Environment.** Greater use will be made of standardized structures, which will contain more computers and sensors. Tall buildings will be taller. More use will be made of areas now occupied by ocean, for purposes such as airports and cities. There will be construction in space.

b. **Design.** The design process will see great change. Most construction companies will employ architects, engineers, and constructors. The Internet will remove the necessity for the design team to be in the same locality. Design coordination by electronic means will lead to fewer design errors and omissions. No one will design an entire project before construction starts; instead some version of fast-track design will evolve into the normal design process. Some aspects of engineering and design will not change. For instance, engineers will always be needed to take borings for the foundation design.

c. **Contractor Selection.** The bid process will disappear. Even the government will find a better way. Contractors and designers will work together as part of the same company. Contractors will be selected based on performance, quality, safety, reliability, and other such factors defined by the owner.

d. **Construction Materials.** The processes involved in construction will change little. The materials will change greatly. 100,000 psi concrete will be common. Ceramics, composites, and fiber reinforced polymers will be in common use. Wood products will be entirely high performance, pre-assembled units. Structures will contain stress indicators. There will be increased use of new aluminum alloys. Construction materials will be 100% recyclable. The time to complete projects will be halved. The change in emphasis on quality and safety will be profound. Technology, in forms not yet envisioned, will be common.

e. **Construction Contract Administration.** Work progress will be monitored automatically and instantaneous payments will be possible. There will still be performance and maintenance bonds; but there may not be bid bonds because there
may not be bidding. Trust-based administration will become standard. Construction services will be more knowledge intensive.

**f. Labor.** The shortages of qualified labor will be severe. As a result, hourly wages will increase greatly. Labor unions and management will work together recruit and train qualified labor. Labor’s main strength will come from its ability to provide highly qualified personnel.

**g. Price Structure.** The price of construction will be based on its value to the customer and the quality of the work, rather than the cost to the builder and a mark-up.

**h. Global Influence.** In the global cyber economy of the future, construction companies will purchase materials and services from around the world.

**i. Infrastructure.** There will be less new construction, and more repair and rehabilitation of existing infrastructure.

**j. Patenting.** NOTAP activities, especially in the area of patenting will be tailored towards the Nigerian business environment so that local indigenous initiatives will be speedily recognized and encouraged.

4. **NIGERIAN CONTRACTORS AND FACTORS INHIBITING MASSIVE USE OF NBRRI TECHNOLOGIES**

Moving away from the academia and peeping into the modus-operandi of Nigerian contractors and (some) manufacturers in patronizing and promoting locally invented/designed and fabricated products, it is easy to observe how under-development remains on our doorsteps in spite of the numerous initiatives by the nation’s researchers and inventors. This is because no contractors are willing to incorporate local building and construction components in their projects; however attractive. The illustration is best made with reference to my Nigerian Building and Road research Institute, NBRRI. The technologies developed by NBRRI are very relevant to the construction industry; particularly in the provision of durable, cost-effective, decent and affordable housing as well as for the construction/maintenance of cost-effective feeder/access roads in rural and urban areas. In spite of the unsubstantiated shortfall of 16 million housing units and the inadequate/poor access road networking in Nigeria, NBRRI technologies are not patronized by Nigerians. NBRRI has evolved several strategies to encourage stakeholders and Nigerians to patronize these innovations which have undergone successful pilot testing. Some of these include

- Dissemination of technologies through flies, pamphlets, documents, etc. to stakeholders and the public
- Continuous involvement and participation in different fora, exhibitions at different levels
• Linkages with professionals, professional bodies and relevant stakeholders including estate developers, government establishments, private sector, multinational organizations, etc.
• Development of various enterprise models on the use of NBRRI technologies to encourage Small and Medium scale entrepreneurship
• Conducting hands on training workshops on the use NBRRI technologies
• Direct engagement in service delivery and the development of infrastructures for interested clientele
• Construction of prototype structures using NBRRI technologies

In spite of the above efforts, only very few Nigerians and indeed the construction industry have taken the initiative to patronize NBRRI products. The major reasons for this trend include but are not limited to the following
• General apathy by Nigerians and professionals to patronize Nigerian made products.
• The erroneous belief by most Nigerians that anything foreign is better
• Lack of funds to adequately advertise NBRRI products in print and electronic media
• The erroneous belief that brick houses are inferior to houses built in concrete
• Lack of funds to produce NBRRI machines en-mass for sale to the general public
• Reluctance of Nigerian entrepreneurs to invest in tested and proven NBRRI innovations and mass produce them
• Absence of statutory provisions to empower NBRRI to effectively engage in the promotion of its proven technologies. The Act setting up NBRRI is deficient in this respect.
• Reluctance of private/public estate developers, housing corporations and other stakeholders to utilize proven NBRRI products
• Complicity by multinationals and companies to dampen the spirit of development of the Nigerian nation.

5. CONCLUSION AND RECOMMENDATIONS

For a strong and technology responsive Building and construction sector in Nigeria, there must be a strong link between academia and industry. The academia referred to in this paper include, but are not limited to, Universities, Research Institutes, and Polytechnics. The industry includes the construction companies, manufacturers of all types of Building and construction materials: Cement, Bricks and Blocks, Aggregates, Roofing sheets, Paints, etc. There are issues of education and research that have been tackled in this paper and not to forget the role of
Professional regulatory bodies in Nigeria. It is suggested that there should be a more complimentary effort to promote the future of building and construction sector. For example, there is no reason why Construction companies and Building Materials manufacturing industries cannot provide all the funding for research and development for the future of an industry that is so pivotal to the economy. Furthermore, Nigeria academics and industry must begin to get ready for global challenges in this sector because our construction cannot continue to remain local. If there is need for coordination on many of the suggestions in this paper, NBRRI is very willing and capable of providing the fulcrum for every activity.

The way forward for NBRRI will revolve around addressing the challenges already mentioned but a few of addendum suggestions especially for the popularization and promotion of our products to alleviate living conditions for Nigerians include:

- The Act setting up NBRRI should be reviewed to empower her effectively carry out consultancy and extension services in the construction industry
- NBRRI should be adequately and continuously funded through statutory contributions from big construction companies, from imports on all finished construction materials/machineries
- Housing Corporations, State, Federal, Local Governments and real estate developers operating in Nigeria should be statutorily mandated to utilize NBRRI/local products in constructing at least 10% of their housing delivery programmes
- Strategies for the mass production of proven technologies should be evolved and implemented. This should be spearheaded by Government with the active participation of stakeholders
- The Federal ministry of Works Housing and Urban development, FMST, Federal Ministry of Industry should jointly work out strategies for the mass production and use of NBRRI technologies
- All Local governments should be directed to adopt the community-based construction technology in the development of access road network in their domain

THANK YOU FOR LISTENING.

Danladi Slim MATAWAL, DIC, PhD, CEng, FNSE, RE(coren)
(Professor of Civil Engineering)
Director-General/Chief Executive Officer, NBRRI
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