SECOND ANNUAL CONSTRUCTION RESEARCH CONFERENCE AND EXHIBITION

"NURTURING THE TRANSFORMATION OF THE LOCAL CONSTRUCTION INDUSTRY ON MATERIALS AND TECHNOLOGIES FOR GLOBAL BEST PRACTICE"
THE FUTURE, NOW.
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Seeing the growth of ACoRCE from a concept to such a critical platform has been a rewarding experience. The depth of knowledge shared during the proceedings brings hope that this industry is indeed headed in the right direction. We are lucky to host under one event the brightest minds when it comes to construction research. This year, the delegates span across four continents, and we will continue to push the construction research agenda until we take ACoRCE to a global level.

Eng. Stephen N. Nyakondo
Project Manager, ACoRCE 2016

A CoRCE is the first major international event we have hosted as an Authority, and the level of support we have received from industry stakeholders who share in our vision has been invaluable. Coordinating with our international partners, delegates and key note speakers was a considerable team effort, and it was a pleasure to forge such key relationships, which we hope to foster into lasting partnerships. We look forward to a game changing event.

Wangui Kabala
Manager, Corporate Communications

A CoRCE remains the most strategic approach through which the Authority packages and disseminates construction research information with a view to spur innovation and development of our country; the conference is an offshoot of the National Construction Research Agenda (NaCRA) currently under implementation. As an outcome of the conference, the Authority will, going forward, run an additional research initiative aimed at commercialization of ideas and innovations. This will make our research efforts more applied and economically gainful.

Qs. David N. Mathu
Manager, Research & Business Development
Our Mandate
We provide efficient, reliable, safe and cost effective means of transporting petroleum products from Mombasa to the hinterland. To meet this objective, we have constructed a pipeline network, storage and loading facilities for transportation, storage and distribution of petroleum products in Kenya and the East African region.
of competitive advantage that the industry should leverage on for favorable expansion.

The Annual Construction Research Conference and Exhibition (ACoRCE) is an outcome of the National Construction Research Agenda (NaCRA) that is currently under implementation by the Authority with the support of various academic and research institutions. The collaborative research approach applied is aimed at enhancing the industry linkage to academia thereby providing ideal platforms for practical application of new knowledge generated.

Support for the above in the form of policies is critical, especially if optimal operational performance of the industry is to be realized. We need the adoption of innovative ideas, and concepts that will lead to improved quality, cost, time and risk performance of construction projects. The local industry has been exposed to many new technologies, but the uptake is wanting and this year’s event has come at an opportune time to allow for discussion on how these technologies and materials can be domesticated for local use. There is a need to develop legal framework to allow for the same.

It is my sincere hope that ACORCE 2016 will have fruitful deliberations which will culminate in truly transforming our industry.
On behalf of The National Construction Authority, I am delighted to welcome all delegates to the Second Annual Construction Research Conference and Exhibition (ACoRCE 2016).

When we launched the National Construction Research Agenda (NaCRA) in 2014, the Authority embarked on a transformative journey for the construction industry in Kenya by carrying out applied research to meet the capacity gaps, which can be summarized as the 6 M’s: materials, methods, manpower, markets, machinery and money. ACoRCE was visualized as an ideal forum to disseminate the wealth of information that stems from research papers and proposals highlighting various stop-gap measures.

The conference provides participants with a platform to network, discover novel opportunities and global trends as well as to broaden their knowledge.

This year has seen the evolution of ACoRCE from a two-day conference into an entire week of several events dubbed the National Construction Week (NCW). This will include artisan trainings in Kisumu, Eldoret, Nyeri and Nairobi and site visits to major construction projects across the country, including the National Housing Corporation project in Mavoko, highlighting the use of expanded polystyrene panels (EPS). In addition, the Authority has partnered with DMG Events, an organization with more than three decades’ experience in the organization of successful events around the globe, and with a renowned portfolio of construction events spanning the Middle East, South East Asia and Africa. Their flagship exhibition, The Big 5 Construct, is taking place in East Africa for the first time as part of the NCW.

I would like to thank the team behind the planning of this event. Professor Robert Rukwaro from the University of Nairobi headed the committee that reviewed the content to be presented during the conference and did a stellar job. The Conference Chair Eng. Maurice Akech and the entire organizing committee worked tirelessly over a period of one year to ensure we executed a quality event, which we can now ascertain will be a permanent fixture on the industry calendar.

I look forward to it.

Daniel Manduku
Executive Director/Registrar of Contractors
National Construction Authority
Industry players are constantly on the lookout for materials and technological advancements that will serve to expedite the construction process while reducing costs exponentially.

The theme of ACoRCE 2016, *nurturing the transformation of the local construction industry on materials and technologies for global best practice*, sets the pace for the above.

This year, we have speakers and delegates from across the globe, presenting papers on key issues such as green and renewable construction technologies, vernacular construction materials and technologies, the development of construction industry policies and funding.

The construction industry in Kenya is a regional leader. We strive to take this even higher in order to attain recognition on a global scale, and this will be achieved by bridging the gaps in several areas. For example, some of the technology currently employed in the industry is outdated. ACoRCE 2016 will offer delegates an opportunity to see what different plant, material or equipment they can adopt towards attaining a higher level of efficiency. The effective introduction and exploitation of new technologies within the industry will enable us to compete effectively in an increasingly competitive global market.

ACoRCE 2016 would not have been possible without the concerted efforts of the Planning Committee, whose members were drawn from key stakeholders across the industry, including the University of Nairobi, Town Planning Council, Kenya Wildlife Service, Jomo Kenyatta University of Science and Technology, The Institute of Clerks of Works Kenya and with support from our line ministry, the Ministry of Transport, Infrastructure, Housing and Urban Development. The success of this conference is truly the success of the industry.

Eng. Maurice Akech
ACoRCE, 2016 Conference Chair
The National Construction Authority (NCA) is a state agency established through Act No. 41 of 2011. The object for which the Authority is established is to oversee the construction industry and coordinate its development.

In the current government structure, the Authority is placed under the Ministry of Transport, Infrastructure, Housing and Urban Development. The Authority’s core functions deal with the promotion and improvement of the construction industry through various initiatives such as training and capacity building, quality assurance, dissemination of research among others.

VISION
A well-coordinated and developed construction industry

MISSION
To regulate, streamline and build capacity in the construction industry for sustainable socio-economic development

CORE VALUES
• Professionalism
• Ethics and integrity
• Efficiency
• Innovation
• Environmental stewardship
• Team spirit

MOTTO
Excellence in the construction industry

The First Annual Construction Research Conference and Exhibition (ACoRCE 2015)

The first ACoRCE conference was held from the 21st to the 23rd of September 2015 at the Kenyatta International Convention Centre in Nairobi, during which 25 research papers and 10 keynote speeches were presented. ACoRCE was conceived because of the increasing need to provide platforms for industry players to showcase research findings within the construction industry.

ACoRCE 2016 is co-located with the Big Five Construct, an international construction exhibition taking place in East Africa for the first time. The exhibition has attracted over 200 international exhibitors.

The benefits of derived by ACoRCE delegates, sponsors and partners include forging new relationships and business opportunities via face-to-face networking with target markets, strengthening existing relationships and increasing business opportunities with existing clients as well as increasing brand visibility.
25,000 Contractors,
over 5,000 live projects
Nairobi county alone, and
over 75,000 construction
workers and site supervisors
already on Xaba!

Xaba is connecting blue collar workers to employment opportunities.

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www.xaba.co.ke

Powered by SevenSeas Technologies Group
NCA National Construction Authority
Eng. B. K. KARIUKI

Eng. Kariuki is a professional mechanical engineer registered with both the Engineers Board of Kenya and the Institution of Engineers of Kenya. He is also a member of the National Quality Institute and the Association of Energy Engineers as well as a Certified Energy Manager. Additionally, he is a senior lecturer in the Department of Mechanical Engineering at Jomo Kenyatta University of Agriculture and Technology (JKUAT). He is the Director of the Directorate of Intellectual Property Management and a university-industry liaison.

His areas of specialization are engineering thermodynamics, heat transfer, building and mechanical services engineering, intellectual property management as well as quality and environmental management systems.

DR. JOHN AKOTEN, PHD

Dr. Akoten has a PhD in International Development Studies (IDS) from the National Graduate Institute for Policy Studies (GRIPS) in Tokyo, Japan. He is currently the Acting Executive Director at the Anti-Counterfeit Agency, a state corporation mandated to prohibit trade in counterfeit goods in Kenya.

He has made presentations in conferences in Africa, Europe and Asia. Before that, he worked in the public sector (Ministry of Trade and Industry) where he was instrumental in the preparation of the Private Sector Development Strategy (PSDS) whose aim was to enhance public-private sector partnership and to provide a conducive and enabling environment for the effective operation of the private sector. John was also involved in the preparation of the Investment Climate Action Plan (ICAP), that was aimed at identifying quick-win strategies and benefits to the private sector. Moreover, Dr. Akoten has worked with the World Bank, FASID of Japan and UNIDO on a consultancy basis.

PATRICK MBINDYO

is the Director of Research in the Research, Production and Extension Division at Jomo Kenyatta University of Agriculture and Technology (JKUAT). Prior to joining JKUAT, he worked at the KEMRI-Wellcome Trust Research Programme. His research areas revolve around human resources for health, reproductive health, malaria, water and sanitation. Dr. Mbndyo holds a PhD in Public Health (University of the Witwatersrand), an MSc in Social Policy and Planning in Developing Countries (London School of Economics) and BA (Hons) in Sociology and Geography (Kenyatta University).

ERICH STEINLECHNER

is the Head of the Pile Division at TRM Piling Systems, responsible for global sales and marketing.

Prior to joining TRM Piling Systems, Erich Steinlechner worked in Marketing and Product Sales, as well as a project engineer at several multinational companies, including Bauer Spezialtiefbau GmbH. Notably, he has 25 years of experience in Special Foundations.

Erich Steinlechner graduated as a Civil Engineer at the Engineering College (HTL), with a specialization in Special Foundations in Innsbruck, Austria.

ENG. CONRAD H. DE TISSERA

Eng. Conrad H De Tissera’s first degree was a BSc. in Civil Engineering. He obtained a Post Graduate Diploma in Housing Planning and Building from
IHS Netherlands, an MSc. in Soil Mechanics and Foundation Engineering from the University of New Castle upon Tyne, UK and a Post Graduate Certificate in Construction Management from the University of California, Berkeley, USA. He is Member of the Institution of Civil Engineers UK and the Institution of Engineers, Sri Lanka.

His professional experience includes serving in the positions of Chairman of the Construction Industry Development Authority (CIDA); Habitat Programme Manager, UN-Habitat Sri Lanka; Secretary (Development), Ministry of Science and Technology and Secretary (Technical), Ministry of Urban Development, Housing and Construction in Sri Lanka. He has also served as the Chairman of Sri Lanka Cement Corporation, Sri Lanka Land Reclamation and Development Corporation and Director General of the National Building Research Organization (NBRO) of Sri Lanka. He has participated in the ninth program conducted by the Center for Financial Engineering in Development, Washington D.C. USA, in its Public/Private Partnership Workshop Series, on 'Analysis and Negotiation of BOO and BOT Projects: Alternative Strategies for Infrastructure Development.'

RICHARD HURDING

Mr. Hurding is a Bio-Composite Material Developer and Managing Director, Zelfo Technology GmbH, Germany. He has lived in Nigeria, Scotland, London, Hong Kong, and Berlin.

He is a professional designer with an MA (Design) from GSA. He is experienced in Exhibition, Interior and Architecture projects in Europe and Asia. In 1992, he designed the first ecological retail interior in London for ‘Komodo’ fashions. In 1998 he was active as developer of the first environmental management systems for use in architecture. 2003 saw him create the BIORAMA-Projekt, an eco-focused initiative in Germany.

In 2003, Mr. Hurding engaged in research for ‘engineered cellulose’, a self-binding natural fibre system. This resulted in ‘Omodo GmbH’, his first material company, followed in 2011 by Zelfo Technology GmbH, which has won 3 international prizes.

In 2015, Zelfo Technology & Bio-Lutions produced the world’s first engineered cellulose packaging made from agricultural residual materials. Currently his main project is insulation for low cost housing.

SAMAR AL-KINDY

Samar is the founder and Managing Director of Impressions Advertising Ltd (IAL) and Master Brands Ltd (MBL) based in Nairobi, Kenya. The companies were founded in 2001 and 2007 respectively and offer Building and Civil Engineering Construction Services. In addition, the companies provide Innovative Communication Solutions across the region.

Through her leadership, IAL & MBL have filled a market niche by providing distinctive value added construction services. Her passion for excellence engenders innovation, foresight, integrity, and aggressive performance to serve with character and purpose that brings honor to God.

Apart from her augmented diversity in business leadership and strategy, Samar’s indulgence in construction research is profound. In her recent seminal works, she has examined the causes of the incessant collapse of buildings in Kenya, a study that revealed imperative information for enhanced quality assurance in the local construction industry.

DR. SIPHILA WANJIKU MUMENYA

Dr. Mumenya holds a PhD in Mechanical Engineering (Materials) from the University of Cape Town, an MSc degree in Civil Engineering Structures from City University in London and a BSc in Civil Engineering from the University of Nairobi.

Dr. Mumenya is currently a Senior Lecturer at the
Department of Civil and Construction Engineering, University of Nairobi. Her teaching is in the areas of Engineering Materials, Structural Engineering and Fibre Reinforced Concrete.

Dr. Mumenya was a Senior Superintending Engineer at the Ministry of Public works. She is a registered Consulting Engineer, and a member of the Institution of Engineers of Kenya, Association of Consulting Engineers of Kenya (ACEK), and Architectural Association of Kenya (AAK). She has a wealth of experience in the construction industry. Her first engagement with industry was in 1980 as a graduate trainee.

**DR. DANIEL K. IRURAH** is a Kenyan Architect and Urban Environmental Policy Planner. He holds a BArch (with Hons, University of Nairobi), MArch and MUP (University of Oregon) and PhD (University of Pretoria). He is a registered Architect in Kenya and South Africa. He previously served as a Member of the Board of Directors of the Green Building Council of South Africa (GBCSA) where he chaired the Education Sub-Committee of the Board. He currently serves as Associate Professor in Sustainable Architecture & Cities in the School of Architecture & Planning, University of the Witwatersrand in Johannesburg, where he convenes a postgraduate programme on Masters of Architecture in Sustainable and Energy Efficient Cities (MArch(SEEC)).

His expertise focuses on sustainability and the built environment within the full spectrum of city-to-buildings and construction materials, as well as from a life-cycle perspective. With research and consultancy interests focused on developing country contexts, his core interest is the understanding and applied resolution to the dilemma of achieving socio-economic development equitably within the tightening eco-limits of our planet.

Although his primary area of interest is on demand-side interventions for energy efficiency and renewable energy for buildings and cities through technologies, behavior-change, market-transformations and policies, he is also intensely engaged in the field of industrial ecology for the construction industry, and especially the cradle-to-grave/cradle cycle of construction materials. His key interests in these fields is the coupling of green innovations to socio-economic development priorities such as jobs/skills and eco-entrepreneurship.

**DR. VINCENT KITIO**

Chief Urban Energy Unit, UN-HABITAT

Vincent Kitio is an architect who graduated from the Institute of Architecture of Venice and he holds a PhD in Appropriate Energy Technologies (energy efficiency and renewable energy) for Developing Countries from the University of Rome, Italy.

He currently heads the Urban Energy Unit of UN-HABITAT, a section mandated to promote universal energy access for the urban poor; energy efficiency in the built environment and adoption of renewable energy technologies in urban areas. Kitio is currently overseeing the implementation of two regional programs in Africa; the first is “Promoting Energy Efficiency in Buildings in East Africa” that aims at mainstreaming energy efficient measures in housing policies, building codes, building practices and building finance; while the second is “Mainstreaming Energy and Resource Efficiency and Renewable Energy into Building Codes in West Africa (Senegal, Nigeria and Cameroon).

Vincent Kitio represents UN-Habitat and UN-Energy, which purpose is to help ensure coherence among all UN agencies on addressing energy issues for sustainable development as well as supporting the SE4ALL decade.
DR. MICHAEL E. JOACHIM
is currently the Chairman of the Construction Industry Development Authority (CIDA) of Sri Lanka, which is the regulating body of the Construction Industry in Sri Lanka. He obtained a B.Sc. (Engineering) in Civil Engineering from the University of Ceylon in 1963, a Diploma in Planning and Housing (developing countries) from the University of Edinburgh in 1970 and a Ph.D from the University of Edinburgh in 1973.

He is a Charted Engineer and an International Professional Engineer. He has served as the Chairman of the State Engineering Cooperation of Sri Lanka, which is doing the core business in Civil, Mechanical and Electrical Constructions. He has served 32 years in the public service holding many positions including Secretary to the Minister of Construction and Building materials; Secretary of the Ministry of Housing and Construction; Property Development Consultant to the Urban Development Authority of Sri Lanka; Director– Department of Buildings; Director (Engineering Services) of the Urban Development Authority; Advisor, Common Amenities Board (CAB); Deputy Commissioner, Department of National Housing and many others. In addition, has been involved in guiding basic research on building materials and techniques, as founder Director of the National Building Research Organization.

Since construction machinery and equipment is an essential part of the construction industry, he was instrumental in setting up the National Equipment and Machinery Organization in early 1992, which services the construction industry to-date. His specialty is in the fields of project formulation, project management, and property development.

The Standard Gauge Railway project is a promise of a high speed, high capacity transport solution premised on reliability, safety and efficiency for the transport sector. It will engineer a significant shift of cargo from road to rail; reduce transit times between destinations; reduce carbon emissions and enhance safety of passengers and cargo.

The project will create a conducive and enhance sustainable economic growth environment for trade, investment, development.

Connecting Nations...Prospering People
2 – 4 November 2016
10:00 - 18:00 Daily
Kenyatta International Conference Centre

SOURCE THOUSANDS OF GLOBAL INNOVATIVE PRODUCTS AT THE OFFICIAL EXHIBITION OF KENYA’s NATIONAL CONSTRUCTION WEEK

Attend the Annual Construction Research Conference and Exhibition (ACoRCE), organised by the National Construction Authority

Develop your career by attending 15+ free CPD certified workshops

Witness the famous JCB dancing diggers in action as they perform their world class act in Kenya

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NCA NATIONAL CONSTRUCTION AUTHORITY

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Endorsed by
National Construction Week 31st October - 4th November 2016  
Kenyatta International Convention Center, Nairobi

### National Construction Week

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<th>DAY 1</th>
<th>DAY 2</th>
<th>DAY 3</th>
<th>DAY 4</th>
<th>DAY 5</th>
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<tbody>
<tr>
<td>MON 31 OCT 2016</td>
<td>TUE 1 NOV 2016</td>
<td>WED 2 NOV 2016</td>
<td>THU 3 NOV 2016</td>
<td>FRI 4 NOV 2016</td>
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<tr>
<td>Construction workers sensitisation and accreditation drive</td>
<td>Annual Construction Research Conference and Exhibition (2-3 November 2016) – ACoRCE 2016 is the annual conference of the National Construction Authority*</td>
<td>Specialised training and site visits across the country (4 November 2016)</td>
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*Entry fee applicable

The Big 5 Construct East Africa exhibition (2-4 November 2016) – a unique platform to source thousands of innovative, international products

* NCA registered contractors shall get 10 CPD for attending ACoRCE 2016

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### NB: Artisans Sensitization programme to happen at Eldoret polytechnic - ELDOROT, Dedan Kimathi University of Technology - NYERI, Kisumu Polytechnic - KISUMU and Shimba Hall, KICC -NAIROBI

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### DAY 1: MONDAY 31 OCTOBER 2016

#### Artisan Sensitisation Programme

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
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<tbody>
<tr>
<td>08:30 – 09:00</td>
<td>Arrival and registration</td>
</tr>
<tr>
<td>08:30 – 09:00</td>
<td>Welcome Remarks (Regional Officers, County Government representatives)</td>
</tr>
<tr>
<td>09:00 – 09:40</td>
<td>Construction Industry Laws and Regulations</td>
</tr>
<tr>
<td>09:40 – 10:20</td>
<td>Presentation on Artisan assessment - NITA</td>
</tr>
<tr>
<td>10:20 – 10:30</td>
<td>Sponsors Remarks</td>
</tr>
<tr>
<td>10:30 – 11:00</td>
<td>TEA BREAK</td>
</tr>
<tr>
<td>11:00 – 11:40</td>
<td>Construction Safety, Health and Disaster Response</td>
</tr>
<tr>
<td>11:40 – 12:20</td>
<td>Life Skills: Work Ethics</td>
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<tr>
<td>12:20 – 14:00</td>
<td>LUNCH BREAK</td>
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<tr>
<td>14:00 – 15:00</td>
<td>Entrepreneurship</td>
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<tr>
<td>15:00 – 16:00</td>
<td>Cross Cutting Issues in Construction Industry</td>
</tr>
</tbody>
</table>
# DAY 2: TUESDAY 1 NOVEMBER 2016

## Artisan Sensitisation Programme

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:30 – 09:00</td>
<td>Welcome Remarks</td>
</tr>
<tr>
<td>09:00 – 09:45</td>
<td>Alternative construction materials and technologies</td>
</tr>
<tr>
<td>09:45 – 10:00</td>
<td>Sponsor Remarks (Gold Sponsor)</td>
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<tr>
<td>10:00 – 10:30</td>
<td>TEA BREAK</td>
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<tr>
<td>10:30 – 12:30</td>
<td>Tour/View of model compliant construction site</td>
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<tr>
<td>12:30 – 13:00</td>
<td>Closing remarks / certification</td>
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<tr>
<td>13:00 – 14:00</td>
<td>LUNCH</td>
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<tr>
<td>14:00 – 15:00</td>
<td>ACoRCE REGISTRATION OPENS</td>
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</tbody>
</table>

ACoRCE and Big 5 Construct East Africa delegate registration opens.

# DAY 3: WEDNESDAY 2 NOVEMBER 2016

## Registration of Participants

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:00 – 08:15</td>
<td>Master of Ceremony, Entertainment</td>
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<tr>
<td>08:15 – 08:25</td>
<td>ENG. M. Akech (GM-RTCB, Conference chair)</td>
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### SESSION 1

**Location:** Hall 1 [Amphitheatre]

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tbody>
<tr>
<td>08:25 – 08:35</td>
<td>Gold Sponsor’s Presentation – Seven Seas Technologies</td>
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<tr>
<td>08:35 – 09:50</td>
<td>Keynote Address:</td>
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<tr>
<td></td>
<td>- Maximizing on the fourth industrial revolution for brick and mortar</td>
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<td></td>
<td>Ms Samar Al-Kindy</td>
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<td></td>
<td>- Impact of innovation at training institutions on the construction industry</td>
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<td></td>
<td>Eng. B. K. Kariuki</td>
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<tr>
<td></td>
<td>- Building inspection report: one year later</td>
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<td></td>
<td>Qs. Moses Nyakiong’ora OGW,</td>
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<td></td>
<td>- Funding of research and innovations in construction materials/technologies</td>
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<td></td>
<td>Dr Patrick Mbindo</td>
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<td></td>
<td>- Bio-based materials for the construction industry with a focus on engineering natural fibre composites</td>
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<td>Richard Hurding</td>
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<tr>
<td>09:50 - 10:10</td>
<td>Plenary Session (Question and Answer)</td>
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<tr>
<td>10:10 – 11:00</td>
<td>GUEST BREAK FOR TEA</td>
</tr>
</tbody>
</table>
DAY 3: WEDNESDAY 2 NOVEMBER 2016

Opening Session

Location: Hall 1 (Amphitheatre)  
Session Chair: ENG. M. Akech (GM-RTCBI, Conference Chair)  
Session Coordinator: Wangui Kabala

SESSION 2

11:00 – 11:15  Master of Ceremony

11:15 – 11:25  Welcome Note by Executive Director, NCA

11:25 – 11:35  Speech by Chair Board of Director, NCA

11:35 – 11:55  Keynote Address

- Role of KEBS in standardization of emerging technologies and materials in the construction industry - Mr Charles Ongwae MD, KEBS
- The fight against counterfeits in construction - Dr. John Akoten, MD Anticounterfeit Agency

11:55 – 12:05  Platinum Sponsor’s Speech – Kenya Pipeline Company

12:05 – 12:50  Chief Guest Speech  
PS State Department- Public Works,  
PS State Department- Housing & Urban Development,  
CS - Ministry of Transport, Infrastructure, Housing & Urban Development

12:50 – 13:00  Vote of Thanks

13:00 – 14:00  GUIDED TOUR OF EXHIBITIONS FOR CHIEF GUEST AND DELEGATES LUNCH BREAK

DAY 3: WEDNESDAY 2 NOVEMBER 2016

SESSION 3 -STREAM 1

Location: Hall 1 (Amphitheatre)  
Session Chair: QS. David Mathu  
Session Coordinator: Eng. Michael Walela

14:00 – 15:30  Keynote: Construction Industry Policy – A Tool for Innovation by Dr. Michael E. Joachim

- Continuity and change: The potential of the NCA in enhancing the integration of vernacular construction process in the contemporary building construction process  
  Dominic Kinyua Gitau

- The role of the NCA in the conservation of vernacular architectural heritage  
  Dr Mugwima Njuguna

- Impact of politics on innovations in construction materials and technologies  
  Oliver Silumbe

- Transforming the Kenyan construction industry: Domestication of global best practices at the firm level  
  Kimani Thomas Njuguna

- Domestication of construction materials and technology. Issues and options for NCA  
  Mariech Mnangat

- The growth of construction project management profession in Kenya: A call for a legal framework  
  Cyrus Babu Ong’ondo

15:30 – 16:00  Plenary Session (Question and Answer)
### SESSION 3 - STREAM 2

**Location:** Hall 2 (Amphitoyer tent)

**14:00 – 15:20**  
**Keynote:** Introduction of structural Eurocodes in Kenya by Jane W. Maina

- Assessment of compliance of aggregates used in construction projects in Nairobi County  
  Moses Onyango Opiyo
- Concrete for sustainable infrastructure development  
  Dr. David O. Koteng
- Performance and cost benefits of using recycled timber in building construction  
  Nekoye Masibili
- Vulnerability and adaptation levels of the construction industry in Kenya to climate change  
  Erick Maklago, Ruth Onkangi
- The dilemmas of construction project management practice in Kenya  
  Mark Obegi Kenyatta

**15:20 – 16:00**  
**Plenary Session (Question and Answer)**

### DAY 4: THURSDAY 3 NOVEMBER 2016

**SESSION 4 - STREAM 1**

**Location:** Hall 1 (Amphitheatre)

**15:20 – 09:35**  
**Improving the Preparedness of the Kenyan Built Environment for Acts of Terrorism through Better Policy Development**  
Gero Callistus Akello

- Local content participation: Case study of Mombasa -Nairobi SGR project  
  Association of Consulting Engineers of Kenya, ACEK
- Evaluation of Incorporation of Universal Design Parameters by the Kisumu City Planning  
  Ahonobadha Marilyn Ochieng
- Infrastructure, New City Growth and Order: Proposed for Design-based Interventions for Nairobi  
  Noel J. O. Okello
- Towards an Inclusive Built Environment: An Assessment of the Preparedness in Public Buildings in Kisii County for Disability Mainstreaming  
  Omosa Elijah Mochama
- Occupational accidents patterns in construction sites in Nairobi  
  Raymond Kemei

**09:35 – 10:00**  
**Plenary Session (Question and Answer)**

**10:00 – 10:30**  
**DELEGATES TEA BREAK**
SESSION 4 - STREAM 2

**Location:** Hall 2 (Amphifoyer tent)

08:00 - 09:35  **Smart Built Energy Technology to Counter Climate Change**  
Nichodemus A. Ishmael

- **Investment in Energy Management: Analysis of Energy Efficiency as a Sustainable Model in Green Building in Kenya**  
  Kamau Brenda Moraa
- **Embracing Technology with Smart Grid in Energy Sector Construction**  
  John Kamanga
- **Saving the Earths’ Extinction through Green Built Technologies**  
  Nichodemus A. Ishmael
- **Nurturing Green and Renewable Construction Technologies in Kenya: Solar Energy Technologies**  
  Dickson I. Kisivuli
- **Mainstreaming Green Buildings and Green Technologies for Sustainable, Climate Resilient Healthcare Facilities** – **Study of UNOPS-UNICEF MNH Programme Funded by DFID (UK)**

09:35 – 10:00  **Plenary Session (Question and Answer)**

10:00 – 10:30  **DELEGATES TEA BREAK**

SESSION 5

**Location:** Hall 1 (Amphitheatre)

11:00 – 12:30  **Key Note presentations**

- **Investment in Infrastructure Development with Special Reference to Mobilising Private Capital Including Foreign Direct Investment**  
  Dr C. H. de Tissera
- **Green and Renewable Construction**  
  Professor Daniel Irurah
- **Construction projects: New constitutional dispensation on land and physical planning**  
  Town and City Planning association of Kenya
- **Role of professionals in standardization of technologies and materials**  
  Eng. Nicholas Musuni
- **Energy Efficiency in the Built Environment**  
  Dr Vincent Kitio
- **Structural Integrity of Buildings in Urban Centers**  
  Dr Siphila W. Mumenya
- **Gold Sponsor’s Presentation**

12:30 - 13:00  **Plenary Session (Question and Answer)**

13.00 - 14.00  **LUNCH BREAK**
13:00 - 14:00  LUNCH BREAK

14:10 – 14:20  Gold sponsor presentation

SESSION 6

Location: Hall 1 [Amphitheatre]

14:20 – 15:30  Structural Audit of Buildings: Perspective and Challenges in Kenya
Moses Opiyo

- The Urban Flash Flooding Phenomena in Kenyan Cities Making Disasters Resourceful
  Akoko Eva Achieng

- An Investigative Study of Safety Measures Coping Mechanisms in Construction Sites in Kenya: A Case Study of Kisii Municipality
  Nyaribo Peter Aubrey

- Importance of footbridges in enhancing safety in areas of difficult terrain, river crossing and slums for pedestrians
  Hillary Nyaanga

- Effects of the regulatory frameworks on safety and health of construction sites in Kenya - case study of Nairobi County
  Jacqueline Legishion

- Socio-economic & Cultural assessment of environmental impact of sand harvesting from Kenya’s dry river basins and its significance in construction industry in Kenya
  Prof. Kitetu

15:30 – 16:00  Plenary Session [Question and Answer]

16:00 – 16:30  DELEGATES TEA BREAK

Construction as a Business

Location: Hall 1 [Amphitheatre]  Session Chair: NCA
                  Session Coordinator: Paul Kariuki

16:30 – 16:55  Keynote Address: The Balance Between Low Cost Construction Materials and Quality Construction in Kenya
National Construction Authority

16:55 – 17:45  Plenary Session: Round Table Discussions on Low Cost Quality Construction and Construction Practitioners in Kenya
Panellists: Professionals, Contractors, Trainers, KRA & PPOA

Closing Ceremony

Location: Hall 1 [Amphitheatre]  Session Chair: Eng. Maurice Akech

17:45 – 18:30  Reading of Conference Resolutions
Rapporteurs: KIPPRA, UON, JKUAT, MOLHUD

- Closing remarks – Chairman NCA paper review panel Prof. Rukwaro, UON
- Address by Chief Guest
- Vote of Thanks
Gala Dinner

Location: Hall 1 (Amphitheatre)

19:00 – 19:10 Arrival of Guests
ACoRCE Secretariat

19:10 – 21:30 Gala Dinner
• Master of ceremony
• Welcome address: ENG. M. Akech (GM-RTCB, Conference chair)
• Speech by: Executive Director, NCA
• Closing remarks
• Award ceremony: Chief Guest
• Vote of thanks

DAY 5: FRIDAY 4 NOVEMBER 2016

Group Tours

9:00 – 10:00 Arrival of Guests in readiness for departure
ACoRCE Secretariat

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<tr>
<th>Time</th>
<th>Group 1</th>
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<tr>
<td>10:00 – 14:00</td>
<td>Tour of the Rehabilitation Work on the Msa-Nrb Oil Pipeline</td>
<td>Tour of National Housing EPS Factory – NHC</td>
<td>Tour of Expansion Work on Outer Ring Road – KURA</td>
<td>Tour of NITA training and assessment facility at Athi-River</td>
<td>Tour of Northern Collection Tunnel – AWSB</td>
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<td>Site visit to Msa-Nrb Oil Pipeline Project in Nairobi</td>
<td>Site visit to the National Housing Corporation EPS factory, Molongo, Nairobi</td>
<td>Site visit to the expansion works at the outer ring road, Nairobi</td>
<td>Site visit to the NITA training school for artisan and accreditation school</td>
<td>Site visit to the ongoing works at the Northern Collection Tunnel – ASWB</td>
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<td>14:00 – 15:00</td>
<td>Lunch to be provided on site</td>
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ABOUT US
The IEK Council is committed to ensuring the continued improvement of the performance in service delivery to members and engineering service to the nation.
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OUR VISION
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CONTINUITY AND CHANGE: THE POTENTIAL OF THE NCA IN ENHANCING THE INTEGRATION OF VERNACULAR CONSTRUCTION PROCESS IN THE CONTEMPORARY BUILDING CONSTRUCTION PROCESS.

Authors: Dominic Kinyua Gitau¹, Mugwima Njuguna, Ph.D², 1Landscape Architect; Lecturer, Kenyatta university school of Architecture and Built environment department of architecture & interior design. P.O Box 43844-00100 Nairobi; Tel +25471699566; Email. designtechlimited@gmail.com 2Architect; Senior Lecturer at the Centre for Urban Studies, Jomo Kenyatta University of Agriculture & Technology; Director, Centre for Urban Studies.

Abstract

Vernacular construction as a process and a product is influenced by the local environment. The macro climate of a given area dictates the use of building materials and technologies. The culture of the society also has a great influence on the resultant building forms. It is a practical activity that pursues environmental adequacy, an action in which people change and restructure nature through cognitive and social activities.

However, most contemporary professionals undertake constructions within the grand tradition and generally lack vernacular awareness and interest. As a result, the vernacular practice exists without formal guidelines. For the practice to evolve, a growing trend to transition from a relatively isolated area into a field that promotes stronger professional involvement is critical.

Consequently, an investigation of vernacular construction processes and technologies will inform the way the built environment professionals approach contemporary design and construction problems in order to ensure continuity and change.

The relationship between vernacular and institutionalized construction materials and technologies will be investigated, and the extent to which they interact in the spacetime continuum. The ultimate goal will seek to establish guidelines which nurture vernacular design principles in a contemporary setting. The results will lead to a knowledge base that properly informs the manner in which vernacular and institutionalized constructions interact to produce viable solutions in the built environment.

Key words: vernacular construction, technology, building materials, continuity and change.

THE GROWTH OF CONSTRUCTION PROJECT MANAGEMENT PROFESSION IN KENYA: A CALL FOR A LEGAL FRAMEWORK

Authors: Cyrus Babu Ong’ ondo¹, Mark Kenyatta² the Centre for Urban Studies, Jomo Kenyatta University of Agriculture & Technology.

The necessity of a construction manager and a construction project manager in projects cannot be denied. The increasing complexity of projects coupled with pressure to deliver projects within set performance targets has forced the construction industry players to embrace the practice of construction project management. However, despite the need for Construction Project Management services in Kenya, it is yet to take a structured and recognized approach.

This paper attempts to track the growth patterns in terms of output capacity from training institutions and mapping the employment opportunities thereof in an effort to underscore the need for a legal framework to regulate the practice. This survey was conducted between May to August 2016 and was achieved through analysis of questionnaires and review of documents from training institutions offering construction management and construction project management programs.

Data was analyzed by way of descriptive analysis aided by graphical representation of findings. It emerged; there are over eight hundred trained construction managers and construction project managers practicing in the construction industry of Kenya forming a critical mass of professional resource that is not regulated.

In addition, the study revealed existence of diverse employment opportunities for these practitioners in the construction industry. This paper therefore, recommends formulation and enactment of a legal framework to regulate the profession and practice of construction management and construction project management in Kenya. This will go a long way in enhancing confidence among the industry players and promote advancement of the practice in the sector.
THE DOMESTICATION OF CONSTRUCTION MATERIALS AND TECHNOLOGY: ISSUES AND OPTIONS FOR THE NATIONAL CONSTRUCTION AUTHORITY

Mariech Mnangat1, Mugwima B. Njuguna Ph.D2
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2. Architect; Senior Lecturer at the Centre for Urban Studies, Jomo Kenyatta University of Agriculture & Technology; Director, Centre for Urban Studies; +254 722 33 28 66, mugwima@gmail.com, mugwima@sabs.jkuat.ac.ke

Abstract
The decision about when and where to outsource foreign materials and technology varies across individuals, firms and government states. The insufficiency of the level of construction technology development in most developing countries, and particularly Kenya, is evident in: the colossal unmet construction needs; failure to use the countries natural human and material resource endowments; and reliance on foreign sources for a large part of construction needs (materials, professional consultancy and contracting).

This result to extreme costs in form of foreign exchange leading to high construction costs with negative impacts on affordability of the poor and an overall pressure on the national budget. Consequently, it also impedes the expansion and growth of construction technology and hence slow development within the industry, and so on. The domestication of construction technologies from the less developed countries (LCDs) to the more developed countries (MDCs) has been of topical interest for decades. The increased state of globalization further highlights construction technology as a key aspect.

This paper explores the domestication of global best practices in both construction materials and construction technology through a theoretical analysis about the concept of domestication and technological transfer. The paper establishes that there are glaring gaps on the relationship between domestic research and development (R&D) and imports of technology. By highlighting those gaps and problems the paper proposes a raft of recommendations to regulate the domestication and outsourcing of foreign technology vis-à-vis domestic technology.

THE ROLE OF THE NATIONAL CONSTRUCTION AUTHORITY IN THE CONSERVATION OF VERNACULAR ARCHITECTURAL HERITAGE

Authors: Mugwima B. Njuguna Ph.D1, Ephraim W. Wahome Ph.D2, Anne Marie Deisser, Ph.D3
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2. Conservator; Associate Professor in the Department of History and Archaeology, University of Nairobi; Associate Dean, Faculty of Arts, University of Nairobi.
3. Conservator; Research Affiliate in the Department of History and Archaeology, University of Nairobi; Honorary Research Associate, Institute of Archaeology, University College London

Abstract
Vernacular architecture is a fluid concept that encompasses structures produced by empirical builders and is sometimes referred to as indigenous, primitive, ethic or even architecture without architects. Vernacular architectural heritage, often found in rural areas and historic urban areas and villages represents a cultural heritage that has been handed down from one generation to the next. This heritage is under threat from modernising forces which cause deterioration in cultural and historic continuity. It is important to conserve this architecture and associated technologies for posterity.

Both tangible and intangible heritage of vernacular architecture are threatened through blatant negligence, emergent and more profitable modes of construction, and lack of funds for minimum maintenance. To a large extent, this heritage is quickly deteriorating and disappearing into the hands of vandals and illegal traders due to the lack of appropriate conservation sensitization and training for the public and heritage professionals in conservation of materials and skills.

The paper explores the vernacular heritage in Kenya, the state of its conservation and the risks associated with its conservation. It is argued that since NCA is
mandated inter alia to undertake research into any matter relating to the construction industry, it should complement the efforts of the National Museums of Kenya in conservation of cultural heritage in so far as materials and building technologies are concerned. There is no clear legal framework for the conservation of vernacular architecture in place and it is often lumped together with other popular forms of architecture which have well-defined and documented historical trends. Emphasis has been on urban architecture. The paper has established that vernacular heritage has only been haphazardly conserved, with no clear management, documentation and preservation policies. The paper has ascertained that no resources are specifically set aside for the conservation of this heritage.

The study concludes that vernacular architecture in Kenya has been neglected and exposed to deterioration. It also concludes that the level of public sensitization on the heritage is low and its conservation and management needs have been ignored. The study therefore recommends public sensitization, practical conservation and appropriate policies to save the heritage from imminent loss. It further suggests that detailed documentation of vernacular building materials and technology should be undertaken as matter of urgency.

Key words: Vernacular architecture, heritage, conservation, Kenya

IMPACT OF POLITICS ON INNOVATIONS IN
CONSTRUCTION MATERIALS AND TECHNOLOGIES

Author: Dr Oliver Silumbe, Information and Communications University, School of Engineering, P.O Box 30226 Lusaka, Email: osilumbe05@gmail.com, Tel: +260976943668

Abstract

The construction industry, is one that is ever growing and as such it has attracted the attention of many players that benefit directly, these range from small scale contractors to large contractors which serve quite a number of clientele but the largest of them is the government.

This paper has been written as a result of the observation and general public consensus that the local construction industry in Zambia and generally Africa is lacking in innovative construction technologies and materials. It aims to investigate the role of politics and its impact on innovative material and technology in the construction industry.

Like any industry, the innovative products used by construction enterprises must suit the requirements of the client. The findings in the paper show that the biggest client in construction are elected governments and as such, the industry is influenced by political will. Political will from elected governments also plays an essential role in ensuring that innovations in the field of construction are nurtured into viable ideas which are able to compete on the market.

The paper further highlights that there is little political will to pursue innovative ideas on construction from learning institutions which results in innovations being shelved while on paper. Assistance such as tax incentives which are given to sectors like energy are absent in the construction industry. This makes it difficult for innovations to thrive on the competitive market.

Keywords: Politics, innovations, materials, construction, industry

TRANSFORMING THE KENYAN CONSTRUCTION INDUSTRY: DOMESTICATION OF GLOBAL BEST PRACTICES AT THE FIRM LEVEL.

Authors: Kimani Thomas Njuguna¹, Ahmad Omar Alkizim², Mugwima Njuguna³

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²Department of Construction Management, Jomo Kenyatta University of Agriculture and Technology, Juja, Kenya, 
³Centre for Urban Studies, Jomo Kenyatta University of Agriculture and Technology, Juja, Kenya.

Abstract

The local construction industry firms continue to face challenges such as poor cost, time and quality performance; slow technology development and bureaucracy in formal procedures relating to project planning and administration. Consequently, many construction projects in the country are beyond the capacity of local firms; owing to the size, novelty and complexity of those projects. This has seen foreign firms take a big share of the construction market and
illustrates that there is unrelenting pressure on the local firms to increase productivity and reduce costs. To assess the Kenyan Construction Industry’s present state and the global best practices that will impact it at the supply chain level, this study was designed as a survey. The research situs was the city of Nairobi with a sample of 20 industry experts from firms that have a national footprint. The data collection methods were questionnaires, semi-structured face to face interviews and a desk study. Analysis of the data was done using content analysis.

The findings show that tremendous opportunities are available through the application of new technologies, materials and tools. Key transformation areas were identified to be the workforce, industry collaboration, business model innovation, corporate cultures and the maturity of construction operations. In conclusion, the study demonstrates the application of the potential innovative activity systems suitable for adoption and devises an industry transformation framework with key areas for development and action at the firm level.

**Keywords:** Globalization, Value Innovation, Construction, Transformation, Framework.

**INTRODUCTION OF STRUCTURAL EUROCODES IN KENYA**

**Author:** Jane W Maina, Kenya Bureau of Standards, Standards development division, P.O Box 5479400200 Nairobi, Email: mainaj@kebs.org, Tel +254 720841686

**Abstract**

A standard provides requirements, specifications, characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose. It is produced by a process that involves a technical committee made up of interested stakeholders and through the principle of consultation and consensus.

Eurocodes are series of 10 design standards. They provide a common approach that guide the design of buildings and other civil engineering works. They are produced by the European Committee of Standardization, CEN. The development of the Eurocodes began in 1975; the aim was to eliminate technical obstacles to trade, and to harmonize technical specifications.

There are 58 parts of the Eurocodes. Each code has two parts General part and National annex- Nationally Determined Parameters. The general part is common for all countries and domestication is allowed in the annexes.

The Eurocodes have been adopted in Kenya since 2012 with the UK annexes. A national committee on implementation of Eurocode (NICE) will be formed from line government Ministries, institutions of higher learning, professional bodies, certification bodies, engineering consultants, civil contractors and producers of construction materials.

NICE will amongst other things oversee the establishment of a secretariat to the introduction and implementation of Structural Eurocodes in Kenya, facilitate awareness & technical introduction workshops, develop timelines for the implementation of Structural Eurocodes, coordinate the development and research to facilitate the development of National annexes.

**ASSESSMENT OF COMPLIANCE OF AGGREGATES USED IN CONSTRUCTION PROJECTS IN NAIROBI COUNTY**

**Author:** Moses Onyango Opiyo- Lecturer, Kenyatta University (opiyo.moses@ku.ac.ke)

**Abstract**

Collapse of concrete buildings has elicited various researches on the quality of construction materials. Aggregates both coarse and fine used in concrete production may not be well graded hence impact negatively on the quality of hardened concrete.

Objectives. The objective of this research was to establish compliance in the grading of aggregates and their effect on bond strength of concrete.

Methods. This paper presents the findings on the quality of building aggregates as sourced from ten supply points in Nairobi County and its environs and the effects of aggregates grading on the bond strength of concrete through the compressive test method to assess contribution of grading to the frequent collapse of buildings occurring in Kenya. Sieve analysis, fineness modulus, absorption and surface moisture content were carried out as detailed in BS 882, and
ASTM standards. In casting of concrete specimens, the quality of cement and water were held constant while sand and coarse aggregates were studied with varying level of grading from varying sources. The results showed that 70% of tested samples were not well graded and the crushing tests revealed a very big variation on the standard deviation meaning they did not comply with BS 5328 also compressive strength decreased with decrease in packing of aggregate content and water content increased.

Discussion. Aggregates having a smooth grading curve and neither a deficiency nor excess of any one particle size generally produce mixtures with fewer voids between particles. Because cement costs more than aggregate and the cement paste requirement for concrete increases with increasing void content of the combined aggregates, it is desirable to keep the void content as low as possible.

If there is not enough fine aggregate to fill the voids between coarse aggregate particles, the space must be filled with cement paste. Such under-sanded mixtures also tend to be harsh and difficult to finish. On the other hand, aggregate combinations with excessive amounts of fine aggregate or excessively fine sands may produce uneconomical concretes because of the larger surface area of finer particles, which requires additional cement.

Conclusion. The gradation of aggregates plays a role in lowering the structural integrity of buildings. That NCA and KEBS come up with a quality assurance program for materials acceptance and assurance testing policies and procedures, Obtain coarse and fine aggregates at the source of supply, characterize and issue certificate of compliance which must be attached to the sale receipt to any buyer of the product to be verified later on site in case of litigation.

Key words: aggregates; gradation; concrete; quality assurance.

PERFORMANCE AND COST BENEFITS OF USING RECYCLED TIMBER IN BUILDING CONSTRUCTION
Authors: Nekoye Masibili1, Dr. Mugwima Njuguna2, 1Department of Sustainable Materials Research and Technology (SMARTEC) E-mail: faithnekoye@gmail.com, Jomo Kenyatta University of Agriculture and Technology (JLUAT), P.O BOX 62000-00200 Nairobi, 2Department of Urban Studies, Jomo Kenyatta University of Agriculture and Technology (JLUAT)

Abstract
Recycling is a key activity for sustainable construction. Every material has a resource footprint and a pollution footprint, particularly during production. Research shows that much of this can be avoided by recycling products rather than manufacturing from new raw materials. Construction requires investment of large amounts of materials, some of which could be residuals and secondary materials generated after primary service in other facilities or as byproducts of processes that extract more valuable materials.

In Kenya, construction and joinery are the major consumers of hardwood in the formal commercial sector and are highly sensitive to the overall state of the economy. Although there is widespread apprehension that supplies of indigenous hardwoods will become increasingly difficult to obtain, surprisingly few users are actively searching for substitutes or alternative sources of supply.

The industry appears reluctant to experiment and promote new timbers. This paper examines the performance and cost benefits of using recycled wood timber in building construction. The material properties of recycled hardwood will be determined experimentally. The experimental results will be used to predict the suitability of recycled indigenous hardwood as a construction material.

The social-economic and environmental impacts will be examined in a holistic approach. A cost benefit analysis will also determine by how far the benefits of implementing the recycled hardwood technology outweigh the costs.

Key Words: Construction Materials, Recycled wood Timber, Sustainable Construction

VULNERABILITY AND ADAPTATION LEVELS OF THE CONSTRUCTION INDUSTRY IN KENYA TO CLIMATE CHANGE
Authors: Onkangi N. Ruth1, Mwangi Peter Njiiri2, Erick Maklago1, Ondari Lilian3 1Research Officer, National Construction Authority, 2Senior Research Scientist, Kenya Wildlife Service, 3University of Toledo

Abstract
Climate change is increasingly becoming a threat to
future development plans and sustainability of existing infrastructure and species. Assessment of vulnerability levels, adaptation measures, models and climate change variables have majorly focused on biological systems. Besides biodiversity, the construction industry faces equally or greater threats from climatic changes with enormous sustainability, energy and carbon price risks. Construction in the developing nations is gaining momentum and is one of the development indicators as well as a major contributor to the GDP.

However, the industry is very vulnerable financially to extreme weather events such as intense and prolonged periods of rainfall, inundation, lower retreating rates of flood waters, increased temperatures and unpredictable wind patterns. This calls for shunning of business as usual and undertaking rigorous risk assessments to determine vulnerability levels, adaptation measures and strengths to initiate early warning and adaptation systems for the industry to thrive, not just survive in a changing planet.

Study conducted among contractors, designers, site managers and workers sought to establish the level of vulnerability and awareness on climate change, bottle necks in construction associated with climate change in Kenya as well as adaptation measures so far implemented. Interviews, predesigned questionnaires and observation are the tools employed in this study. The study recommends a change from business as usual through increasing level of awareness of the menace, research into resilience of materials and technologies used locally, advocating use of resilient materials and techniques, mainstreaming climate change into the construction sector through policy and introduction of incentives to increase adaptation and mitigation measures in the sector.

**Key Words:** Climate Change, Construction, Adaptation, vulnerability.

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**IMPROVING THE PREPAREDNESS OF THE KENYAN BUILT ENVIRONMENT FOR ACTS OF TERRORISM THROUGH BETTER POLICY DEVELOPMENT.**

*Author: Gero Callistus Akello Bachelor of Construction Management, 4th Year Jomo Kenyatta University of Science and Technology. Email: gero.callistus@students.jkuat.ac.ke, Tel: +254703849644*

**Abstract**

Terrorism has grown to be one of the greatest tumors that most governments worldwide are investing heavily in combating. The last decade has seen the wildest rise in acts of terrorism with many losing their lives to it. Kenya has also been the scene of various attacks attributed to terrorist elements. The most recent and worst hits by Somalian Al Shabaab were at the Westgate mall and the Garissa University College with many losing their lives. Most of these attacks took place in public buildings (malls, office blocks, universities).

Had there been certain policies enforced into the design of the buildings right from preconstruction, terrorism couldn't have bit so painfully. Statistics show that terrorism is not any close to declining, therefore the Kenyan construction industry should have learnt much to rise up and act. There are loopholes in the current construction policies in regards to terrorism preparedness that should be sealed if only to make Kenya's built environment safer.

As a student and a hopeful prospective employee of the construction industry, I believe that this conference will bring together different professionals in the industry that will not only see the loopholes in the current construction policies in relation to terrorism but also see the need to upgrade them. This paper is therefore significant to all of us; we are all concerned about each other’s safety in light of rising terrorist extremism.

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**EVALUATION OF INCORPORATION OF UNIVERSAL DESIGN PARAMETERS BY THE KISUMU CITY PLANNING OFFICE.**

*Authors: Ahonobadha Marilyn Ochieng’1, George Mark Onyango2, George Godwin Wagah3 1Maseno University, School of Arts and Social Sciences, Department of Art and Design, P.O. Box Private Bag, Maseno, Kenya; Email: aholnabadhah79@gmail.com*

**Abstract**

Consideration of the normate template by designers usually leads to production of living spaces which fail to meet most of the spatial requirements of would be users. This phenomenon arises due to the fact that the normate template keeps a walking and fleshy body at the center of thinking about design. As a
result, the template fails to consider additional space requirements for bodies that use technologies to navigate space. In order to sustain itself, the normate template relies upon the impression that normates are normal, average, and majority bodies.

When built up spaces block out potential users then the view point which is reinforced is that certain spaces are meant only for those who are “privileged” to use these spaces independently. The presence of accessible spaces on the other hand confirm that designers hold that built environments should serve all potential users regardless of physical stature. Universal Design thereby provides a platform for making the weakest person in society strong through design. Embracement of a Universal Design perspective therefore becomes a stepping stone in the provision of public spaces which are accessible to all regardless of physical stature.

This study therefore evaluated the incorporation of Universal Design parameters in the design process of public spaces in Kisumu City. The study established that Universal Design requirements are usually executed only on new constructions. There is need therefore for major renovations to take place in buildings open to the public that are not necessarily classified as “new” constructions.

Key Words: Universal Design, Planning Practice, Kisumu City

INFRASTRUCTURE, NEW CITY GROWTH AND ORDER: A PROPOSAL FOR DESIGNBASED INTERVENTIONS FOR NAIROBI

Author: Arch. Noel J. O. Okello, B.Arch., M UrbDes., Ph.D., MAAK . Department of Architecture – School of Architecture and Building Sciences, Jomo Kenyatta University of Agriculture and Technology

Abstract

Nairobi has been described in various urban studies as a dual city. In other words, it is a heterogeneous mix of more formal and less formal urbanisms rather than a clear dichotomy between formality and informality. In Nairobi infrastructure development – particularly the construction of new transportation infrastructure, is driving rapid urban growth. Formerly peripheral areas are being incorporated into the existing fabric of the city. The result of this growth is diametric juxtapositions between the older more formal parts and newer more informal parts. The city is a simultaneous physical and spatial representation of worsening inequalities, the rise of neo-liberalism, rabid speculation on land, and, the reduction of public space that is cast into sharp relief by the simultaneously increasing dependence between the dual city and its metropolitan region.

In spite of this adverse situation, the disciplines that constitute urbanism –in their traditional rejection of both transdisciplinarity and collective social values, have either kept their preference for methods of the modern and postmodern past or embraced honest explorations of the emergent socio-spatial (dis)order without substantively incorporating their lessons convincingly into the fledgling and complicated practice(s) of design, planning and implementation in the Global South. The fundamental questions arising out of the current recidivism to the methods of modernism or the benign neglect of urban order for the sake of the flourishing of thousands of designers are: With the rapid growth currently experienced in the cities of the Global South what kind(s) of order actually matter? What are the forces driving this order? Is this order visual and constructible? How can the explorations into this order be incorporated into design, planning and implementation of projects?

This paper tackles the daunting task of addressing rapid growth and order in Nairobi. It is predicated on the basic understanding that design, planning and implementation guide development in ways that are decidedly spatial, visual and plural. It gives broad suggestions as to how the processes of design, planning and implementation may be improved upon to address practical problems related to the scarcity of resources and fragmented governance regimes in cities of the Global South. A multimethod approach, including archival material, observation, mapping, argumentation, and select case studies, is used to support the ideas expressed. Even though there are conflicting arguments and arguments about the import of order in construction, I argue that it is possible to draw broad principles that can be used to improve design, planning and implementation under conditions of scarcity, inequality, multiplicity, heterogeneity and fragmentation
that define urban construction in Nairobi.

Key words: Nairobi, urbanism, growth, construction, order, Global South.

TOWARDS INCLUSIVE BUILT ENVIRONMENT: AN ASSESSMENT OF THE PREPAREDNESS IN PUBLIC BUILDINGS IN KISII COUNTY FOR DISABILITY MAINSTREAMING

Author: Omosa Elijah Mochama, Email: omosae@yahoo.com, Mobile Telephone: +254722346953

Abstract

The research set out to establish how well the public buildings in Kisii County are designed and built for ease of access to persons with disabilities. The study employed a survey of public buildings of 30 selected establishments in Kisii Municipality. It examined the buildings in terms of horizontal and vertical movement, signage, lighting, restrooms and common service areas. It sought to find out how the buildings have been designed and built to conform to the ISO World Standards and the Kenya Bureau of Standards (KEBS) ISO Standards. Buildings with at least one floor were sampled from within the municipality and a checklist was used to get the necessary data sought.

Data collected was analyzed using the Statistical Package for Social Sciences, SPSS. Over 80 percent of the buildings do not conform to the required standards, with some lacking ramps, lifts or both. Where the ramps are available they were found to be very steep: not at the recommended 1:12 standard. The service points did not cater for people on wheelchairs or very short ones. The common utilities such as electric switches, sinks, gas controls are also inaccessible for such a group of people with disabilities. The study recommended that public buildings should be renovated or designed and built to take care of persons with disabilities.

Keywords: Disability, Built environment, accessibility, standards

Piling in general is a very messy and cumbersome activity and there are various traditional piling systems on the market, each with their relative strengths and weaknesses. To address the long overdue need in the construction industry for a safe, fast, simple, modern and universally usable prefabricated driven piling system, TRM introduced the TRM piling system, which requires little preparation of site working platforms, thanks to the compact and versatile piling rigs which allow access to the most difficult working conditions, ranging from sites with head room as low as 4.5m to congested, fully active sites.

As the TRM piling system is extremely versatile and adaptable, even when unexpected geotechnical conditions are encountered, the risk of significant disruptions to the piling programme is effectively eliminated.

Keywords: TRM, Duktus, Pile systems, Piling, auger, friction, end bearing, displacement, replacement.

OCCUPATIONAL ACCIDENT PATTERNS IN CONSTRUCTION SITES IN NAIROBI COUNTY KENYA

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Abstract

Construction accidents don’t just happen, they are initiated by unsafe acts, unsafe conditions or both. The construction industry in Kenya plays a vital role in achieving social economic development goals, providing shelter, infrastructure and employment. A study was carried out to identify the common accidents in construction sites and to examine the characteristics of the injured and deceased workers and evaluate factors that cause these accidents in Nairobi County, Kenya. The study cross examines data from Directorate of Occupational Safety and Health (DOSH) from Nairobi County ranging from 2010-2014.

Accidents were classified by the age of workers, time and month of accident, location of accident and causes of accident. The study establishes that 65% of all reported accidents occurred to workers below 37 years old. The accidents peaked between tea break
In order to improve safety in the construction industry, each company should have a health and safety policy which should be implemented in each contract. Furthermore, construction companies need to provide workers with the necessary Personal Protective Equipment (PPE), such as safety belts, retaining belts, safety ropes, and safety harness, and catch nets to prevent workers from being hit by falling materials and secure them against falling from heights.

Keywords: Safety, Occupational Safety and Health (OSH), Construction sites, Nairobi, Kenya

SMART BUILT ENERGY TECHNOLOGY TO COUNTER CLIMATE CHANGE

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Abstract

Even with a magic bullet, how long will it take for technology to turn the tide against climate change is a slow process. You can understand climate change as a mostly technical problem to which there is a mostly technical solution. Wild fires, extreme earthquakes and rising temperatures need to be stemmed. This study spells out smart built technology’s role in establishing a cleaner planet.

While governments naturally focus on policy, some of the world’s most powerful entrepreneurs have joined the campaign to help bring energy technology solutions to the global warming debacle. The commercial and residential building sector accounts for 39% of carbon dioxide (CO2) emissions in the United States per year, more than any other sector. U.S. buildings alone are responsible for more CO2 emissions annually than those of any other country except China. Most of these emissions come from the combustion of fossil fuels to provide heating, cooling and lighting, and to power appliances and electrical equipment.

By transforming the built environment to be more energy-efficient and climate-friendly, the building sector can play a major role in reducing the threat of climate change. Decision-Makers present the current state of thinking on how the potential for greenhouse gas emission reductions in buildings can be realized. Given the massive growth in new construction in economies in transition, and the inefficiencies of existing building stock worldwide, if nothing is done, studies show greenhouse gas emissions from buildings will more than double in the next 20 years.

The methodology used is literature survey. The researchers will undertake to study the existing smart built energy technologies that can be used to counter climate change. The study found that adapting building designs for climate change is about managing the unavoidable climate change catastrophe.

Keywords: Built environment, Carbon dioxide, Clean Planet, Climate Change, Energy Technology, Global Warming, Green House Gas, Smart Technology

INVESTMENT IN ENERGY MANAGEMENT: AN ANALYSIS OF ENERGY EFFICIENCY AS A SUSTAINABLE MODEL IN GREEN BUILDING IN KENYA.

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Abstract

The construction industry relies on power, both in large scale; for exploration, extraction and production of construction materials and in small scale; in construction sites for powering construction plant and equipment. This power is obtained from various sources mostly hydroelectric power plants, geothermal power plants and in few instances, as solar generated power. This industry alone is estimated to consume more than half of annual global power production according to global energy reports.

The construction industry however, is not the only industry that relies heavily on power. Energy consumption in various sectors of the economy has been observed to have grown significantly. There is great room for investors to inject resources into this
great opportunity and there has essentially been great investment in the same.

However, investments in the energy sector have not been enough to curb the rising energy deficit created. This concern, as well as the rising fuel prices, scarcity of water and other resources as well, together with the construction industry’s rising impact on global warming, has led to the re-evaluation of how we design structures, so as to further efforts to conserve this energy, Kenya not being left behind.

Asymmetric information in the power industry has not been of much help as well, since the limited knowledge of the energy crisis within players in the energy field, has left local developers unsure and uninformed on how to implement such strategies in their own backyards. This leads to the country losing out on a whole and drawing progress backward, a situation that can easily be solved by analysis of this problem.

This research, therefore aimed at identifying the impact of green building through energy efficiency in the country as well as the opportunities of investment for interested parties. Additionally, it aimed at providing information on the sustainability of such projects with the overall aim at identifying the economic life of energy efficiency drives and in the long run, as a basic of reference for practitioners and all interested.

Targeted sample population of study included industry practitioners; engineers, construction managers, designers as well as professionals involved in various fields such as researchers and lecturers.

A variety of data collection methods will be employed for this research, both primary and secondary methods including dissemination of questionnaires, firsthand information from professionals in the field and interviews. This will be followed by a thorough analysis of research findings with comparisons to projects already in play.

EMBRACING TECHNOLOGY WITH SMART GRID IN ENERGY SECTOR CONSTRUCTION
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Abstract
Smart Grid is an intelligent power network providing reliable services with high efficiency using power electronics and current technologies. The development and implementation of a smart grid for power supply is one of the pressing issues in modern energy economy, given high national priority and massive investments, although the entire subject is still in its infancy stage.

The smart grid delivers electricity from producers to consumers using two-way digital technology, and allows control of appliances in the consumers’ houses and of machines in factories to save energy, while reducing costs and increasing reliability by cutting off outages and ensuring transparency. Such a modern electricity network is promoted by many governments as a way of handling energy independence, global warming and security of supply. Smart meters are part of the smart grid, but do not themselves constitute a smart grid.

A smart grid includes an intelligent monitoring system that keeps track of all the electricity that flows in the system. It could incorporate the use of superconducting transmission lines to reduce losses, as well as the ability to integrate electricity from alternative sources such as solar, wind and geothermal. This in effect can enhance a subsidize in electricity cost. When electricity cost is low, the smart grid can offer the customer to run intensive consumption household appliances, such as smart homes with washing machines and other smart appliances, or processes in plants that operate at flexible hours.

On the other hand, smart grid at peak hours can, in coordination with the client, turn off selected appliances and machines to reduce demand hence banking for future. In principle, the smart grid is an upgrade of the common electricity grids that operate mostly to provide one-way power from several major power plants to a large number of consumers.

This upgrade is expressed in the ability to operate in conditions of uncertainty in order to route the power supply in an optimal way that responds to a wide variety of situations, to encourage users in off-peak hours and charge premium rates from consumers.
who use energy during peak hours. The key to this capability is fast, accurate and two-way transmission of information between all parts of the grid. Situations that require fast response can occur at all parts of the grid – at the chain of production, transmission and consumption.

The source of the event could be in the environment (sudden cloudiness that decreases solar power, or a very hot day that increases the demand for air conditioning), in parts of the grid itself (sudden failures, the need for proactive maintenance) or in the demand (work hours compared to hours of rest). Several countries have devoted significant efforts to the issue of smart grid and it is possible to learn from their experience.

Italy is considered the most advanced of the European countries with the Telegestore project that was completed in 2005. This project is considered the first on commercial-scale for residential buildings and saves about 500 million euros per year with an investment of approximately 2.1 billion euros. In the U.S., the city of Austin in Texas replaced one third of the meters in its area with smart meters and has about 200,000 units that are interconnected by a communications network. Smart grid brought many benefits to Israel’s energy economy, including optimal production of electricity and combining storage while reducing the need for it, a natural integration of decentralized producers - in particular from renewable energy sources, efficient planning of power consumption to reduce consumer costs, and security of supply.

The smart grid network will enable metering and monitoring, consumption management and many other benefits, the most important of which is a reduction of total consumption and intelligent exploitation of energy resources. The expected applications and services in the short term are mainly in the field of optimization, resources and providing information to consumers; however, it is difficult at present to imagine the full range of related innovations that will be developed, as it happened following the creation of the Internet network.

The smart grid does not have to be based on a hierarchical structure that characterizes the conventional grid of “from the manufacturer to the consumer”. It is reasonable to expect that it would be a matrix structure based on interconnected clusters, each in itself constituting a smart grid for its own producers and consumers, similar to communication networks or the Internet.

For example, the smart grid could be at the city level, integrated into a national grid, or at the plant level, integrated into the urban grid or a residential estate integrated into a rural grid. The physical infrastructure (transmission and distribution lines) requires innovations and the introduction of disciplines that do not exist today in the standard power supply grid. This include; speedy switching, direct or alternating current with synchronization, coordination and transmission of information on the same network or on an attached network, developing applications for operators and consumers and enabling control of the systems.

Data transfer, communication and control – all require a universal protocol for communication and grid management, communications equipment and metering and consumption control. The Smart Grid subject is still an elusive vision, both Kenya and the third world, but is clearly of national importance. Kenya has much to contribute in this field, both as a quick adaptor of various technology areas and in particular in ICT, and because of its ability to serve as a testing field, being an energy “potential-nation”.

The cost of the smart grid is quite high. According to estimates, turning the entire grid into a smart one will cost billions of dollars. Though it be expensive, it is possible and probably desirable to perform the process gradually.

**Recommendations:**

(1) An action plan to implement a smart grid in Kenya should be prepared. One proposed way is to formulate this plan in a work group of experts who can work in parallel with groups and organizations in even other continents. There is an immediate need to bring to the discussion table parties that do not consider the power system as part of their natural playground.

(2) A policy must be set and objectives have to be mapped out: the course of action is not necessarily
electricity consumption, compared with full supply of all consumption at any time or introducing maximum renewable energy into the electricity sector. As part of the policy, the desired benefits should be defined, and then the business model has to be determined, as well as the processes and the technology from which the expected costs and the expected added value will be derived.

(3) Implementing the smart grid should start at the consumer side. This is worthwhile and practical since the basic infrastructure is simple and exists already. Smart Metering should be installed nationwide since its benefits have been proven and it constitutes an essential infrastructure for the smart grid. It is possible to create clusters of regional smart grids in areas with high profitability. These clusters will be interconnected later on, and be connected to the national grid. With consumption of more than 4-5 MW, many plants will benefit from self-production of electricity, especially if they could use cogeneration.

(4) Standards should be set – with international coordination – for the components of the smart grid, such as smart meters. A universal communication protocol for communications and grid management, communications equipment, metering and control of consumption is required.

(5) Appropriate personnel should be trained to operate the smart grid. The required profile is a combination of energy, mechatronics and telecommunications engineers.

(6) Kenya has a national interest in maximizing the use of renewable energies. The smart grid should be designed with suitable flexibility so as to be able to absorb maximum electricity produced from solar and wind energy.

(7) As this is an international mission, it is recommended to act mainly through international cooperation, in order to maximize the relative advantages of the various countries in various fields, and achieve the maximum benefits at possible low-cost.

(8) Whereas the development of Kenya moves in the high-tech direction and electricity consumers in this area need reliable and available electricity, at a very high quality and reasonable prices (but higher than other consumers), it is recommended to give priority to these consumers, in collaboration with all relevant parties, regarding the implementation of a smart grid.

**Keywords:** Smart Grid, ICT, MW, smart metering

**SAVING THE EARTH's EXTINCTION THROUGH GREEN BUILT TECHNOLOGIES**

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**Abstract**

Green construction becomes more than an environmentally friendly option: It becomes a necessary step in how we live our lives and can be as beneficial for our wallet as it is for the Earth. Advanced green built technologies bring cool advancements in science to the construction industry. Green technology or clean technology is technology whose use is intended to mitigate or reverse the effects of human activity on the environment. Human activities adversely contribute to global warming that is threatening to wipe out the face of the earth today.

Across the planet, nations are experiencing a wide variety of impacts as the world has gone through unprecedented heating. According to the US National Oceanic and Atmospheric Administration, most of Earth's land surfaces were warmer than average, with record warmth notable across various areas of South America, much of southern Africa, southern and eastern Europe, around the Urals of Russia, and most of south-east Asia, down to northern Australia.

In order to effectively address global warming, we must significantly reduce the amount of heat-trapping emissions we are putting into the atmosphere through buildings. The good news is that we have the technology and practical solutions at hand to accomplish it. As individuals, we can help by taking action to reduce our personal carbon emissions. But to fully address the threat of global warming, we must demand action from our elected leaders to support and implement a comprehensive set of climate solutions. The methodology used is literature survey.

The researchers will undertake to study the existing...
green technologies that can remedy the suffocating world from daily raising world temperatures. The study found that to save the world from imminent extinction, green technologies must be incorporated in the built environment.

**Keywords:** Built Environment, Carbon Emissions, Cool roofs, Eco-friendly, Green Technology, Global Warming, Milk Paint and Smart Buildings

**NURTURING GREEN AND RENEWABLE CONSTRUCTION TECHNOLOGIES IN KENYA: SOLAR ENERGY TECHNOLOGIES**

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**Abstract**

Renewable are energies that are refilled by natural processes at least fast as we use them. All the renewable energy comes ultimately from the sun ie solar energy, hydro electric power etc. Renewable supplies can become exhausted if we use them fast than they become replenished. Kenya demand for electricity is increasing at a laming rate. A big chunk of electricity is required is based on the fossil and other convectional energy such as the hydro and geo energy.

The transmission of these energies, from the generating stations to the user via the grid, requires the construction of a very expensive infrastructure network. There is some proposal to increase the supply and keep in pace with the increase in energy demand by embracing the nuclear technology which has a very high energy value but a high source of pollution. Kenya has vast range of natural resources which can be nurtured to embrace the renewable energy sources for the power generation. Technologies such as the wind, solar and geo energy are pollution free, green and recycled. The generation plants are always close to the consumer and thus less expensive in transmission infrastructure construction.

The paper will focus on solar energies (solar thermal system and solar electric (PV systems) technologies). Emphasizes will be on the comparison between solar construction in Kenya and countries that have embraced this technology ie the EU countries have PV solar integrated in the building design. design practice One of the PV solar integrated design of buildings. Suggest the suitable solar energy construction for the local.

**Keywords:** Green technology, Renewable energy, Solar thermal technology, Solar electric technology.

**MAINSTREAMING GREEN BUILDINGS AND GREEN TECHNOLOGIES FOR SUSTAINABLE CLIMATE RESILIENT HEALTHCARE FACILITIES-A STUDY OF UNOPS-UNICEF MNH PROGRAMME FUNDED BY DFID (U.K.)**

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**Abstract**

Sustainability has become an approach from prodigy over the last few decades in the wake of growing concern over climate change and adversities it brings along. The effects of climate change are felt in everyday life where a global idea of GHG emission transforms into temperature extremes, draughts, cyclones, torrential rains and floods affecting the environment.

The most vulnerable of human race are the people who live in closest contact with the environment, who depend on the same environment for their annual food, shelter and livestock. These people who have historically bore the cost of modernization and connected environmental exploitation and degradation, often live in the most challenging natural environment and with least resources and technological capacity to moderate their surroundings to adapt to climate change.

The DfID (UK) funded UNOPS-UNICEF MNH (Maternity and Neo-natal Healthcare) programme being implemented by UNOPS is addressing the challenge faced by such vulnerable people. By upgrading and rebuilding the maternity and infant care facility in over 150 health facilities spread in various rural remote destinations across five Kenyan counties of Nairobi, Kakamega, Homabay, Turkana and Garissa; the project aims to reduce the number of maternal and no-natal deaths through provision of self-sustainable, climate responsive and resilient...
infrastructure solutions based on green buildings and green technologies principles.

The paper attempts to describe in a comprehensive yet concise manner the innovative, audit-based, scientific approach of UNOPS EAH (East Africa Hub) to research, document, identify and design green building and green technologies based solutions for health facilities spread in five counties selected under UNOPS-UNICEF MNH programme and implement the designs for effective results.

Starting with the description of project ethos, the paper delves into methodology of audits carried out, design solutions based on green building and green technologies for sustainable energy, water supply, sanitation and hygiene; features of sustainability in new designs for maternity building herby ending whit how the project envisages the effects and results of sustainable built environment for reducing the maternal and neo-natal death rates in five counties in Kenya.

STRUCTURAL AUDIT OF BUILDINGS: PERSPECTIVES AND CHALLENGES IN KENYA

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Abstract
This paper aims at creating awareness amongst the construction stakeholders (Governments, Architects, civil engineers, residents and owners) in the building industry towards the health examination of existing concrete buildings called Structural Audit.

The need of structural audit is normally for maintenance and repairs of existing structures whose lives have exceeded the age of 30 years to avoid any mishaps and save valuable human life, however in cases of incessant collapse of buildings as has been the case in Kenya, structural audit becomes mandatory. Concrete is widely used as construction material, because it is cheap, easy to mould in plastic state and has a high strength-cost ratio. More than ever, the construction industry is concerned with improving the social, economic and environmental parameters of sustainability.

Since independence, Kenya has witnessed tremendous growth of private investment and infrastructure in construction industry. However many of these buildings have been built without following the due processes. Whereas there are many high-rise buildings whose structural performance is questionable due to age, material deterioration, unexpected over loadings or physical damage some are due to impunity in the construction industry.

If further use of such deteriorated structure is continued it may endanger the lives of occupants and surrounding habitation. There is demand of appropriate action on such building structures to improve their performance and restore the desired functions of structures which may lead to increase in their functional life. The periodical structural auditing and diagnosis for health of existing buildings is thus of utmost importance for determining the current serviceability and structural viability of structures.

The structural audit should be carried out following standard norms, methods of non-destructive testing and code provisions. The structural auditing will help to weed out death traps inform of habitation and inform maintenance and repair work which will lead to prolonged life of the building and safety of the occupants.

Keywords: Structural Audit; Non Destructive Testing; Repair; Concrete.

AN INVESTIGATIVE STUDY OF SAFETY MEASURES COPING MECHANISMS IN CONSTRUCTION SITES IN KENYA: A CASE STUDY OF KISII MUNICIPALITY

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Abstract
Construction sites have been regarded has the most dangerous place to work in. Accident and injury rates in construction project sites is very high in comparison with other sectors of the industry. This study investigated safety and coping mechanisms in place on construction sites for the purpose of highlighting the critical safety issues affecting the overall welfare and safety of the construction workers on building construction sites. It is expected that the findings of
this research would help to improve the conditions of the construction workers on the sites and protect their rights.

This study adopted a descriptive case study design. The study employed purposive and snowballing sampling techniques by using questionnaire and interview schedule on respondents for data collection. The data collected was analyzed using Statistical Package for Social Sciences (SPSS). Descriptive statistics was used to present quantitative data while qualitative data were organized into themes and narrated using direct quotations.

The study revealed that accidents, injuries and fatalities were most commonly caused by falling objects and these were never reported to the relevant government ministries/authorities. The study concluded that safety reporting mechanisms on construction sites in Kisii Municipality were poor and inadequate. The study recommends the necessity of the contractors to report all accidents, injuries and fatalities that occur on construction sites to the relevant government ministries for record keeping and documentation.

**Keywords:** Construction Safety, Construction Workers, Site accidents and injuries, Kisii-Kenya

**IMPORTANCE OF FOOTBRIDGES IN ENHANCING SAFETY IN AREAS OF DIFFICULTY TERRAIN, RIVER CROSSING AND SLUMS FOR PEDESTRIANS**

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**Abstract**

A good population of Kenyans live in rural areas and slums within urban centres. Most of these people reside and earn their livings in slums and areas which are hilly, steep and next to rivers which pause difficulties in travel and crossing to access social and economic places including markets, shopping centres, schools, religious places and even visiting relatives.

To make accessibility possible, bridges (both pedestrian and vehicular) are a necessity. The bridges will require approach roads, embankments, protective measures (guardrails) and staircases. While crossing rivers, people (especially the elderly, children and the physically challenged) are exposed to dangers of being washed downstream by rivers and flooded valleys. To minimize the dangers footbridges are constructed to be used for crossing rivers and accessing areas with difficult terrains. In addition to being used to cross from one point to another protective measures also prevent soil erosion.

Footbridges are facilities which are used by pedestrian to cross valleys, rivers (both seasonal and non-seasonal), storm water drainage, deep gulleys, roads and railway crossings to mitigate against avoidable accidents. They shorten travel distances between two points and in the process promote economic and social activities. They also open up areas for mutual interaction of neighboring villages and communities. Students easily cross over to go to school, farmers can sell their produce in markets, worshippers can reach worship areas easily, relatives can visit their kin conveniently and activities requiring public participation may easily be attended. Awareness forums can become easily accessible.

Footbridges can be constructed from steel and concrete. For ease of construction, steel decking is normally preferred to the concrete construction. The construction can be done in three phases

- **Phase I – substructure works**
- **Phase II – Main deck erection**
- **Phase III – Finishing works**

The substructure works consist of foundation, column and beams.

The main deck consists steel fabrication, hoisting and placement on site.

Finishing works consist of alignment on site and final welding and bolting, painting and commissioning. Geotechnical site investigations and reconnaissance surveys are carried out when a need has been identified. Designs are carried out based on the span of the footbridge has been determined. Since the construction is done in areas with difficult terrain, safe implementation logistics are put in place in terms of delivery of materials, on site construction safety and hoisting of main deck on site.
For a long time, crossing of river valleys and areas with difficult terrain has been through logs laid across the river and valley or gulleys. During period of flooding and heavy rains the improvised crossing by way of logs has proved to be very difficult and dangerous. Many cases of people and animals drowning or washed downstream have been reported.

With construction of professionally designed footbridges with proper approaches and ramps, cases of people being washed away and drowning have drastically reduced. Economic and social activities have been enhanced. The program started in 2005. Professionally designed footbridges make it convenient for human beings, donkey carts, domestic animals and the physically challenged to cross with ease.

Monitoring and inspections will expose areas which require maintenance and rehabilitation. Ownership by the local community is critical to avert any cases of vandalism especially by scrap metal dealers. The presenter is the originator of the program and coordinator since 2005.

EFFECT OF THE REGULATORY FRAMEWORKS ON SAFETY AND HEALTH OF CONSTRUCTION SITES IN KENYA

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Abstract

Construction is a large, dynamic and complex industry that plays an important role in the economy of a country. Typically, construction industry contributes to 11% of Gross Domestic Products (GDP) of most developing countries. Currently, Kenya is going through a construction boom and the Government has invested intensely in the construction sector in order to improve the current ramshackle infrastructure of the country. Construction industry is labour intensive and it provides opportunities for employment.

According to ILO the industry is the world’s largest industrial employer, employing over 100 million people who are skilled, semiskilled and unskilled. Despite its significance, construction industry is considered extremely risky with frequent and high accident rate and ill-health problems and therefore its close regulation on safety and health cannot be gainsaid. The construction industry business in Kenya, just like other countries, cannot be tackled effectively without harnessing its health and safety issues especially in regards to safeguarding the workers and the entire community surrounding them. Construction industry, unlike many other industries is unique in nature.

It is characterized by continual changes, use of many different resources, non-steady employment, tough and temporary environments. Further, it requires coordination of different interdependent contractors, sub-contractors and operations that result in increased risk of injury and accidents. However, practice of safety and health on Kenyan construction sites is limited. In Kenya Occupational Safety and Health Act (2007) is concerned with preserving and protecting human and facility resources in the workplace and is concerned with the preventive measures laid down to guide the employers, the workers and their representatives on the requirements for a safe, healthy working environment.

This paper seeks to discuss the relevance and linkages of the current regulatory frameworks that provide guidelines on safety and health of construction sites in Kenya. It aims to find out the current practice of safety and health in construction sites. It looks at the US, UK and SA practice as a yardstick and how these regions have considered construction as a unique industry and have enacted construction regulations that are specific to management of safety and health of construction sites such as the UKs ‘Safety, Health and Welfare at Work (Construction) Regulations 2013’ and the SAs ‘Construction Regulations, 2003’.

This paper pursues to stir debate and provoke conscience of policy makers and implementers to give the matter the weight it deserves and brings solutions to the menace in the construction industry.
Key Words: Construction, Safety, Health, Regulatory Framework, Act

SOCIO-ECONOMIC AND CULTURAL ASSESSMENT OF ENVIRONMENTAL IMPACTS OF SAND HARVESTING FROM KENYA’S DRY RIVER-BEDS AND ITS SIGNIFICANCE TO CONSTRUCTION INDUSTRY IN KENYA.

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Abstract
As much as 90% of the Nairobi city’s demand for building sand is met from upper river Athi basin, which was the study area, and the sand harvesting permit system offers a valuable source of revenue to local authorities such as Machakos and Makueni Counties. However, the various assessment methods used in this study showed that the each of the two counties was realising about 10% of the revenue available to them because of the weak enforcement structures and endemic corruption within the system.

Local authorities must play a more effective role in the planning and management of environmental resources. The significance of different socio-economic, cultural and environmental impacts were assessed by the application of monetary evaluation techniques and from the analysis of questionnaires distributed to sand harvesting companies, local residents and government administrators. It was established there were over 4000 people per annum employed in the river sand harvesting industry in the study area in 1994. This employed number of people has important implications for the circulations of money in the relatively under-developed area.

Off-site impacts were acute in regard to traffic flows. Heavy sand haulage lorries damaged the rural roads and farmland with attendant social and economic costs. Social disruption associated with the influx of miners damage the fabric of local communities and caused unrest through nuisance impacts (dust and noise). As sand and gravel extraction has expanded with the national economy there has been a buildup of traffic moving sand between the river bed and market places.

The increased number of sand haulage lorries had caused increased risk of traffic accidents on Kenyan roads, in additions to hydrocarbon pollution and exhaust fumes. This study found that the total sand harvested had risen to 9.8 Mt by 1994 and confirmed the steady growth in demand for building aggregate, in spite of economic recession in the early 1990’s.

The market value of the 1994 sand harvest was estimated at 850 M Ksh (8.5 M £UK) which was equivalent to 0.2% of Kenya’s GDP (GOK, 1996). It is estimated that in excess of 5,000 workers are connected to the industry, with the majority concentrated in Machakos District.

The overall conclusion of this is that most of the negative impacts (costs) of the sand mining industry are environmental in nature whilst most of the positive impacts benefits of the project are socio-economic in nature and are experienced within and away from the sand source areas.

THE DILEMMAS OF CONSTRUCTION PROJECT MANAGEMENT PRACTICE IN KENYA

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Abstract
While projects differ from industry to industry, the central mission for a construction project is to create a desired facility like a housing complex, a highway or even engineering plants like geothermal and or fertilizer plants. Further, the management of a construction project mission entails multidirectional interaction of dynamic forces represented by time, resources and costs. This therefore calls for competent managers to perform this role.

However, the role of construction project management and construction management discipline particularly in Kenya has not received adequate attention. In this regard, this paper seeks to addresses this gap by inter alia focusing in two objectives. First, is to explore the challenges that are being experienced by both the construction project management and construction management practitioner. Secondly, given the construction project management and construction management roles - examine the industry’s feed on
whether the trained graduates are meeting expectations. Based on secondary data triangulated by an online questionnaire survey, the study establishes that there is not only a clash of roles among the traditionally more established disciplines such as architecture, quantity surveying and civil engineering but the problem is complicated by the absence of a structured scheme of service particularly from the public sector employer. Although there is need to continue improving the skill levels of graduates, the industry is generally satisfied with the performance of this cadre of discipline.

**Key Words:** Construction Project Management, Project Management, Construction Industry.

**EXPRESSION OF INTEREST (EOI) FOR EXHIBITORS/POSTER PRESENTATIONS**

*Sub theme: Construction industry policy development*

*Exhibitor: Eng. Peter Muthuci, Email: whiteheadsolution@gmail.com, Tel: +254788251602*

Relevance to the sub theme

Policy makers in Kenya have raised specific issues with technical designers to come up with affordable housing solutions that:

- Attract many clients including those below the middle class into the formal sector
- Close the gap between monthly mortgage charges and monthly rent.
- Are environmentally appropriate

These important issues to date remain unresolved. Solutions to the above issues require high quality designs resulting in affordable homes with genuine mass appeal. The successful inducement of many new low income clients into the formal housing sector may lead to the transformation of the local construction industry.

I propose to present two exhibits which fully address all three issues, partly by liberal use of time tested sanitary technology. The sanitary fixtures in question are widely available in local hardware shops and come in different types, makes and prices thus offering a wide range of choice.

The first exhibit is a branched system of stairs that transforms an ordinary four bed roomed duplex into a home where all bed rooms are self contained. The Kombo-Y access system will create universally appealing homes conforming to global best practice. The second exhibit is a simple one storey house so configured as to greatly enhance utility. The versatile U house provides four self contained bed rooms, ample neatly enclosed open air space, and excellent possibility to harvest rainwater by roof catchment. This second exhibit is more affordable and can conveniently be put to alternate commercial use. Both designs can easily be used by small families to host single paying tenants, especially students.

Feedback obtained from respondents visiting the exhibition may provide relevant nurture to support the proposed policy direction of availing ample amenities for personal hygiene in all homes. The result would be appropriately conducive living environment for Kenyans.

**THE PIVOTAL ROLE OF DATA IN SUSTAINABLE CONSTRUCTION**

*Author: Julian Dennis Omutoko Otanga (BSc. Civil Engineering-University of Nairobi, Lorient Engineering)*

**Abstract**

The paper looks into how best to make use of available data as a tool for sustainable construction. Data, and in fact research can be used as a transformative tool for the Kenyan construction industry. It's under-utilization locally has denied growth and transformation of local practitioners (consultants, designers and contractors alike).

With appropriate structures and more efficient management of the data, the industry has the potential to provide more sustainable solutions and thus in effect foster development as is done in more developed parts of the globe. In line with the sustainable development goals of 2016 by the United Nations and those recently announced by the Ministry of Devolution in Kenya on 14th September 2016; of key importance to the construction industry is goals:

- Goal 9: Industry innovation and infrastructure
- Goal 12: Responsible consumption and production
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The National Construction Authority (NCA) through its Research Department, with support of industry stakeholders planned ACoRCE 2016. This event would not be successful without mentioning the NCA fraternity who were on hand to accord the conference planning committee the required support. The Board of Directors, the Executive Director and senior management were an integral part of the process. It is also important to acknowledge the stakeholders who came on board as members of the Planning Committee and endured the long planning meetings week in week out. Our sponsors, delegates and exhibitors, we appreciate you.

Delegate Participation

Fig. 1: distribution of conference participants based on employers

Keynote Speakers and presenters

There were 8 sub-thematic areas for which the speakers did present their papers. 12 keynote speakers, of notable influence worldwide more so within the thematic areas, were identified. The keynote speakers who participated in this conference include:

- Arch. Eric Noir, Director, Design for Abundance, South Africa
- Dr. Heather Yates, Dean at the Oklahoma University, United States of America
- Eng. V. K. Rastogi, Director at Stone Technology Center, India
- Qs. Martin Smith, Founder of Viable Computing, South Africa
- Eng. Grace Olukune, Chief Engineer, Power Utility Company, South Africa
- Qs. Moses Nyakiongora, Inspectorate of Buildings, MoLHUD, Kenya
- Dr. Humprey Njogu, KIPPRA, Kenya
- Mr. Kiprono Kittony, Chairman, Kenya Chamber of Commerce and Industry, Kenya
- Dr. Moses Ikiara, Managing Director, KEN investment authority, Kenya
- Eng. Solomon Ouna, Engineer, Kenya Railways, Kenya
- Arch Oliver, Landscape Architect, Kenya Wildlife Service.
- Mr. Tim Hitchens, Athena Properties ltd, Kenya

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Fig. 1: distribution of conference participants based on employers
Conference Proceedings

Upon arrival of the Chief Guest, the Former Ag. CS. Ministry of Lands, Housing and Urban Development the conference delegates were called to order and the session begun.

Speeches

The speeches done during the conference include;

Speech by Steven Oundo OGW, Board Chairman, National Construction Authority,

Good Morning. I'll begin with a short story. An American writer named Morgan Robertson once wrote a book called The Wreck of the Titan. The book was essentially about an “unsinkable” ship called the Titan that set sail from England to New York with many rich and famous passengers on board. On its journey, the Titan hit an iceberg in the North Atlantic and sunk. Many lives were lost because there were not enough lifeboats.

The question now would be: what is unique about this? Well, the Wreck of the Titan was written 14 years before the Titanic sunk, and would prove to be a prophesy of doom.

Research and development are critical for planning, be it for identifying potentially fatal flaws in what everyone thought was an unsinkable vessel or generation of new ideas and innovation, which can be commercialized for socio-economic prosperity. Indeed, all world-class companies have large and effective research and development units (popularly referred to as R and D) which help them remain relevant, competitive and above all, profitable.

An example would be Google, IBM and Apple, some of the world's leading companies, especially when it comes to innovation. Any entity, I think we would all agree, is as good as its research and development wing.

The same applies to the construction industry. In order for us to build better, cheaper, faster more durable and quality structures, we must carry out research. Construction industry research should aim at improving quality of the built environment, timeliness of project delivery, and affordability. In this instance when we refer to the built environment, we mean buildings and infrastructure, inclusive of roads, bridges, dams and even irrigation systems.

Construction industry research also plays a critical role in risk reduction and management, which in the long run saves both money and lives. Good research would help the sector remain competitive, as it

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Fig. 2: distribution of conference participants based on areas of interest
would be always be a step ahead. Why are structures collapsing? Is it because of substandard materials? Use of unskilled labour? Are the professionals in the industry playing a role in the same? If so, what can we do to remedy the situation? All these questions and more are all answered with research.

The National Construction Authority takes research with the due seriousness it deserves, and today’s forum is a testament to this. Today, we bring together the most critical stakeholders in the industry to share ideas and how to move the industry forward using research as the most effective tool.

I urge everyone today to become a researcher in whichever capacity you can. Whether it is reading and collecting articles on certain topics or meeting to discuss ideas you may have, the idea is to keep moving forward and to continuously improve and build on what we have. And that, ladies and gentlemen, begins today.

Thank you.

Speech by Principal Secretary, Ministry of Lands, Housing and Urban Development (MoLHUD), Arch. Mariam Elmawi

Good Morning. It is always a pleasure to be amongst like minds, and today, we are hosting some of the best and brightest when it comes not just to construction in general, but construction research.

Research is of course the backbone of any entity, industry or nation that chooses to stay ahead of its time. I’ll give the example of Dubai. A previously oil-rich emirate, the city leaders realized that eventually, their much valued mineral would run out, and they would need an alternative source of sustenance. Today, Dubai’s spectacular cityscape boasts the world’s tallest building, and it has emerged to become a global city and business and tourism center, soon to house the world’s largest mall.

Dubai is also firmly established as a major transport hub, bringing in millions to the economy. All of these impressive development projects are all construction-based. In order to attract tourists, we need to build bigger and better resorts. In order to boost our financial viability, we need to have a fully developed infrastructure to attract business. In order to explore our natural resources, we need to excavate. And if the developments projects are construction based, then they are certainly research based.

In 2015, we are blessed with resources at our disposal that were almost unheard of in previous years. Cutting-edge research methods mean that we can now achieve results faster and in more dynamic ways. In the Ministry of Land, Housing and Urban Development, we have developed more than 43,000 units since just after independence, including estates such as Ayany, Kyuna, Uhuru Gardens, Kibera Highrise, Jonathan Ng’eno, Nairobi West, Madaraka and Kileleshwa in Nairobi. Kenya is currently experiencing a housing deficit of 150,000 units, and we are working towards meeting this gap.

One way of doing this is by utilizing new construction technology that greatly lowers both the cost and time of building, allowing us to deliver new homes to our citizens as fast as possible. An example of this is the Police Staff Quarters in Ruai, built using expanded polystyrene panels. Another instance of research working towards uplifting the industry.

In the backdrop of all this on-going construction, we also have to be conscious of our environment and how much of a carbon footprint we are leaving. Researchers are coming up with more and more green materials to be incorporated in construction, and even the aviation industry is now embracing biofuel as a viable alternative to fossil fuel.

I’m happy to note that the Kenya Green Building Council is represented at this forum, as we continue to work towards a green building rating in the country, to extend even further to all aspects of the industry.

In conclusion, research is inextricably linked to development, which is what we all want to achieve. I applaud NCA for conceptualizing this forum, and I have full confidence many great ideas will be borne from this.
I wish us all a fruitful conference.

Thank you.

Speech by Ag. Cabinet Secretary, Ministry of Lands, Housing & Urban Development (MoLHUD), Dr. Fred Matiangi

Good Morning. What a pleasure it is to officially open the First Annual Construction Research Conference and Exhibition, a first of its kind not just in Kenya but in the region. Research, the systematic investigation conducted in order to unearth new information and draw new conclusions, is undoubtedly critical when it comes to the construction industry.

As we enter the Second Medium Term Plan of Kenya’s Vision 2030, the country is focusing on developmental milestones that are set to propel us into the middle-level economy status, and construction is center stage in all the pillars. Under the Economic Pillar, there is mining, now more concentrated on oil, gas and the exploration of minerals. Under Agriculture and Livestock, there is irrigation, with measures being taken to mechanize agricultural production.

Under the Social Pillar, the government aims at increasing access to education for all, which means more schools are going to be built. The industry is also experiencing a boom in the energy, water, infrastructure and housing sectors. These are just a few examples, but they all involve elements of construction.

As an industry, we have been experiencing setbacks with regards to collapsing structures, a regrettable and wholly avoidable occurrence. In accordance with the Rules under the Occupational Health and Safety Act of 2007, any workplace, inclusive of a construction site, with twenty (20) or more regular workers is required to have a health and safety officer. I am working closely with my colleague in the Ministry of Labour to enforce this; I am recommending that from now henceforth, this will be added to the National Construction Authority’s quality assurance checklist whose contravention will lead to the suspension of construction works.

In order for us to keep growing, we not only have to comply with the law, but also find faster, smarter, bigger and better ways of doing things, and that is all supported by research. Our government has already put in place plans to roll out the 10,000 kilometer roads project through annuity financing. The first phase of this, covering 3,000 kilometers of road, commences in the next few weeks. In addition, the 5,000-megawatt power project that was launched almost two years ago is well underway, with new power stations already commissioned.

Not forgetting the Standard Gauge Railway that is set to transform our infrastructural sector upon completion. The question of how research comes in can be answered through capacity building and innovation: as a nation, we need the labour force to undertake the construction projects, and we need to find inventive methods that conserve energy, preserve the environment and cut costs while undertaking the said projects. For example, as part of the 5,000 megawatt project, we have secured funding to build a 50-megawatt solar plant in Garissa, taking advantage of the natural and readily available solar energy.

Current innovations being explored in the industry include the use of sustainable construction materials and technologies being used to construct buildings, roads and other infrastructure projects due to their durability, low cost and environmental friendliness amongst other various benefits.

Other than material technologies, the industry is also embracing the use of ICT in construction, for example Viable Software, a program useful in analyzing the economic or financial viability of infrastructure projects. Another example is Building Modelling Information Systems, an intelligent model-based process that provides insight to assist in the planning, design, construction and management of buildings, and in turn changing the face of the industry.

In the finance and procurement side of construction, more governments are embracing the Public-Private Partnerships, popularly known as PPPs, as alternative project financing initiatives, which is greatly benefitting infrastructural development.

In essence, we are at a time of great innovation and
change, both rooted in research. Forums such as this one provide a meeting of the minds that can only lead to collaborative efforts that further the cause of construction in the country.

I take this opportunity to appreciate The National Construction Authority for organizing the conference and for bringing us together under one meeting, which I trust is only the beginning of even greater things. I urge us all to approach it with an open mind, and to garner as much as one possibly can because you never know; an idea that sparks here today could change the lives of many tomorrow.

Thank you.
The Automatic Brick Layer is a machine that lays bricks to a prescribed blue print by the click of a button. It is a technological masterpiece that performs the duties of a brick mason to millimeter accuracy in similar fashion as a three dimensional printer works.

Construction in Southern Africa today is booming but marred by enormous challenges. Most of these problems are related to quality issues, affordability to most lower classes of the societies, availability of the current sustainable and green construction technologies, and Africa’s inability to understand and develop its own solutions. This machine will enable construction companies to mass construct affordable buildings in record time with accuracy. Governments will also be able to meet the challenges of poor housing at reasonable cost without most problems that accompany poor workmanship.

Keywords, Automatic Brick Layer, technologies, robots, programming Researcher Motivation .

The interest in automating bricklaying tasks comes as a result of cutting edge technological possibilities and the saddening absence of qualified personnel likened to the enormous demand for affordable housing. Some key features of automating bricklaying tasks are; high usability, support for multimedia services at low cost, personalization and integrated services.

Robotic Technology

A system in which autonomous robots assemble three-dimensional structures out of concrete blocks and a fixed set of local control rules is discussed in which blocks are inert and indistinguishable.

Automating construction could facilitate endeavors such as the production of low-cost housing, and alleviate problems such as high accident rates reported with traditional construction. Automation would be particularly useful in settings where human presence is dangerous or problematic. For instance, robots could be sent to build habitats in extraterrestrial environments, to await later human travelers. Similarly, robot construction systems might be especially well-suited to underwater settings, where human building activity is difficult, but the environment has advantages such as effective weightlessness and mobility in three
dimensions; conceivably their use could one day even open up the oceans for colonization. This work is complementary to previous research such as issues related to construction, such as inter-robot communication or debris cleanup. These studies are focused on the problem of building a particular desired structure given a high-level description.

**Robot Programming**

Sensors are used for different purposes in robot programs; each purpose has a separate impact on the system design. The principal uses of sensing in robot programming are as follows: initiating and terminating motions; choosing among alternative actions; obtaining the identity and position of objects and features; and complying with external constraints. The most common use of sensory data in existing systems is to initiate and terminate motions. Most robot programming systems provide mechanisms for waiting for an external binary signal before proceeding with execution of a program.

This capability is used primarily to synchronize robots with other machines. Motion specification for the automatic bricklayer requires: A coordinate frame in which the force sensor reading are to be resolved, known as the constraint frame; the desired position trajectory of the robot. This specifies the robot's nominal position as a function of time; and stiffness's for each of the motion freedoms relative to the constraint frame. For example, a high stiffness for translation along the x-axis means that the robot will allow only small deviations from the position specified in the trajectory, even if high forces are felt in the x direction. A low stiffness, on the other hand, means that a small force can cause a significant deviation from the position specified by the trajectory.

The specification of a compliant motion for inserting a concrete block in place in a stretcher bond is as follows: The insertion motion will be a linear displacement in the positive z direction, along the wall axis, to a position where the joint of the lower blocks is exactly in the middle of the block being inserted and this becomes the final destination of the block.

The stiffness's are specified by a matrix relating the Cartesian position parameters of the robot end effect or to the force sensor inputs. $f = [K][A]$ where $f$ is a 6 X 1 vector of forces and torques, $K$ is a 6 X 6 matrix of stiffness's, and $A$ is a 6 X 1 vector of deviations of the robot from its planned path.

While inserting a block in position, the constraint frame should follow a trajectory straight down the middle of the block to the joint in the lower course, but complying with forces along the x- and y-axes and with torques about the x- and y-axes. The stiffness matrix $[K]$ for this task would be a diagonal matrix $[K] = diag[ko, ko, kl, ko, ko, kl]$ where ko indicates low stiffness and kla high stiffness. The complexity of specifying the details of a compliant motion argues for introducing special-purpose syntactic mechanisms into robot languages.

**Components of the Automatic Bricklayer**

The machine has the following major components: Control systems, mortar feeder and storage, brick dispenser, exterior shape/form and frame, and convenient innovations. These components are discussed below:

**Control Systems:**

The automatic bricklayer works in line with all construction techniques. Reprogrammable electronic circuits perform a critical role in making possible automation in construction. This serves as the brain of the machine. Mechanical links also make it possible for high logic tasks to be executed in line with bricklaying principals.

**Mortar Feeder and Storage:**

his part of the robot incorporates a mechanical brick trowel which is the ‘main stay’ of any bricklaying operation; coming in a range of sizes from around 3 to 13 inches whose length is measured along the underside of the blade has been built-in. The machine is capable of
doing pointing tasks and ensures that the mortar has the correct amount of moisture. When bricks have been laid in place the trowel will be useful for finishing mortar joints. A thin layer of oil is run over the blade to stop any rusting effects when not in use.

**Brick Dispenser:**

This component covers the entire process from the time a brick is collect to the time it is finally placed. A cutter either cut a block in half or in the ratio of one-to-three parts where necessary. In the process of brick laying using this robot valuable time is recovered in that no building lines have to be mounted since the it has capabilities of building in space.

Hydraulic Hammer is used in conjunction with a bolster and or cold chisel. It has a range of other uses were it is necessary to knock things down or smaller demolition jobs.

Spirit Level technology has also been adapted and levels are taken automatically including distance measurement. A Builder’s Square on many occasions is needed to ensure that the walling is square at the corners. Accuracy relies on these functions each time it will be used. For the brickwork project to pass the quality test it needs to be: upright or vertical; level or horizontal over the full length of the walling and be in line across the diagonals i.e. from corner to corner.

These elements are achieved by paying attention to Plumbing, Leveling and Gauging. At the moment the robot can only make a stretcher bond.

**Exterior Shape/Form and Frame:**

The guiding principal here is that form follows function. Thus, the overall shape is the sum total of the individual components. The robot comes with an incorporated scaffolding system that serve as a temporary storing base masonry (bricks/blocks) as well as a fixed support to the rest of the automatic brick layer.

**Convenient innovations:**

Any computer aided drafting CAD can be used provided the plans are complete. Tables and schedules of work in terms of hours and the number of blocks/bricks that is laid can be accessed using touch sensitive led screens. Conclusion In this paper briefly outlined the background and the possible realization of the Automatic Brick Layer.

It has been done to alleviate the enormous challenges faced by the boom in construction for most African states. Most of these problems are concerned with quality issues, affordability to most lower classes of our societies, availability of the current sustainable and green construction technologies, Africa’s inability to understand and develop its own solutions.

The Automatic Brick Layer will enable our communities to meet most of the above problems by the click of a button. It is a machine that lays bricks to a prescribed blue print by the click of a button. It is a technological masterpiece that performs the duties of a brick mason to millimeter accuracy in similar fashion as a three dimensional printer works. This research focused on transforming the Construction Engineering and Management that has been lagging behind. This technology should be accessible by most small business owners and individuals. Construction companies and Governments can now mass construct affordable buildings in record time with accuracy. Selected

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Forensic Study of Building Failures in Nairobi County

Bullutt, Biwott Lawrence; Moses, Onyango Opiyo; Omosa, Isaiah

This paper assesses the cause of structural failures in Nairobi County and its environs. There are several factors that might lead to the collapse of buildings but the research only focused on one. Reinforcement was the only factor considered for the structural analysis. The occurrence of structural failures either partial or total offers an opportunity for a forensic study to be conducted.

This paper assesses the cause of structural failures in Nairobi County and its environs. There are several factors that might lead to the collapse of buildings but the research only focused on one. Reinforcement was the only factor considered for the structural analysis. The occurrence of structural failures either partial or total offers an opportunity for a forensic study to be conducted. The studies are aimed at providing expert witness services for court proceedings or for research into the causes of structural failures. In this paper, the key aspects of failure considered were the reinforcements used in the collapsed building.

A case considered for this study is the collapse of a building under construction in Kiambu (2009). Structural analysis was performed on a frame of the building developed in a CAD environment. Concrete strengths considered for the design was 20N/mm2 and the designs were done based on BS8110. The implication of this paper is that reinforcement is an important factor in the strength of a structure but not a factor that causes failure in every case.

Key Words, BS8110, Forensic, collapse building

Introduction

Partial and total collapse of structures and buildings has been experienced in the last decade. The construction industry being an economy driver every disaster affects certain quarters of the population. Particularly Nairobi County and its environs have had a majority of the collapses. With a fast-growing real estate sector, there is a need to learn from the past disasters and move forward with proper construction technologies. Every collapse should be investigated and the knowledge be used for litigation or for further research. With the current trend, there is likelihood that other buildings might collapse if no proper strategies are applied to learn from the previous failures. Forensic structural engineering is the engineering investigation and determination of the causes of structural failure in buildings, bridges and other infrastructures as well as rendering expert opinions and giving testimonies in judicial proceedings. A structural failure is an
Structural forensics provides a great frontier for investigating building failures and applying the engineering principles in the investigation process. It provides diagnostic procedures and proper recommendations to the investigating body for further action. A forensic engineering study helps in pointing out the deficiencies in supervision and the construction techniques that are unsuitable.

In addition to the other methods of investigating the failure of building collapse the method considered here was structural analysis and studying of reports from the collapse. Assumptions are made considering the lowest strength of concrete recommended for structural elements. The analysis was performed considering that during construction the strengths were achievable. Reinforcement was the factor considered during the structural analysis. Table 1 presents a list of collapsed buildings and the casualties.

### Research Methods
Report of the collapsed building was obtained and used to provide the basic information of the building history and the site investigations conducted after the collapse. The reports provided key data on the site immediately after the collapse and a few weeks later when the investigation was conducted. The histories of building collapse are documented in the print media and other reports either carried out by the CID or the police. Documentation proved to be a very important tool in providing information on the possible causes of collapse. This formed a basis for the research to be conducted on the building in a software environment. The observation method provided photographs showing the state of the collapse building immediately after collapse. From some of the photographs it was difficult to establish clearly the collapsed members. Photographs taken from other collapsed buildings also showed the conditions of the reinforcement that was provided for the structural members. For the Kiambu building the pictures showed the aftermath of the collapse and also indicated which sections collapsed completely. The photographs also indicated the effect of the collapse on the adjacent buildings. In forensic engineering studies the photographs are key components of the investigation process.

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<tr>
<th>Description</th>
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<td>Kisii Collapsed Building at Kisii district</td>
<td>6/6/2009</td>
<td>1 dead</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 hospitalized</td>
</tr>
<tr>
<td>Ronald Ngala Junction building</td>
<td>23/9/2006</td>
<td>14 dead</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Several injured</td>
</tr>
<tr>
<td>Comcraft House in Nairobi City</td>
<td>16/09/2008</td>
<td>None</td>
</tr>
<tr>
<td>Kiambu Town Buildings</td>
<td>19/10/09</td>
<td>Dead – 16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Survived with injuries – 16</td>
</tr>
<tr>
<td>Building in Pipeline Estate, Embakasi</td>
<td>14/06/11</td>
<td>4 – dead</td>
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<tr>
<td></td>
<td></td>
<td>14-Unaccounted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Many injured &amp; hospitalized</td>
</tr>
<tr>
<td>Nyeri, Skuta estate</td>
<td>18/11/2014</td>
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<td>Makongeni</td>
<td>17/12/2014</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>11 injured</td>
</tr>
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<td>Haruma estate</td>
<td>4/1/2014</td>
<td>5-dead</td>
</tr>
<tr>
<td></td>
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</table>

*Source: Author (2009)*
In this case the photographs showed the extent and the disintegration of the concrete materials. Photographs form the evidence that can be used for court proceedings or for litigation purposes. Figure 1 presents collapsed building in Kiambu in 2009.

**Structural analysis**
The model of the Kiambu building was drawn and analyses for the member forces in STAAD PRO and the structural analysis performed. Samples of the members were selected for structural analysis based on limit state analysis and the reinforcement was checked for adequacy. The anticipated loadings were factored for the design. A minimum concrete strength of 20N/mm² was adopted for the design of the structure. The obtained reinforcement was the checked against the provided reinforcement.

**Results and Discussion**
The documentation from the collapse of the building in Kiambu in 2009 and other buildings that have collapsed in the last decade showed that most buildings did not have approved structural drawings. It indicated a challenge in the prosecution process and litigation exposing the rot in the construction industry.

Figure 1 presents collapsed building modeled in STAAD PRO.

Fig. 2: Collapsed building modeled in STAAD PRO
Source: Author (2009).
Witness accounts that were documented showed that the members were not given enough time to set. Photographs showed the disintegration of the concrete and how separation of the aggregates and the sand occurred. It indicated that there was insufficient cement in the concrete mix or the batching was not done right.

Structural analysis showed that the reinforcement provided on the sampled structural members were sufficient at a concrete strength of 20N/mm². Thus reinforcement was sufficient for the designed forces. On the slabs with a factored load of 18.72KN/m² after the design and selection of the reinforcement it was sufficient to resist the generated moments and the shear forces.

The reinforcement that was provided for the slabs that collapsed was sufficient with the assumed concrete strength of 20N/mm². The beams after analysis in STAAD PRO the moments generated were used for the design. The beam design was done from support to support considering the hogging moments generated. A beam on the 4th floor was selected for design. After reinforcement selection and concrete strength of 20N/mm² the reinforcement was sufficient. Figure 3 presents bending moment diagram of a beam section from STAAD PRO. The reinforcement that was provided for the beams during construction was sufficient. The columns analyzed also showed that the reinforcements provided were enough to support the axial loads. Columns were also analyzed from floor to floor and the reinforcement provided initially was checked for sufficiency. Foundation design was also done but with assumed site conditions.

It was noted that the reinforcements were sufficient but site investigations were not sufficiently done for the foundation design. Conclusion The reinforcement provided for all the structural members were sufficient with minimum concrete strength of 20N/mm². Therefore reinforcement inadequacy was not the cause of the building collapse. The concrete quality was the cause of the building failure.

The concrete strengths at the site were investigated and found out to be 8N/mm² instead of the minimum recommended strength of 20N/mm². Insufficient time was given for the curing of the concrete members, which lead to the lower strengths. Poor concrete workmanship is attributed to the many building failures in Nairobi and Kenya in general. A shorter period for curing is given to the structural members and floors are erected before enough time for curing.

More efforts should be put into the supervision of concrete batching and casting.

Selected Bibliography


Women in Kenya have made tremendous inroads in predominantly male-dominated careers and businesses. The Kenya Government on its part has played a part in the pursuit of job equality for all. Women are involved directly and indirectly in the construction sector as importers, distributors and sellers of construction equipment and materials; in all areas of actual construction like road building, bricklaying, concrete mixers, tiling, painting and the like; and, as property developers and sellers.

However, despite this good intention, women continue to face serious challenges in a society that still has traditional gender demarcations in roles and responsibilities. This paper attempts to profile the obstacles and opportunities that women face in the construction industry. Interviews, desktop research and previous research have been used to compile and articulate factors that have led to this dire situation.

This paper recommends the following multi-faceted strategies to increase women participation in the construction industry; active promotion of construction careers, provide scholarships for women entering or advancing in construction careers, encourage women apprenticeship, partner with communities to fund short-course programs and child care centres and provide mentorship and ongoing employment support.

Further, the study recommends establishment of a standardized policy for worksite inspections, and mechanisms to address bullying, harassment and violence; and development of indicators to track the number of women hired and retained by employers.

Finally, the article recommends expand technical advice and build on successful women role models, offer technical assistance in recruitment and retention to employers and unions, enforce and update non-discrimination and affirmative action rules and increase research and communicate the findings on women working in construction.

Key words, Construction industry, women, gender discrimination

Introduction
Women in Kenya have made tremendous inroads in predominantly male-dominated careers and businesses in both the public and private sectors. The Kenya Government on its part has taken measures in pursuit of job equality. Women are involved directly and indirectly in the construction sector as importers, distributors and sellers of construction equipment.
and materials; in all areas of actual construction like road building, insulators, cabinetmakers, painters/decorators, tile-setters, floor covering installers, bricklaying, mixing, painting and the like; and, as property developers and sellers (The Smith Institute, 2014; GoC, 2010). However, despite this context, women continue to face serious challenges in a society that still has engraved traditional gender demarcations in roles and responsibilities.

In traditional African societies women were responsible for gathering roofing materials for house construction (Lowe, 2014). They fetched water to mix with soil, with the mixture being used to construct walls. Roofing was mainly done using grass, which is not a durable building material especially during heavy rainfall. This was a tedious and time-consuming activity. The advent of land consolidation and cash cropping resulted in less usage of thatching grass and the consequent introduction of alternative materials such as iron sheets and bricks.

New building construction materials and emerging construction methods, however, brought in a masculine image requiring physical strength, long-time shifts, poor working conditions, poor work relationships and basically a macho culture. This made both men and women reluctant or uninterested to join the industry, with women being affected more (Bennett, Davidson & Gale, 1999; Fielden et al., 2001). Women represent only 2% of the global labour force in the construction sector (The Smith Institute, 2014). The trend is similar even in the developed world. For example in the UK, women constitute around 11 percent of the workforce in the construction sector and as little as one percent of the manual trades (The Smith Institute, 2014). The Smith Institute further notes that there appears to be little concern in large parts of the industry about this low level of female employment, and only modest attempts to remedy it.

Furthermore, the UK Office for National Statistics observed that numbers of women who work as roofers, bricklayers and glaziers were so low as to be immeasurable in its recent national survey. Likewise, a report by The Construction Sector Council acknowledged that in Canada women constituted 12.6% of the Canadian construction industry workforce in 2006, but the rate of their employment (4%) in the construction trades was much smaller (GoC, 2010).

The construction industry is of immense economic importance as it contributes 10% of the Gross Domestic Product (GDP) in developing countries (UNDP, 2010). The industry consumes about one-sixth to half of the world’s wood, minerals, water, and energy and generates employment and income in a variety of technologies and practices on different scales, (UNDP, 2010).

For example, in 2011, the Nairobi City Council registered an 11.8% increase in private building works (ROK, 2012). Further about 109,000 people were employed in the construction industry which contributed 4.1 percent of the GDP in 2011 (UNDP, 2010). Overview of Women Representation

Amaratunga et al. (2006) opine that the poor image of the industry, inadequate career knowledge, inhibitive culture and working environment, family commitments, male dominated training courses and unfair recruitment practices have been major barriers to women in construction.

Whilst women may be entering the general workforce in increasing numbers, they remain concentrated in some sectors such as education, health and service sectors, like banking, insurance and the retail trade. In contrast, women have continued to be under-represented in construction, technical and engineering sectors which are stereotypically regarded as male occupations (Clarke & Wall, 2014).

Underrepresentation of women is also observed in trade union membership and leadership levels, which the International Labour Organization (ILO) views as a crucial area of strengthening inclusion in social partners (Tshabalala, 2005). In Kenya, the Central Organization of Trade Unions (COTU) has set the goal of attaining a threshold of 30% female trade union leaders. COTU collaborates with other unions in the region to promote gender equality within the labour movement (Tshabalala, 2005).

This paper attempts to profile the obstacles and opportunities that women face while working and
doing business in the construction industry. The goal is to assess these in a scientific way using a recognized change model—the Lewin Change Model. Interviews, desktop research and previous research have been used to compile and articulate factors that have led to a dire situation in women integration. The study also gives recommendations on how the issues mentioned can be resolved.

According to the Economic Survey 2014 the construction industry registered the highest increase in private sector employment with a growth of 13.5 per cent in 2013, providing 13,300 new jobs (KNBS, 2014). Table 1 presents the Kenya labour market profile for the year 2013.

The table below highlights participation by the women in Kenya. It indicates that women in Kenya will mostly be found in agriculture (54%), trade, restaurants and hotels (54%), transport and communications (48.5%) and Public administration and Services (44.8%). There is however low employment of women in construction (2%), electricity, gas and water (15.6%) and finance, real estate and business services (30.7%).

Further, the insufficient training in technical skills for women is a barrier to running their own firms and enterprises successfully, obtaining better-paid jobs and having a better bargaining power (Tshabalala, 2005). Even where they are a majority, in the agricultural estates women hold at low levels of work and very rarely attain management positions (FKE, 2013).

Table 2 presents gender distribution of employment and the total earnings from each sector for the year 2012 and 2013. The figures show that out of the five top earning sectors, there is low employment for women in three of them (manufacturing, construction, and finance and insurance services). Further, although there are a high number of women employed in the remaining two top earning sectors (agriculture and transport and storage), nonetheless a significant number of them have lower earnings than their male counterparts. In agriculture, for example, a significant number of women will be found in peasant farming where they earn meager incomes (Burnes, 2004). The table below highlights participation by the women in Kenya. It indicates that women in Kenya will mostly be found in agriculture (54%), trade, restaurants and hotels (54%), transport and communications (48.5%) and Public administration and Services (44.8%). There is however low employment of women in construction

<table>
<thead>
<tr>
<th>Sector</th>
<th>Male Employment</th>
<th>Female Employment</th>
<th>GDP share per sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining and quarrying</td>
<td>872</td>
<td>255</td>
<td>0.8%</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>330,653</td>
<td>118,183</td>
<td>11%</td>
</tr>
<tr>
<td>Electricity, gas and water</td>
<td>18,581</td>
<td>3,440</td>
<td>2.7%</td>
</tr>
<tr>
<td>Construction</td>
<td>295,390</td>
<td>5,697</td>
<td>4.9%</td>
</tr>
<tr>
<td>Trade, restaurants and hotels</td>
<td>796,359</td>
<td>937,188</td>
<td>14%</td>
</tr>
<tr>
<td>Transport and communications</td>
<td>360,430</td>
<td>336,545</td>
<td>11%</td>
</tr>
<tr>
<td>Finance, real estate and business services</td>
<td>95338</td>
<td>42,148</td>
<td>12%</td>
</tr>
<tr>
<td>Public administration and Services</td>
<td>992,656</td>
<td>806,564</td>
<td>18%</td>
</tr>
<tr>
<td>Agriculture</td>
<td>3,535,092</td>
<td>4,169,458</td>
<td>26%</td>
</tr>
</tbody>
</table>
(2%), electricity, gas and water (15.6%) and finance, real estate and business services (30.7%). In sectors like agriculture and trade, restaurants and hotels where women employment is higher, for example, they participate in low-cadre jobs due to significant structural barriers, gender discrimination by employers, and training that provided them with insufficient technical skills to enable them perform in the workplace (Mbarika et al., 2007). Further, the insufficient training in technical skills for women is a barrier to running their own firms and enterprises successfully, obtaining better-paid jobs and having a better bargaining power (Tshabalala, 2005). Even where they are a majority, in the agricultural estates women hold at low levels of work and very rarely attain management positions (FKE, 2013). Table 2 presents gender distribution of employment and the total earnings from each sector for the year 2012 and 2013. The figures show that out of the five top earning sectors, there is low employment for women in three of them (manufacturing, construction, and finance and insurance services). Further, although there are a high number of women employed in the remaining two top earning sectors (agriculture and transport and storage), nonetheless a significant number of them have lower earnings than their male counterparts. In agriculture, for example, a significant number of women will be found in peasant farming where they earn meager incomes (Burnes, 2004).

Kenya is one of the 108 member states who are signatories to the Millennium Declaration of September 2000 which adapted eight goals that aim to tackle identified development challenges by 2015, and whose third goal was to promote gender equality and empower women (UNDP, 2010).

It is for this reason, and the search for Equal Employment Opportunity interests, that this study is based. There is a great dearth of academic and empirical research on women in construction in Africa, with most of the literature coming from government and institutional reports. This research attempts to review available national and global literature to add to the existing body of knowledge. The research also gives

<table>
<thead>
<tr>
<th>Sector</th>
<th>Male Employment</th>
<th>Female employment</th>
<th>total 2013</th>
<th>total 2014</th>
<th>Earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining and quarrying</td>
<td>7.3</td>
<td>1.7</td>
<td>128.9</td>
<td>346.7</td>
<td>2,045.5</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>192.8</td>
<td>78.1</td>
<td>30.7</td>
<td>9.4</td>
<td>66,360.9</td>
</tr>
<tr>
<td>Electricity, gas steam and air conditioning</td>
<td>10.3</td>
<td>4.0</td>
<td>14.3</td>
<td>14.7</td>
<td>1,041.4</td>
</tr>
<tr>
<td>Water supply, sewerage, waste management</td>
<td>5.6</td>
<td>2.9</td>
<td>8.5</td>
<td>9.5</td>
<td>167.0</td>
</tr>
<tr>
<td>Water supply, sewerage, waste remediation</td>
<td>62.2</td>
<td>13.0</td>
<td>75.2</td>
<td>76.4</td>
<td>47,686.0</td>
</tr>
<tr>
<td>Finance and insurance services</td>
<td>33.8</td>
<td>27.8</td>
<td>61.6</td>
<td>67.0</td>
<td>64563.4</td>
</tr>
<tr>
<td>Public administration and Services</td>
<td>133.5</td>
<td>73.9</td>
<td>207.4</td>
<td>217.8</td>
<td>N/A</td>
</tr>
<tr>
<td>Education</td>
<td>220.8</td>
<td>164.0</td>
<td>384.8</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Agriculture, forestry and fishing</td>
<td>209.9</td>
<td>127.8</td>
<td>337.7</td>
<td>53,822.1</td>
<td>62,821.3</td>
</tr>
</tbody>
</table>

Table 2: Wage employment by industry and sex, 2012 and 2013
Source: KNBS (2014).
recommendations based on the Kurt Lewin change theory with the premise that change will be necessary if women have to be fully integrated to the construction sector.

The research intends to stimulate debate as well as arouse the conscience of policy makers and implementers to a subject that has not been tackled as robustly as it should given its importance.

Theoretical framework for change
There are numerous models that have been advanced to describe the change process. Some of the best known include those developed by Lewin (1951), Beckhard (1969), Quinn (1980), Nadler & Tushman (1980) and Bandura (1977).

This study will employ the Kurt Lewin’s change model to explain why and how change should happen in order for more integration of women in non-traditional careers. Lewin identified three basic mechanisms for managing change;

**Unfreezing:**
The first phase in the process of change is to unfreeze the existing situation. Lewin believed that the stability of human behaviour was based on a quasi-stationary equilibrium supported by a complex field of driving and restraining forces. He argued that the equilibrium needs to be destabilized (unfrozen) before old behaviour can be discarded (unlearnt) and new behaviour successfully adopted (Burnes, 2004).

This phase therefore involves deliberately altering the status quo that supports existing behaviours and attitudes. To do this will require deliberating on the threats that change is likely to bring and the need of motivating the people to attain the natural state of equilibrium through accepting that change is necessary (Armstrong, 2009). The phase also involves developing a compelling message on why things cannot go on like before. Also involves challenging beliefs, values, attitudes and behaviour, actions that are most difficult and stressful. Like before. Also involves challenging beliefs, values, attitudes and behaviour, actions that are most difficult and stressful.

**Changing:**
This phase involves moving from a less acceptable to a more acceptable set of behaviours (Burnes, 2004). Something new takes place in the system, and change is actually implemented. It involves developing new responses based on new information gathered to steer the change process (Armstrong, 2009). Here people begin to believe in ways that support the new direction. However change needs to be introduced gradually as some people will be genuinely hurt by it. Other people may resent the change as it disrupts what they already know. To be successful in the change process, this phase requires superior communication, negotiation and persuasive skills.

**Refreezing:**
This final phase seeks to stabilize the change in order to ensure that the new behaviours are relatively safe from regression (Burnes, 2004) and to create the necessary conditions for its long-term continuity. It involves solidifying the change by introducing new responses to those involved in the change effort. This stage requires organization to internalize and institutionalize the new direction, while some cultures and behaviours have to be remodeled to accommodate change. Organizations need to celebrate any minor or major successes achieved so as to help people find closure and the understanding that the change was worth the effort.

Lewin also suggested a methodology for analyzing change which he called field force analysis' and that involves: analyzing the restraining or driving forces that will affect the transition to the future state; these restraining forces will include the reactions of those who see change as unnecessary or as constituting a threat; assessing which of the driving or restraining forces are critical; and taking steps both to increase the critical driving forces and to decrease the critical restraining forces.

**Results and Discussion**
This section discusses the status of women in the construction industry in Kenya. It is structured along Lewin’s 3-step change model. The section identifies obstacles in dealing with the integration of women into the construction industry (Freeze stage), what needs to be done to rescue this situation (Change stage) and gains that have been made so far and which needs
to be institutionalized (Refreeze) in the system in Kenya.

**Freeze**

In this stage a discussion is made based on research from around the world in general and in Kenya specifically.

**Construction Industry’s image:**

The predominant perception of the construction industry in that it is a male-domain requiring brute strength and tolerance for outdoor conditions, inclement weather and foul language. It is also perceived to promote adversarial business relationships, poor working practices, environmentally insensitivity and has a reputation for under performance (Davis, 2014). This image discourages both men and women, with the latter being more affected.

**Knowledge of the career options:**

There is a general lack of knowledge and information about the construction industry, the career opportunities the industry offers and the qualifications required for employment (Fielden et al., 2001). Kenyan parents, teachers and school children believe that the jobs in construction industry are limited to bricklaying, joinery, painting and decorating (Fielden et al., 2001). Further, teachers, parents, career advisors and students have only a vague, superficial knowledge of the industry. This means that a significant number of women do not know of the options available and cannot therefore make informed choices (Ngure, 2013). In Canada as in most other places, half of the young women aged 18 to 34 who were surveyed by the Construction Sector Council in 2010 had never received information about careers in construction trades or management (GoC, 2010). Most of those who indicated that they might consider such occupations had parents or older siblings already in the trade. Conditions of work: The construction industry work conditions affect the outcomes of women more than those of men for various reasons, including: inadequate equipment at the workplace, making work more physical and difficult to do; strenuous employment conditions; long working hours; discriminatory recruitment and selection practices; inflexibility; limited areas of work; lack of training; the persistence of a macho culture; and short-term concerns with output (Graft-Johnson, Manley & Greed, 2003; Lowe, 2014).

**Lack of role models:**

Females in Kenya lack role models in the construction. The few women who persist and enter the industry feel alienated, discriminated and downgraded as their physical features and gender are used against them (Ngure, 2013). This is especially critical in technical, construction and engineering courses, and in certain courses trainers show open bias against women (UNDP, 2010).

**Culture and Environment:**

Many Kenyan cultures have role delineation between the different genders. In most cultures, construction is more perceived to be aligned to men than women. Women who are attracted to the construction industry face stereotypical barriers and expounded, just like women in other male-dominated sectors (Amaratunga et al., 2006). Even when they enter the industry women are expected to behave like men, or be contented with unimportant roles where they tend to fill technical specialist positions rather than general managerial posts. Culture also dictates what kind of businesses different genders engage in. In Kenya a majority of MSE’s are owned by women, are operated from the home, and are confined to a limited number of trades and services, which include tailoring and dressmaking, and hospitality (Ngure, 2013). To the contrary, men are concentrated in repair services, metal-based manufacturing, construction, carpentry and joinery.

**Family Constraints:**

In general women are the primary caregivers and therefore work-family conflict is more acute
for women than for men. This is more visible in careers in the construction sector because they entail long hours and difficult working conditions. Clarke & Wall (2014) observed the nature of the construction industry is transient, moving from one project to another. Women therefore find it difficult to deal with family responsibilities and this kind of work model, because they perceive that they have to choose between career and a family-oriented lifestyle (GoC, 2010).

Male Dominated Training Courses:
According to cultural beliefs among Kenyan communities, women are discouraged from enrolling in technical courses (Ngerechi, 2003). This has led to a lower participation rate than men at the higher levels of technical training. For instance, in 2004, female enrolment in science, mechanical and technological courses across all levels was extremely low—1.4 per cent in mechanical engineering, 4.4 per cent in electrical and electronic engineering and five per cent in building and civil engineering (GoK, 2005).

According to Armstrong (2009), training is seen as a valuable tool and an investment in organizations that help to improve profitability, reduce costs and increase employee motivation, commitment and effectiveness. To a great extent, training activities are the key drivers of organizational development and growth.

Armstrong (2009) further argues that training should be applicable to performance in a current or anticipated task, providing all the necessary learning. By improving employees’ ability to perform tasks required by an organization, training allows better use to be made of human resources and further gives employees a masterly over their work, leading to improved performance.

Careers advice in schools is certainly poor and often gendered, on-site culture can sometimes be inhospitable to women and the working pattern can be incompatible with family life and the kinds of responsibilities women tend to take on at home (Ngure, 2014). Where one section of the population is left out of relevant training, then disparities would always be felt in program implementation and its results.

Recruitment Practices:
The recruitment process in the construction industry is said to be biased against female workers. The terms and conditions within the construction industry were general for both genders. Many employers still consider women unsuitable for some traditionally male dominated jobs, for instance in the manual trades workers need a reasonable level of physical strength and fitness, with some job requiring above average upper body strength for lifting and heavy operations (Greckol, 1987).
Even when the women enter full-time construction training in colleges, they still find difficulties gaining entry into the workforce (Clarke & Wall, 2014). In a study in post-school outcomes in VET, Maliranta, Nurmi & Virtanen (2010) observed that male graduates were 4.7 percent more likely to get a job than were female students. There is a big hiatus of information of what the construction industry entails in developed economies like Canada as well. In interviews with representatives of employers, owners, unions, labour organizations and construction associations, many interviewees indicated that women have aptitudes and abilities that suit best in certain professions. These professions include engineering, the lighter construction trades, customer relations, human relations, communication, and organizational skills such as project management, site inspection, and health and safety (GoC, 2010). However, the study noted that even in these professions, the number is still very low.

**Lack of Capital:**
In many traditional African societies, women face increasing difficulties in starting and running their own enterprises as they are not entitled to own anything (Onsomu, Wambugu & Wamalwa, 2009). In fact, a wife is owned by the husband, making it very difficult for her to make independent decisions. Additionally, there exists a variance in earnings in self-employment between males and females. Rosti & Chelli (2009) illustrate the consequences of this discrepancy: since earnings in self-employment are related to entrepreneurial ability and since survival in self-employment is related to earnings, self-employed female graduates will have lower survival rates than self-employed male graduates. And further, the wage gap between males and females in employment has a negative effect on the chances of entrepreneurship among female graduates. This is despite the fact that the effect of training on improved work performance is remarkably higher among females—an outcome that can be deduced as proof that women are inclined to acquire a superior match between the workplace needs and the competencies learnt (Budria & Telhado-Pereira, 2009).

**Change**
In this section, detailed activities that need to be addressed on the subject of women in construction are discussed. Most of these are derived from the challenges outlined above and which needed to be ‘freezed’ in order for change to take place.

**Active promotion of construction careers:**
Addressing gender imbalances in the construction sector training requires formulation of concrete policies that would make the training program attractive and accessible to women (Ngure, 2014). It has been widely argued that the removal of discriminatory employment practices and the provision of equal opportunities is good for business and gives a competitive edge (Barglehole, 2014). Some beneficial effects of equal opportunities are direct and quantifiable, such as the reduction in costs related to staff turnover, and accessing largely untapped reserves of skill and talent through a wider and higher-quality pool of applicants (Barglehole, 2014). Indirect benefits include improved customer service and enhanced staff morale.

**Provide scholarships for women entering or advancing in construction careers:**
Women who want a career in the construction industry would benefit a lot from scholarships since a big number may not have access to training funds.

**Change recruitment and selection practices:**
Both public and private sector need to negotiate for women inclusivity, recruitment and selection policies, more friendly work practices, and the stamping out harassment and bullying.

**Encourage women apprenticeship:**
Training as an apprentice leads to greater success as trainees get to experience first hand how work is performed (Ngure, 2014). Encouraging women to train and join the industry at different life stages would increase participation as would supporting business owners to engage women apprentices. Government and the private sector need to appreciate more the benefits that would accrue by having more women joining the industry.

**Mentorship and leadership coaching:**
Lack of role models has been sighted
as one of the main reasons for poor participation of women in the construction industry. Successful women in the construction industry would be a great source of knowledge, motivation and encouragement for young girls and women wishing for a career in the industry. Davis (2014) views mentoring and leadership coaching as being crucial factors in helping women reach their potential, especially in male-dominated industries such as construction.

Mentoring programmes enable women to learn from each other, share experiences and develop strategies to overcome the challenges they face on a day-to-day basis; they can also help to retain talent in the industry. In addition, leadership coaching gives one an opportunity to reflect on successes and challenges, and to remain focused on their goals and personal development.

Establish policies targeting the workplace:
Many women find the construction industry difficult to work in as they have to grapple with unfair labour practices, sexism and bullying. A standardized policy for worksite inspections, gender reporting desks, and mechanisms to address bullying, harassment and violence are needed to encourage women at work.

Offer technical assistance in recruitment and retention to employers and unions:
Retaining good workers and assisting those facing difficulties would reduce employee turnover. Factors that encourage retention include: better working conditions, flexible working policies and programmes aimed at supporting women who join the construction industry (Barglohole, 2014). This would not only provide an attractive career path, but also build a more diverse management, who in their turn are more likely to attract and recruit a diverse workforce (Clarke & Wall, 2014).

Enforce non-discrimination and affirmative rules:
Increased monitoring, investigation, and education by the relevant civil bodies and state enforcement agencies are necessary to end discrimination by contractors and unions (Hegewisch & O'Farrell, 2013). In addition, issues of Equal Employment Opportunities, Occupational Health and Safety and affirmative action are vital in ensuring conducive environment for women.

Research:
This research paper has benefitted from many research work done by scholars and institutions. However, there is still a need to carry out more empirical research in the area of women in construction. This is especially so in emerging markets like Kenya where there is a construction boom and in which a lot of people are seeking work. Studies are needed to understand why there is a high women labour turnover in the industries, to find out what can be done and to document effective employer and workplace practices (Hegewisch & O'Farrell, 2013).

Refreeze
Career progression
Efforts by the government and other stakeholders have had a significant impact on women participation in the labour force. For instance, this study revealed that science, technical and engineering entry requirements for most of the courses in craft and diploma were revised downwards for women because their enrolment numbers were too low (GoK, 2005). Although this was a small step in addressing gender inequality, it increased the enrolment of women.

In addition, the establishment of the Keriri Women's University of Science and Technology, which trains women in science and technology, is a positive affirmative action because it offers young women a chance for creativity and innovation, which are essential elements of employment (Mwobobia, 2012).

Promotion of training activities and practices:
This can be achieved through electronic, print and sound media, business and management forums, innovative exhibitions and trade fairs, which will most likely interest women. However, to motivate more women to take up technical courses that are more marketable and produce higher returns, more deliberate and aggressive interventions are necessary (Ngure, 2013).

Duetothedifficultiesencounteredin getting women to take engineering and technology courses, the Kenya government practices
'positive discrimination' by offering full scholarship to any woman wishing to enroll in these courses, resulting in a small but significant enrollment increase (Ngure, 2014). Additionally, the African Union (AU) recommends close linkages between science and technology with the learner’s culture so as to improve learning outcomes, to increase female participation, and, to validate indigenous knowledge and technology for sustainable development.

**Funding women in business:**
As indicated earlier women lack funds to start and expand their businesses. Some positive action has been taken in Kenya in the form of a Women Enterprise Fund (WEF) whose mandate is the provision of sustainable financial solutions to the challenges Kenyan women face (KNBS, 2014).

The aim of the fund is to empower women to venture or expand their businesses by offering interest free loans to registered self-help groups. Additionally, the recent government policy that provides for 30% of all government contracts to be awarded to the youth, women, and persons with disabilities without competition from established firms has aroused a special interest in women and women groups.

Build on successful women role models: Successful stories of women in construction as highlighted by the media and researched by different people have raised the profile of women in the construction industry. Recently in Kenya, the National Construction Authority (NCA) has supported awards that recognize women in construction. These awards have motivated more women and made it possible to learn about opportunities available in the market, giving the women a forum to interact and network. Furthermore, monetary and material support awarded to the best women enterprises encourages competition in the industry.

The awards have attracted major sponsors, giving the awards ceremony the recognition and seriousness it deserves. Encourage more businesses to employ women: Contractors who achieve gender parity, or have at least a third of staff being women, should be feted. For instance one construction company, Greenspan, has recognized the role of women in construction as expounded by a programme that trains and employs women in all areas of the construction (Greenspan estate, 2014).

The training combines personal development, business skills, technical skills and industry exposure; and has resulted in 60% of the workers being female. This is the first major construction company to engage the services of women at such a scale in a male dominated industry with the results being ‘a perfect blend of beauty and quality for the finished units.’ Carry out tracer studies:

It is expected that women who have been trained in construction will be absorbed into the industry. Feedback gathered through tracer studies of women in the construction industry would be an effective way to gauge how they are fairing at worksites. The tracer studies would gather data on the percentage of graduates who gain employment, how well the skills acquired are utilized at the workplace, how long they last and areas that would need improvement to make training more appropriate (Ngure, 2014). Further, program evaluation will point out areas that have been successful, those that require revision, and priority areas for future programmes.

**References**


With the increase in construction activities in Kenya, there is a tandem increase in labour demands. For example, a record 30,000 people including artisans are expected to eventually be employed in the construction of the Standard Gauge Railway (SGR).

Important questions then arise: Is the country in a position to meet the labour demands that arise out of construction sector growth? Specifically, do we have enough practical skills to supply this market? The National Construction Authority (NCA) has so far registered a database of 3000 trained artisans (data from NCA in April 2015). In practice the world over, the need for specialists in any one line of specialization dictates that you have a pyramid of skills whereby the higher up the pyramid you go, the fewer the specialists. The lower on the pyramid, the higher the number of persons required and the more important is their support role to the one at the top of the pyramid. If the balance of skills is disturbed, then the market that requires these skills starts to suffer, and this is Kenya’s undoing. Traditionally, Governments have been the sole supplier of the practical skills training through polytechnics and technical institutions. However, growing demand in the quantity and quality of skills available necessitate collective action by both private and public actors to work together.

In doing so, the construction industry will not only be effectively served in its labour needs, but the country will also be well positioned to take advantage of upcoming infrastructure opportunities as a stimulus for the much needed job creation.

**Key words:**
construction industry, skills, private sector.

**Introduction**
There exists a growing disconnect between Construction Industry needs for practical skills and the quality and quantity of skills supplied in Kenya. The research sought to establish the construction labour requirements of industry vis a vis the quality and quantity of available skilled personnel and whether there is a role for the private sector.

The research sought to answer the question ‘Is the construction industry in Kenya well served with the current labour available in terms of quantity and quality
of skills available?’ To find answers to the question above, the research needed to find out from players in the industry what their requirements were in terms of quality and quantity of labour and what limitations if any they had with the available labour. Both qualitative and quantitative research methods were used.

**Methods**

Data collection was undertaken through questionnaires administered to different construction industry stakeholders (both private and government). Structured interviews schedules were also administered to representatives of industry associations and some private sector players. Secondary data in form of literature review was collected from newspapers, construction review magazines and Government statistics.

Primary and secondary research analysis was undertaken. Secondary analysis of data was undertaken through reviewing past researches done on construction labour related issues and evaluation of the questionnaires. The private sector was found to be very sensitive to opening up on data regarding human resource issues. Hence a lot of bidding was required and a few companies refused to respond to the questionnaires altogether.

However, the sampled responses were representative of the market.

**Results**

The private sector was found to be very sensitive to opening up on data regarding human resource issues.

The research was conducted between March 2015 and Friday 17th April 2015. The number of corporate bodies interviewed was seventeen (17) in total and government bodies were three (3).

The Demographic and other details of the institutions interviewed were as follows: Age: (15%) of the respondents were aged between 18-25 years, (15%) of the respondents were aged between 26-40 years and (70%) of the respondents were aged between 41 – 60. Gender: 85% interviewees were male while 15% were female.

**Size of firm:**

80% of the companies had over 100 employees; 20% below 30 employees.

**Age of organization:**

70% of all organizations ranged between 20-125 years old while 30% ranged between 1 -12 years.

**Profession of persons interviewed:**

100% of the personnel interviewed were senior (technical) managers – Site Supervisors, Site Agents, Quantity Surveyors, Site Engineers, Human Resource Managers, Regional Managers, Senior Water Engineers, Products Support Engineers, Retail Executives, Marketing Managers, Construction Managers and Chief Logistics Officers.

**Nature of private sector companies interviewed:**

The private sector players interviewed were under: building and construction, logistics, equipment distributors and housing development companies.

**Training Aspects:**

90% of the companies interviewed had undertaken a needs assessment of skills that they require. Over 70% of the companies have used staff trained by Government to provide skilled labour. Most organizations have had to expensively retrain their personnel on the job, or (for the larger ones) built in-house trainings. Some specialized skills needed by industry were non-existent in the market. Some companies resort to hiring trainers to train their staff from other countries at a very high cost. A few big companies choose to employ foreigners for specialized skills at operative level, which is not only cost and time efficient, but is also not in tandem with nationalistic policies of employment creation for locals at these basic levels.

**Conclusion and Recommendations**

The biggest challenge for the industry was lack of professionally well-trained skilled workers and knowledge of the latest technologies in construction trades. Industry’s demands are becoming more and more sophisticated and Kenya must endeavor to keep up with the labour demands arising out of this.

There is need for private sector to compliment government effort in training and research in skills development. The private sector needs to take a lead in training on specialized tailor made skills that may not fit within the existing academic curricula.
MOMBASA CEMENT

Lets Build A Stronger World
An Evaluation Of Technical, Vocational, Education And Training (Tvet) Processes In Kenya

This paper examines key stakeholders evaluations of the Technical, Vocational, Education and Training (TVET) processes in Kenya. The paper responds to on-going debate in the business community, media and training practitioners to the perceived mismatch of the skills required in the industry and those produced by the TVET program. Data for this paper were collected from government documents, previous research papers, and business reports and editorials.

In addition, primary data were collected by using semi-structured questionnaires, focus group discussions and observations. Respondents included education officers, business employers and employee and trainers and trainees of four TVET institutions. Most stakeholders were happy with TVET objectives and its contribution in furnishing the industry with requisite skills. However, they enumerated various challenges that make it difficult for TVET to respond adequately to the industry's skill needs. Discussion was guided by the Kirkpatrick's evaluation model that has four levels: reaction, learning, behaviour and results.

Key words:
Human resource development; technical vocational education and training; Kirkpatrick's evaluation model

Introduction
Education and training are two intertwined mechanisms through which economies nurture their labour forces with the view to producing necessary technical and generic skills required nationally, regionally and even globally. Authors Wargonhurst (2002) and Wallenborn (2009) have observed that skills acquisition (such as basic literacy, technical and interpersonal skills) is the ultimate aim of any training system.

Further in Kenya, skills development is recognized as important for economic development, poverty mitigation, and social inclusion. It contributes to equity and access to training, and social responsibility by stimulating competitiveness and entrepreneurship to realise life-long learning concepts (Masson & Fretwell, 2009). Translating skills development into skills utilization, and therefore economic growth and poverty reduction, is dependent on such factors as quality of education, supportive environment, facilitative infrastructure and a conducive work environment (Tikly, 2010).

A major aim of training is to improve and maintain workers' productivity. This requires continuous updating of competencies to enable the workers adapt and take advantage of emerging opportunities and global trends (Ngure, 2003). In addition, there is need to ensure that the skills developed are actually utilized at the workplace (Buchanan, 2006). Employers do not see the need to raise salaries for employees who have trained in skills that do not raise productivity (Cooney, 2002). However, it is vital to acknowledge sociopolitical...
There is need to ensure that the skills developed are actually utilized at the workplace.
documents such as the KESSP (GoK, 2005) and Kenya Vision 2030 (GoK, 2007), which expose skill shortages across industry.

For the purpose of a comprehensive study, the research is limited to the motor vehicle repair and industry (automotive industry), which is a skill-based industry that includes mechanics, tuners, welders, electricians and tailors. Evaluation

Evaluation is the means by which a training program’s outcomes are compared to set objectives with the aim of finding out the extent to which the training process has achieved its purpose (Armstrong, 2009). A particular training is tailored to suit the needs of a specific time (Staley, 2008).

Evaluation examines the level at which the training program meets the set targets through activities such as organisational performance changes, training content and design evaluation, and changes in learners (Alvarez, Garofano & Salas, 2004). The effectiveness of the training program should be a major concern for training providers and policy makers as it acts as a guide when considering the relevance and suitability of an activity.

The accurate definition of goals and objectives of the training program determine the evaluation procedures and constructs that form the basis of a comprehensive assessment. This varies depending on different target groups’ emphasis, and between different countries. For instance, a major TVET goal of different governments is to empower young people to adapt to a dynamic environment through life-long training; for the workers, however, the emphasis could be wage increases; to the employer, improved productivity; to the trainee, employment and wages; while from a policy-maker’s view it may be to decrease societal expenses (Fretwell, 2003).

Interest in evaluation of training programs has led different researchers to develop models of training evaluations, four of which are discussed in the section below this. Models of training evaluations

First, in 1959, Kirkpatrick published a four-dimensional evaluation method that tests reactions, learning, behaviour and results—a simple measurement method for comprehending training evaluation, and the most quoted procedure (Kirkpatrick & Kirkpatrick, 2005).

In this model, …learning is measured during training and refers to attitudinal, cognitive, and behavioral learning. Behavior refers to ‘on-the-job’ performance and, thus, is measured after training. Additionally, reactions to training are related to learning, learning is related to behavior, and behavior is related to results. (Alvarez et al., 2004, p. 388) The Kirkpatrick model has stood the test of time and is widely used to evaluate training and development programs in different fields.

For example, van Eerde et al. (2008) used the four levels to measure the effect of training programs to organisational effectiveness, while Piyali et al. (2011) used only the reaction level. The four dimension measure different aspects of the training program because they progress from the stage of simply getting a reaction to the training to the more complex processes of measuring results.

The second model was developed by Tannenbaum, Mathieu and Martineau, (1993) who added post-training attributes to Kirkpatrick's model and separated evaluation outcomes into transfer and training performances. This model was tested by Alvarez et al. (2004) when constructing ‘An integrated model of training evaluation and effectiveness’. The authors used evaluation measures such as training and transfer performance, and cognitive learning; and effectiveness variables such as pre-training experience and self-efficacy, and post training interventions, such as mastery orientation and learning principles.

In the third model, Holton (1996) incorporated three evaluation objects: transfer, learning and results. He did not consider reactions as a main outcome of training; he regarded them as an intervening or regulating outcome between trainees’ learning drive and the actual learning. Thus, learning is linked to transfer, which in turn is associated with the outcomes.

Finally, in the fourth model, Kraiger (2002) provided a model that emphasises three objectives for an evaluation program: learning material and design (i.e. delivery,
strategy, and rationality of training), learners’ behavioural modifications (i.e. emotional, intellectual, and developmental) and structural benefits (i.e. transferability, work performance, and outcomes).

This fourth model advances the measurement of the learners’ behaviour changes as a result of the training. These measurements can be quite challenging given how difficult it is to tell if the learners’ emotion or intellect have changed as a result of training. A different perspective in training evaluation was advanced by Kearns and Miller (1997) who advocated for a ‘return on investment’ (ROI).

They opine that ROI is a means of assessing the overall impact of training in organisational performance, further arguing that particular measures should be used to evaluate specific training, for example customer satisfaction or return on sales, which should improve by some percentage (Alvarez et al., 2004). Armstrong (2009) adds that besides concentrating on the traditional levels of evaluation there is need to ‘concentrate more on the validation of the total learning process and on the outcomes of learning, which means focusing on the return on expectation’ (p. 696).

This could be achieved through attributes such as increased customer satisfaction, volume of sales and increased production. The models of evaluation discussed above assist in conceptualising how, where and why evaluation measures can be used. The Kirkpatrick model that was first published in 1959 and composed of four levels reactions, learning, behaviour and results is simple and most comprehensive for use in a training, because the other models components can be integrated into its four levels.

For instance: post-training attitudes proposed by Tannenbaum (1993) and transfer of learning proposed by Holton (1996) can be integrated in the behaviour phase; learning material and design, learners' behavioural modifications and structural benefits learning materials proposed by Kraiger and Kearn (1997). Research Focus The KESSP document highlights the low participation of the private sector and other stakeholders in training needs analysis, curriculum design and implementation (GoK, 2005).

In response to this assertion and the concerns expressed in the Kenya Vision 2030, this study involved key stakeholders in the industry, training institutions as well as technocrats in the relevant Ministry in examining the training processes.

The TVET training process has been identified as a problem by key stakeholders in the industry (Kenya Private Sector Alliance [KEPSA], 2010), and by the government in its review of TVET (GoK, 2008), necessitating research on key components of a training system, to discern issues that may hinder effectiveness in that particular sector.

Despite this important role that TVET plays in addressing labour challenges, major policy documents lack an explicit approach by which this role can be achieved (Nyerere, 2009). This failure to fully embrace the role of skill training is particularly baffling given that most African governments and development partners are consistent in emphasising the need for intensive structures that shape the human capital of the marginalised (UNESCO-UNEVOC, 2008).

Bennell (2000) observed that since the late 1980s, most African governments have accorded limited significance to donor financing systems and dialogue, leading to limited inclusion of TVET in mainstream education systems. However, funding has to go hand in hand with other strategies such as building trainers capacity as there is a challenge of ensuring that once resources are availed in training institutions, they are used effectively to promote skills acquisition (Tinkly, 2010).

Furthermore, translating skills development into skills utilisation, and therefore economic growth and poverty reduction, is dependent on various factors like quality of education, supportive environment, facilitative infrastructure and a conducive work environment (Tikly, 2010).

This study therefore, looks at the TVET processes from the stakeholders’ perspective by addressing the following question: How do key stakeholders in TVET evaluate its responsiveness to emerging global trends? Methods To examine the research
question, the researcher sought the views on training processes from a sample of major stakeholders: 19 business employers and 57 of their workers, four training institutional managers, four trainers, 32 trainees and four government officers responsible for curriculum design, implementation and supervision.

This study employed the use of semi-structured interviews that were carried out with the education officers, employers, employees and trainers. Although semi-structured interviews rely on pre-formulated questions for guidance, they allow respondents to talk about those things that are of interest and importance to them (Baker & Foy, 2008).

Four focus group discussions (F2) of eight students each were used to gather data from final year learners of each training institution under study. F2s allow shared opinions of a particular defined subject that is of interest to a group of individuals who have had certain shared experiences (Myers, 2009). They attempt to answer the ‘how’ and ‘why’ questions that produce rich, multifaceted, nuanced and even challenging interpretations of how people attribute meaning to and construe their understandings (Kamberelis & Dimitriadis, 2011).

Observation was used in the institutions and businesses under study to discern the day-to-day processes and activities. In the businesses observations were made on working conditions, relationships among employee, employer and customers, equipment in use and occupational health and safety issues; and in the training institutions, equipment, other facilities, relationships and documents mounted on walls. Baker and Foy (2008) noted that observations ‘…avoid the possibility of distortion that may arise when people are asked to report their own behaviour’ (p. 147). In addition, the researcher gathered data from government documents, and archival records in line with the six types of information recommended by Yin (2004): archival records, direct observations, documentation, interviews, and physical artefacts that bring a contextual understanding by relying on multiple sources.

Content analysis, a systematic method of qualitative data analysis that seeks structures and consistencies (Myers, 2009), was used to deal with the enormous amount of data. This involved coding data using thematic areas and then further segregating them to smaller groups. To easily identify the participants in analysing and reporting the findings for this study, the following codes were used.

<table>
<thead>
<tr>
<th>Study Respondents</th>
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<tr>
<td>Employers</td>
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<tr>
<td>Employers</td>
<td>57</td>
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<tr>
<td>Study Respondents</td>
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<td>TR1-TR8</td>
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<td>Trainers4</td>
<td>focus group discussions</td>
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The initiation for the development of a constructed facility has always been and still remains the fundamental role of a client. A client may additionally take other different functions, which may include owner function, financier function, sponsor function, user function, promoter function or developer function.

The strict use of the term client is comparable to a customer, both of whom are recipients of services, but the client demanding and receiving personalized services. In the same way a patient assists the clinician by giving his medical history, or a plaintiff or a defendant provides particulars of a case to his lawyer; so is the construction client obliged to participate in formulating his objectives, identifying the risks and constraints.

He has a role in directing the processes of achieving the desired deliverables. The individuals that support the client in performing his basic mandate can be considered as the service providers to the client. The extent of services by the client and the number of service providers are determined mainly by the scope of the project as well as by its complexity.

Over the history of physical development (creating the built environment), the project scope and project complexity have undergone tremendous changes in growth. The historical growth has, in some regions, been matched with appropriate changes in the level of services provided. In others, the changes have been resisted and not without negative consequences to the project.

This paper attempts to trace the changes in growth of project scope and complexity since the time of the great Master Builder to the present day and correspondingly assess the response to the changes by the demand and provision of services.

Key Words: Project management; construction management; construction manager (CM);

Introduction
A project is a temporary endeavor undertaken to create a unique product or service. Temporary means that every project has a definite beginning and a definite end. Unique means that the product or service is different in some distinguishing way from all similar products or services.

Project management is the application of knowledge, skills, tools, and techniques to project
activities in order to meet or exceed stakeholder needs and expectations from a project.

The four epochs of projects development start with the era prior to 1958-craft systems to human relations; 1958-1979- application of management science; 1980-1994- Production Center Human Resource; 1995-present -creating a new environment where internet became fast, interactive and customized medium that enables browsing, purchasing, tracking of products and services. This lead to firms being more productive, efficient, client oriented since internet allows input, monitoring and observation of status, progress and schedules and it further enables stay ‘in the loop’ for the participants Scope and Level of Integration.

Increased diversity in project complexity, number of stakeholders, number of specializations, physical size and the need for project integration has elicited the need for project management role through planning, coordinating, communicating, organizing, controlling both the events and the actors.

Recognition of Integration Function – state of Board of Registration of Architects & Quantity Surveyors (BORAQS) regulates the relevant professional dimensions; Institution of Engineers of Kenya (IEK) safeguards the profession of Engineering; International Federation of Consulting Engineers (FIDIC) – none of its many forms of contract recognizes Project Managers (PM).

Protects engineers' interests; RIBA supports the appointment of an Architect as project manager; Royal Institution of Chartered...
Surveyors (RICS) is a professional body that accredits professionals within the land, property and construction sectors, RICS has paths to become a project manager; Project Management Institute (PMI) and College of Performance Management (CPM) certification programmes in continuous education, Chartered Institute of Building (CIOB) Founded in 1884.

Most elaborate in promoting the role of a PM, Public Procurement Oversight Authority (PPOA) replaced DR with a PM and retained architect, engineer, and quantity surveyor under CAP 525 as PMs.

In Kenya, Jomo Kenyatta University of Agriculture and Technology (JKUAT) undergraduate and graduate programmes in construction management started in 2003, while University of Nairobi (UoN) graduate programmes began in 1983, while undergraduate began

in 2007, PPOA recognition of the title PM, Architectural Association of Kenya (AAK) a chapter for PM, Institution of Construction Project Managers of Kenya (ICPMK) is still struggling for recognition, while Business Continuity Management (BCM) lobby group of young graduates into fighting for their space.

Way Forward
Formation of a board to regulate the practice and development of construction project management and construction management;
Development of a scheme of service for the two careers in the relevant departments. NCA should also enforce employment of competent Construction Managers (CMs) by contractors as mandatory requirement for registration; moreover, the approving authorities should require submission and enforcement of safety and health plan as part of project documents for plan approval.

The extent of services by the client and the number of service providers are determined mainly by the scope of the project as well as by its complexity.
Automated Machine Guidance in Road Construction

Gathura S.N., E-mail: gathura@landinfoservice.com
The Automated Machine Guidance in heavy equipment has graduated from being an add-on to now being fully integrated into the equipment. This is because it has shown how it increases productivity, shortens the project duration, increases quality and thereby reducing the project cost. However in Kenya this system has not been integrated into the work flow processes. There are 3 necessary components that need to be developed in order for this to be realized.

These are the Government fast tracking the development of the CORS (Continuous Operating Reference Station) infrastructure; the Road designer’s migration from presenting 2D designs on paper to the contractor to 3D digital files; and the relevant road authorities encouraging the contractors to invest in this technology. This paper expounds on the science involved in the CORS network. We will then explain how the AMG operates. We will then delve into the 3 above listed issues that need to be addressed before this technology can be utilized.

Abstract:
The Automated Machine Guidance in heavy equipment has graduated from being an add-on to now being fully integrated into the equipment. This is because it has shown how it increases productivity, shortens the project duration, increases quality and thereby reducing the project cost. However in Kenya this system has not been integrated into the work flow processes. There are 3 necessary components that need to be developed in order for this to be realized. These are the Government fast tracking the development of the CORS (Continuous Operating Reference Station) infrastructure; the Road designer’s migration from presenting 2D designs on paper to the contractor to 3D digital files; and the relevant road authorities encouraging the contractors to invest in this technology.

This paper expounds on the science involved in the CORS network. We will then explain how the AMG operates. We will then delve into the 3 above listed issues that need to be addressed before this technology can be utilized. Keywords: Continuous Reference Stations (CORS); antennas; Automated Machine Guidance (AMG); Global Navigation Satellite System (GNSS); Inertial Measurement Unit (IMU)
the advent of satellite positioning 40 years ago, a surveyor who wanted to determine the position of an object, had to take angular and/or distance observations to and from pillars, which were usually located on top of hills.

These pillars had their positions determined accurately and these pillars were distributed in such a way that they covered a country in a network. In the modern era these pillars have been replaced by antennas usually placed on rooftops. These antennas receive signals from positioning satellites from which they are then able to calculate their positions. However they already know their positions accurately, and they are thus able to know the errors that occur as a result of the signals from each satellite passing through the atmosphere. Like their predecessor's they are strategically located around a country and they are collectively called Continuous Reference Stations or CORS. They continuously receive the positional signals from the satellites, which they process and then relay the corrections to whoever needs them either by the internet, wireless or radio. Usually a person with a navigation system in his car or phone can get his position to within a couple of meters.

However someone who has the proper equipment and obtains the CORS data can improve his accuracy to millimeters. Knowing where you are to within a few millimeters in real time is a big thing as this opens the door to many possibilities. This paper will dwell in one area that this technology is having a big impact and that is road construction but in passing we can mention that it also has a big impact on farming in what has evolved to be called precision farming and it also used in the weather forecasting.

Keywords:
Continuous Reference Stations (CORS); antennas; Automated Machine Guidance (AMG); Global Navigation Satellite System (GNSS); Inertial Measurement Unit (IMU)

Introduction
Before the advent of satellite positioning 40 years ago, a surveyor who wanted to determine the position of an object, had to take angular and/or distance observations to and from pillars, which were usually located on top of hills.

These pillars had their positions determined accurately and these pillars were distributed in such a way that they covered a country in a network. In the modern era these pillars have been replaced by antennas usually placed on rooftops. These antennas receive signals from positioning satellites from which they are then able to calculate their positions. However they already know their positions accurately, and they are thus able to know the errors that occur as a result of the signals from each satellite passing through the atmosphere. Like their predecessor's they are strategically located around a country and they are collectively called Continuous Reference Stations or CORS. They continuously receive the positional signals from the satellites, which they process and then relay the corrections to whoever needs them either by the internet, wireless or radio.

Usually a person with a navigation system in his car or phone can get his position to within a couple of meters. However someone who has the proper equipment and obtains the CORS data can improve his accuracy to millimeters. Knowing where you are to within a few millimeters in real time is a big thing as this opens the door to many possibilities. This paper will dwell in one area that this technology is having a big impact and that is road construction but in passing we can mention that it also has a big impact on farming
in what has evolved to be called precision farming and it also used in the weather forecasting.

Automated Machine Guidance (AMG) Road construction basically involves moving or replacing soil with other materials to make a road. In designing a road the designer taking into account the topography of the area, designs a road whereby a process of cut and fill will have to be undertaken in order to complete the road. To achieve this earth moving equipment is used and by staking out the design the earth moving personnel are able to turn the design into reality.

There is a lot of human involvement in these operations of staking, earth moving and checking whether the geometric design parameters have been achieved. This translates into a lot of time. These equipment use a lot of fuel and having the machine undercut or overcut translates into high fuel bills and time wastage. With AMG there is no staking and the road design which is in digital form is input into what is known as a control box on the equipment.

The operator has a screen in front of him, which displays the road design. The position of the equipment and its blades in relation to the design is displayed on the screen. This is achieved by having positioning sensors on the equipment. The primary sensor is the GNSS (Global Navigation Satellite System) receiver(s) on the machine. They are also other sensors like the imu (inertial measurement unit) sensors placed in strategic positions on the equipment. Collectively they are able to know the exact position of the machine components. Thus when the operator moves the blade he can know whether the design grade has been reached. The control box is interfaced with the hydraulics of the machine so that the operator can leave the controlling of the blades to the control box. This makes it very easy on him, as all he has to do is steer the machine while the controller automatically moves the blades to the required positions.

The AMG is more precise and quicker than a human operator and there is no over or undercutting. In this way there is up to 50% reduction in the time for these operations. There is also significant cost savings in the fuel bill. Many contractors recoup the costs of their investment in this equipment from one project. With the above in mind the question that comes to mind is why has there been no uptake of this technology in Kenya.

CORS Implementation:
As explained the core component of the AMG is the GNSS receiver. To be able to accurately know its position, it needs to receive corrections either directly from the CORS network or a base station, which acts similarly to the CORS network. However this base station still has to rely on the CORS network for it to be set up. Thus the CORS network is an essential component for this technology to work. Currently in Kenya the only working CORS station is located at the Regional Center for Surveying at Ruaraka.

Kenya requires at least 40 stations to have a well-distributed network around the country. Ideally the mandate of putting up this network should be with the Survey of Kenya. In some countries, the transport departments put up their own networks and as there are other beneficiaries to having the CORS network, an intergovernmental task force should be set up to fast track its implementation.

Road design is done using design software on a computer. The software enables one to design in 2D or 3D. Many road engineers prefer to make their designs in 2D and even if they design in 3D, the final drawings to the contractor are paper based. AMG requires 3D data files and if a contractor tried to utilize this technology, he would need to have the design in 3D digital form. Therefore there needs to be a shift in how the design is done and presented.

Conclusion
A typical AMG system costs 10 million shillings. To invest this kind of money on this equipment, the above two points should have been addressed. Thus the road authorities need to be proactive in addressing these issues by:

- Lobbying the decision makers to fund the CORS network
- Mandating that all design be presented in 3D digital format.
- Encouraging and educating the contractors on the benefits of investing in this technology.
The activities of bogus, greedy “professionals” in the construction industry have tarnished the image of the building profession in the recent past. The constant cases of collapse of buildings in some parts of the country have resulted in the loss of lives, property and left many people injured. Quite a number of factors are responsible for collapse of buildings. Government, professional bodies and people are asking countless questions as to who should be responsible and how solutions could be proffered. This paper therefore, intends to highlight causes of collapse of buildings in Kenya, the roles professionals and other participants’ play in the industry. It concludes by suggesting possible measures to be taken by government and other regulatory bodies in the building industry to avert this.

Keywords: Building, Collapse, Failure, BS8110, EC2

Introduction
Building failure should not be taken to mean only a structural failure but also includes its nonperforming with the requirements expected of it. Common examples of building failure includes defects as cracks in walls, beams, columns, foundations majority of which arise during construction period or after, while others are due to natural phenomena (Jack, 1983). This study however only focused on catastrophic failure of building collapse, where lives are lost. (Lingard & Rowlinson 1994) and (Spillane et al., 2011) observed that the construction industry worldwide has been adjudged to be performing very badly in the area of safety by international standards. Study by G. Mwasame et.al 2012), reported that the rate at which buildings collapse has been on the rise countrywide, they cited the following examples: building collapse in Nairobi Ronald Ngala Street in January 2006, in Kiambu town October, 2009, in Embakasi, June 2011, in Langata, June 2011, in Ngara, July 2011, in Luanda, September 2011, in Bungoma town in April 2012 and Roysambu, Nairobi March 2015. Methodology Information for the study was received from books, observations, interviews, past works, newspapers on building collapse and the internet.
The researchers used qualitative research and classified them under two categories, namely, exploratory and attitudinal. Exploratory research was used due to the fact that there is limited amount of written knowledge about the failure of buildings in Kenya as opposed to other countries such as Nigeria. The purpose of exploratory research is intertwined with the need for a clear and precise statement of the recognized problem (Zikmund, 1997).

Attitudinal research was used to ‘subjectively’ evaluate the perception of respondents, towards a particular question. Historical data on building collapses which occurred in the last ten years were analyzed to identify the trend and the common features of structural collapses in Kenya. Questionnaire and face to face interviews were conducted and analyzed on role of the professionals, clients, craftsmen and other stake holders.

Causes of building failures
Kenya has recently witnessed buildings collapsing when under construction and even after they have been completed. Buildings do not fail due to architectural issues. Almost in all cases, failure occurs due to an engineering and or construction related problems. Principal causes of failure are:
(a.) Inadequate geotechnical and materials investigations.
(b.) Lack of a customized version of international specifications and manuals.
(c.) Incompetent design team (Quacks).
(d.) Poor workmanship.
(e.) Lack of ethics.
(f.) Poor supervision.
(g.) Close relationship between parties to the contract
(h.) Using substandard materials
(i.) Weak laws
(j.) Lack of quality control
(k.) Corruption
(l.) Non involvement of all relevant players in the construction team

Inadequate geotechnical and materials investigations Mandatory comprehensive geotechnical and materials investigations are rarely carried out for many building structures. Sadly, this is one area that is usually neglected or inadequate resources are allocated for the exercise.

This is either due to ignorance or the client/developer has the false notion that he can save money by carrying out minimal investigations or none at all. The consequences are usually catastrophic since the whole design of the proposed structure is based on wrong assumptions. Nature is usually unforgiving to those who ignore this phase. (Typical example of this is the Kiambu residential structures that collapsed in 2010 shown in pic.1).

Remedy
Approval to proceed with the construction of major structures should at all times be subject to production of authentic reports that give evidence that comprehensive geotechnical investigations have been carried out with a stern warning that material testing be done before construction work commences and design of the foundation should be based on the test results obtained.

Inclusion of appropriate factors of safety must be demonstrated. Never cut costs by carrying out inadequate investigations. Lack of a customized version of international specifications and manuals. The causes of building failures in most cases have been attributed to misunderstanding of the foreign codes and manuals and lack of a customized version tailored for local construction environment. (Shitote and Nyakiore, 2004) questioned why the British standards, which have not been customized to suit local conditions, are commonly used in design of reinforced concrete buildings in Kenya.

They further spelt out that the standards rely on materials and load safety factors to guarantee safety of these structures during their lifetime. The use of these standards is on the assumption that construction materials and loads in Britain and Kenya are similar. But this assumption may not be right. For instance BS 8110, code of practice for design and
The construction of reinforced concrete is commonly used in Kenya to design structural elements of reinforced building.

They underscored the fact that this code has undergone revision and advancement in technology in the building industry in Britain so that reinforced concrete structures are not over designed and are more reliable. One notable revision is the adjustment of steel safety factor from 1.15 in BS 8110-1:1985 (Withdrawn) to a current value of 1.05 in BS 8110-1:1997.

These adjustments indicate that quality of steel used in the construction industry in Britain is quite high and there is almost 100% chance that steel used in construction industry has the desired design strength. In contrast a survey conducted by (Shitote and Nyakiore, 2004) on concrete, found out that the failure rate of concrete samples is 20-25% while another study by (Munyazikwiye, 2010) found that 69% of reinforcing steel bars collected from distributors failed in yield strength because the mean value for Ys was below the BS 4449 standard value of 460 N/mm2.

Typically only maximum failure rate of 5% is expected in the production of concrete and reinforcement under good quality control (Mosley et al, 1999). It is important that the designer uses the correct, relevant and most up to date Specifications and Manuals. To update Specifications and Manuals, lessons learnt from failure of constructed structures and research is important. Remedy The government must invest in research and performance monitoring of completed structures. Specifications and Manuals must be reviewed, amended and domesticated to suit the local conditions on regular basis if found necessary. It is important that the private sector and universities are involved in these exercises.

Incompetent Design team (Quacks) A number of projects being implemented have been designed by persons who are not qualified to do any design. Others have been designed by inexperienced professionals but no review is carried out by qualified and experienced professionals. Promoters engage these kinds of people to save on design costs.

The consequences are often catastrophic.

Remedy

Heavy fine or make it a serious criminal offence for one who does not possess a practicing license as an Engineer to design or approve design of engineering structure. Engineer’s registration body’s act should be implemented to the letter. Audit work should be carried out on all ongoing or recently completed major engineering structures. Lack of ethics Ethics is a strange term to a number of Contractors and even supervising engineers. A Contractor who has a workforce that values professional ethics will require minimal supervision. Any Contractor or Engineer who wishes to stay relevant in the market in the long term must embrace professional ethics.

Needless to say, this will always lead to high quality work, all things being equal. Remedy Contractors and other professionals involved in the construction industry, who continuously demonstrate lack of professional ethics, should be struck off the register and be blacklisted for a period to be defined in law but should be punitive enough.

Close Relationship between Parties to the Contract As a matter of fact, close relationship between the employer and contractor is not wrong in itself. It could even be beneficial to the project in certain respects. The problem arises when this relationship becomes too close for comfort. The Engineer, though not party to the Contract, finds it very difficult to fulfill his roles and responsibilities since the contractor will only listen to the Employer.

International Building & Construction ShowUnfortunately, the Employer, who may be the custodian of taxpayer’s money, will not be on site to see things going wrong. The Contractor will ignore...
In a number of cases, this could be due to the fact that those employed to supervise are inexperienced and may not know when to reject materials or completed works. A Consultant who tenders low is unlikely to engage experienced and competent engineers and support staff. So at the end of the day, the employer will get what he is ready to pay for. Poor supervision will also be witnessed on sites where the engineer and/or his support staff have been compromised by the Contractor. So they look the other way when things are going wrong.

Remedy

It is the task of the National Construction Authority to decentralize to the counties and inspect rural building projects and if they come across any illegality, all works should be stopped or even order the building demolished. Only engage competent and experienced persons with integrity to supervise the works but keep them motivated and well remunerated.

Corruption

This is perhaps one of the most difficult problems to tackle. Over 50% of the causes discussed above would be solved if we could tackle the vice.

Remedy

It is the task of the National Construction Authority to decentralize to the counties and inspect rural building projects and if they come across any illegality, all works should be stopped or even order the building demolished. Only engage competent and experienced persons with integrity to supervise the works but keep them motivated and well remunerated.
collapse by not involving engineers at all stages of construction.

Today, architects are seen undertaking buildings all alone without the consultation of engineers. Structural engineers are also involved in carrying out structural analysis without site inspection, possessing inadequate soil knowledge and geological formation of the site.

Clients contribute to building failure by erection of structures on unapproved land, additions of extra floors on existing buildings without any consultations with the structural engineers, altering a structure's purposes, and lack of maintenance culture, cutting corners, monetary delays, involvement of non-competent professionals and building without building plans.

**Remedy**

Consultants should always provide specialized knowledge and skills to supplement those of the architect. They should be hired directly by and responsible to the architect. The architect must then coordinate and control all aspects of the design process.

**Conclusion**

This study has been able to identify several causes of building failure in Kenya. It has highlighted positive /negative roles of the players in the construction industry and remedies.

The losses always experienced as a result of building failure are enormous, ranging from loss of lives, several forms and degrees of injuries, loss of properties, etc. The Kenya building Code should be updated as the present one is obsolete.

The authorities need to give direction on which code to be used by both practitioners and institutions of higher learning: that is the use of either, BS 8110 or EC2 and domesticate the recommended document to be passed to parliament and adopted as a legal document for litigation purposes in cases of construction disputes.

**References:**

Concrete has been a popular building material and was first used by the Romans for construction as early as 300BC. In the 1950s, resource efficient hollow-core slab were invented.

In the 1990s, a new system, the Plastic Voided Biaxial Slab was invented that locked the hollow ellipsoids between the top and bottom reinforcements meshes, thereby creating a natural cell structure that acts as a solid slab.

The slab is created with the same capabilities as a solid slab, but with considerably less weight due to the elimination of excessive concrete. The application of these resource efficient slab system ensures realization of lightweight structures, offer excellent freedom in architectural design and at the same time saves on construction costs.

A Voided Biaxial Slabs (VBS) uses spheres made of recycled industrial plastic to create air voids while providing strength through arch action. This allows the hollow slab to act as a normal two way spanning concrete slab. This paper is a report of a recent research study carried out to compare the structural characteristics of biaxial voided concrete slabs and solid concrete slabs.

The research is timely since the demand for low-cost buildings in Kenya is extremely high. The use of conventional methods in construction i.e. solid slab systems has proven to be expensive over the years, creating a great need for proper structural member designs.
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The application of the VBS will ensure realization of lightweight structures, offer excellent freedom in architectural design and at the same time save on construction costs.

Key Words: VBS, concrete, Bubble deck, Cobiax

Introduction

In buildings, the slab forms one of the largest member consuming concrete. Concrete has been a popular building material and was first used by the Romans for construction as early as 300 BC. In the 1950s, resource efficient hollow-core slab were invented. The concept behind the hollow core system was to remove concrete from the center of the slab, where it is less useful and replace it with a lighter material in an effort to decrease the dead weight of concrete floor. However, these hollow cavities significantly decrease the slabs resistance to shear and fire, thus reducing its structural integrity. In the 1990s, a new system, the Plastic Voided Biaxial Slab was invented that locked the hollow ellipsoids between the top and bottom reinforcements meshed to provide vertical support; (ii) plastic spheres – the hollow spheres are made from recycled high-density polyethylene (HDPE) or polypropylene (PP); and (iii) concrete – the concrete is from standard Portland cement and no plasticizers are necessary for the concrete mixture.

Fig 1: Details for the spherical hollow cores flat slab system

Materials for the Plastic Voided Slabs: the plastic voided slabs are composed of three main materials namely: (i) steel – the steel reinforcement is fabricated in two forms (meshed layer for lateral support & diagonal girders to provide vertical support; (ii) plastic spheres – the hollow spheres are made from recycled high-density polyethylene (HDPE) or polypropylene (PP); and (iii) concrete – the concrete is from standard Portland cement and no plasticizers are necessary for the concrete mixture.

Fig 2: Typical illustration of a voided slab and its components

Plastic Voided Slab Systems: Since the inception of the Plastic voided slab systems in the 1990s many European companies have patented their own systems. The main brands of this system are as follows:

1. Bubble Deck

Bubble Deck is a plastic void system which comes in three forms- a precast filigree element, reinforced modules and finished planks (Nasvik, 2011).

2. Cobiax

In Cobiax system, decks form the bottom of the slab, and the bottom layer of reinforcing steel must also be placed. The voids are locked in steel wire meshes which can be altered to fit the particular application (Corey, 2013). The top layer of steel reinforcement can be placed after the bundles are in place. Concrete is then poured in two lifts. The first concrete pour covers the bottom reinforcement and a portion of the voids and holds the voids in place as the concrete becomes stiff. The second lift is poured after the first lift is stiff but still fresh, finishing the slab. This method requires more formwork and on-site labor, but requires less transportation of materials.

3. U-Boot Beton

U-boot is a voided slab system which uses recycled polypropylene formwork designed to create two-way voided slabs and rafts. These void formers create many “I” shaped beams making up the slab (U-boot Beton, 2011). The U-boot system is cast entirely on-site using formwork. After forms are erected, the steel and void formers are placed before the concrete is poured in two lifts. In addition, this system is advantageous because the shape of U-boot void formers allows them to be stacked efficiently during
transportation to the site, saving space and potentially leading to reduced shipping costs compared to spherical former systems (Corey, 2013)

Research Methods The overall procedure for carrying out the analysis and design of the voided biaxial slab is as outlaid as below:

![Diagram of voided biaxial slab](image)

Stiffness and Weight reduction The stiffness of uncracked Cobiax slab sections was investigated with theoretical calculations.

The second moment of inertia of a solid slab without void former was calculated using the following notations:

$$ I_s = \frac{bh^3}{12} $$

Where, $b =$ Width of solid section surrounding a single sphere.  
$h =$ Thickness of the slab 

The second moment of inertia of circle was obtained from the following equation which considered the average void area with radius $y$.

$$ I_c = \frac{\pi y^4}{4} $$

The stiffness reduction factor was then be derived from the below

\[
\text{Stiffness reduction factor} = \frac{I_s - I_c}{I_s}
\]

Bending Strength

If $\mu_{ms}$ was less than 0.2, then the moment stress was allowed to redistribute within the section of the slab and the voided biaxial slab designed using conventional design principles.

That is, 

$$ \frac{M_{\text{void}}}{M_{\text{us}}} $$

Note: The variable $\mu_{ms}$ refers to the ratio of the moment resisted by the void region to the total moment resisted by the whole cross section. The ratio $\mu_{ms}$ was be calculated as:

Where; $D =$ Ball diameter  
$h =$ Overall depth of the slab

$\mu_{ms} = \frac{M_{us} 1.96D}{f'_c h^3} \leq 0.20$

Data Analysis Results and Discussion 

The data calculated was plotted on graphs and tables then compared for different slab thickness. The data was then presented in form of a relationship.

1) Stiffness Reduction Factor and Weight Saving 

In this study for the second moment of inertia and percent weight saving, the slab thickness was taken from 280mm to 600mm with their respective ball diameter being from 180mm to 450mm. The computed stiffness reduction factors are as shown in the table below. For this analysis, the computations of weight reduction was carried out by the same section that of used for stiffness reduction factor. The stiffness reduction factor and weight saving were as shown in Table 1 below:

![Stiffness Modification Factor](image)

Fig 3: Slab Thickness Vs Stiffness modification factor (Source Author 2015)
2) Bending Strength

In this study, the design moment was derived by considering the span of voided slab 7m x 7m interior panel, while load applied on the voided flat plate slabs was 4 KN/m² Live load and 1 KN/m² floor finish load and self-weight of the slab was also considered. The grade of concrete was considered to be 25 N/mm².

The results are as shown in the table below.

Conclusions

From the analysis it was found that we could achieve 30 – 50% concrete reduction in slab. The Biaxial design allows weight reductions in steel reinforcement. Further reductions from reduced columns, beams, foundations.

Potential cost savings of 4% for the slab, Concrete and reinforcement steel saving. Further cost savings for supporting structure. Reduced weight can result in lower transport costs and cheaper lifting equipment. Up to 40% time savings have been achieved due to Few columns and beams hence faster
The National Construction Authority to encourage and adopt new techniques of structural designs in order to facilitate the construction of cheaper and structurally sound housing units. This study mainly focuses on the structural analysis of the voided slabs. It is recommended that further study be conducted on the material properties of the voided slab elements and tests performed on the same.

### References


<table>
<thead>
<tr>
<th>Slab Thickness (mm)</th>
<th>Ball Diameter (mm)</th>
<th>Factored Load (KN/m²)</th>
<th>Design Moment (Mₚ₀) (KN.m/m)</th>
<th>( \mu_{\text{ms}} )</th>
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<td>280</td>
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Construction and installation of services. Potential embodied carbon reductions of 41% for the slab. Further embodied carbon reductions for supporting structure. It is possible to incorporate heating/cooling within the slab to reduce operational energy consumption. Recycled HDPE spheres can be used. Downstand beams can be eliminated. Since the value of variable \( \mu_{\text{ms}} \) for all cases falls below 0.2, strength calculations of voided biaxial slabs can be performed same as conventional solid flat plate slabs with the substitution of modified moment of inertia.

**Recommendations**

Further studies should be conducted with a view of assessing the viability of VBSs as a new construction method of buildings.
Challenges in the Implementation of Knowledge Management Strategies
by Construction Consultancy Firms

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This paper presents the challenges experienced by construction consultancy firms in implementing knowledge management (KM) strategies. Its focus is on knowledge management (KM) strategies to increase the efficiency of the services these firms offer. The paper is based on a study carried out in Nairobi, Kenya in 2011, to look at the extent of use of KM by individual quantity surveying firms in Kenya.

The paper outlines how knowledge in consultancy firms is created and the challenges faced when disseminating it to other people within the firm and applying the same knowledge to future scenarios that may arise.

The most common challenges to the implementation of KM are pointed out to be: failure to align KM efforts to a firm’s objectives, failure to link KM to an individual’s work activities, an overemphasis on formal learning as a mechanism for sharing knowledge, and focusing KM efforts to within an organization’s boundaries.

It is recommended that further study be carried out on the extent of use of KM by contractors to consolidate the knowledge on this field for the construction industry.

Keywords: knowledge management, project organization, information, knowledge sharing, performance improvement
Introduction
The term Knowledge Management was coined by Karl Wiig in 1986 (Beckman, 1999). It refers to the ability of an organization to create, share and use the collective knowledge of its products, processes and people to increase workplace productivity and reduce activities that ‘reinvent the wheel’ (Fontaine & Lesser, 2002). KM focuses on the reuse of previous experiences to help improve future decisions. The need for KM in the construction industry can be gauged by considering common problems that may arise in a project. Egbu (2008) posits three questions that summarize these problems:

(i) If you do not employ direct labour, it may be that anything your employees learn on your job, they take with them to someone else’s job. How can you optimize the benefits of their learning by retaining knowledge in your business? (ii) You may be acutely aware that some of your projects are profitable, some break-even, and others make a loss. How can you transfer best practice across the projects? (iii) Is your own work affected by ignorance of others, be they clients, consultants, main contractors, trade contractors, or suppliers? Could sharing knowledge beyond your firmimprove your own project performance?

In a construction project, a lot of knowledge is generated, ranging from new ways of approaching particular problems, to an awareness of problems that may arise in the course of a project and the solutions to the same. KM is all about capturing this knowledge and passing it on to the next person who will find it useful should they experience similar situations in future.

Knowledge Management Application and Use
The key KM applications are based on a model that sees the role of KM as that of sharing knowledge in an organization in such a way that each individual or group understands the knowledge with sufficient depth and context so as to apply it effectively in decision making and innovation (Frappaolo, 2002). Four core KM processes can be distilled from an eight-stage process proposed by Beckman (1999): knowledge creation, knowledge capture and storage, knowledge sharing, and knowledge application. The core processes can be briefly described as follows:-

a) Knowledge Creation
This could be done through the acquisition of external knowledge, for example through mergers, recruiting new personnel, acquisition of patents and the use of consultants; or establishment of integrated project teams that include clients; or application of ‘lessons learned’ as well as ‘methods to elicit tacit knowledge’.

b) Knowledge Capture and Storage
This could be through manuals, databases, case studies and reports. This is explicit knowledge. Knowledge will also be stored in the memories of the company’s employees (tacit knowledge).

c) Knowledge Sharing
This is facilitated by various tools and methods which include information technology applications like the internet and the company intranet. It could also include document management systems, information retrieval engines, data warehouses and data mining tools (Dataware Technologies, 2006).

Despite the various theoretical advantages of applying KM in firms and to processes
projects. The main limitation of this form of knowledge transfer is that it relies on the goodwill of the person with the knowledge to identify opportunities to apply the knowledge on a different project, and a willingness to share the knowledge with other people.

2. Personal communication:
   This could be either formal or informal. Large amounts of personal and contextual information can be shared whenever people communicate and this kind of information is always more easily understood by the recipient. This form of knowledge sharing is limited by the fact that it relies on the right people having the right conversation at the right time.

3. Knowledge interview:
   In this form of knowledge ‘harvesting’, an interview is carried out on someone possessing specific knowledge, which the interviewer finds interesting or they think might be useful to others. Where the interviews are recorded, the information is guaranteed to be accessible for a longer time and whenever required.
   The limitation is that the interviewer may not necessarily know which knowledge may be useful to another person. The interview is best done by the final user of the sought knowledge.

4. After-action review:
   This allows an analysis of the performance of the project, on things that went well and where things could have been done better. For a fruitful after-action review meeting, the people involved in the project are brought together with potential users of the knowledge that will be generated during the meeting and informed outsiders who can ask leading questions.

5. Mentoring:
   This is where a member of an organization with valuable skills or knowledge, transfers the knowledge to younger, less experienced members of staff. Other than skills and experience, mentorship could also be about providing guidance and support. Even though mentorship tends to address the knowledge deficiencies of an individual rather than an entire organization, it can be used to generate a ripple effect where small mentorship networks are formed within the organization.

6. Secondment:
   Within an organization, this will take the form of moving a member of staff to a different part of the business or a different project. This helps the person gain knowledge of another aspect of the organization and may also challenge the people he finds in the new department by questioning the way they have been doing things. On returning to their original role, the secondee can also bring new experiences to his colleagues or project staff.

7. IT tools:
   These could take the form of project extranets, intranets or groupware, knowledge bases, knowledge mapping and case-based reasoning.

d) Knowledge Application
   This is the most essential task of KM. Successful application of KM can only be done after the prejudice of barriers within the firm have been overcome. Challenges in the Implementation of KM Strategies
   Despite the various theoretical advantages of applying KM in firms and to processes, this may not always be easy. Difficulties may be encountered in doing so. Fontaine & Lesser (2002), Carrillo et al. (2004) and Kagiri (2008) cite the following as the major barriers to the implementation of KM in construction companies: -

1. Lack of time
   The pressure to deliver products under a very tight schedule does not always permit a knowledge-sharing culture. This pressure is common in construction project, where the team members focus more on delivering a project and less on lessons learnt from the successes or failures of the project.
2. Failure to align KM efforts with the firm's objectives
Firms may fail to align their KM efforts with their most urgent business needs. When this occurs, significant time and effort is spent on projects that have minimal impact, while key needs are not addressed or are completely overlooked.

3. Lack of agreed standard work processes
This is a recurring problem in the construction industry where there are very few agreed standards procedures in running projects. This means that in the end there are very few processes that can be successfully borrowed from one project and directly implemented in a different one.

4. Negative organizational culture
This could be either at the firm or project level (or both) and could end up being a significant barrier to the implementation of KM. This is usually the case where small teams are formed and little communication takes place between them and where these are unwilling to admit the existence of a problem. An organization with a 'blame culture' where people tend to shift blame to other people will also not encourage knowledge sharing.

5. Creation of databases without addressing the need to manage content
A lot of attention might also be placed on the creation of databases (designed to capture and store structures, or written knowledge). These databases can take be as basic as a shared file systems or much more elaborate such as a fully implemented intranet site. Installing these systems without thinking about how the content will be managed can create a lot of problems. Firms have to realize that human intervention cannot be overlooked, for updating these spaces on a regular basis, soliciting content from practitioners, updating these spaces on a regular basis and getting rid of outdated or irrelevant information.

6. Organizational structure
Where an organization has a top-down structure, only the top management is considered capable of generating knowledge. Any knowledge generated by lower level employees can be easily disregarded. This will discourage the lower-level staff from sharing the knowledge they possess or acquire in the course of working on a project.

7. Failure to understand and connect KM into daily work activities of individuals
Some organizations implement a 'one-size-fits-all' KM solution without understanding the unique needs of various user groups. For KM strategies to be successful, they have to be customized to the daily activities of the people who are going to be used to generate, disseminate and apply the information.

8. Lack of social and analytical skills among the employees in an organization
These two skills are crucial for the knowledge manager and any other person interested in developing the knowledge bodies of any organization. As mentioned earlier, storytelling is an important means of sharing knowledge. This, however, requires that both the storyteller and the listeners be able to interact well at the social level.

9. Secrecy
Protracted efforts by firms to keep the knowledge they possess secret in an attempt to maintain a competitive advantage. This is contrary to the main focus of KM which encourages the sharing on knowledge both within and outside an organization.

10. Overemphasis on formal learning efforts as a mechanism for sharing knowledge
Formal learning techniques, such as classrooms and seminars, have traditionally been considered the most effective ways of sharing knowledge. Studies done (Center for Workforce Development, 1998) have, however, shown that over 70 percent of actual learning is accomplished through informal channels. This could take the form of communities of practice or mentoring programs.

Fontaine & Lesser (2002) state that successful companies recognize that significant learning occurs when employees attempt to jointly solve problems on a day-to-day basis. One way that organizations have fostered informal learning is by using and supporting communities of practice, or informal groups of employees who have a common way of working.

These communities bring...
individuals together to ask questions, share documents and tools, and provide a forum where practitioners can tap into the experiences of others.’ Mentoring programs are important in the transfer of tacit knowledge associated with operating in a given environment.

Research has shown that mentoring programs not only help junior employees better understand informal organizational rules and guidelines, but can also increase the job satisfaction of senior employees who can be recognized for their experience and insights (Fontaine & Lesser, 2002). Story-telling has also been listed as a very important tool when it comes to sharing knowledge within an organization.

Egbu (2008) points out that what is not just the successes or failures people tell stories about, but the discussion and debates this stimulates. A story can ‘pave the way’ for a person to ‘open-up’ and describe an issue that they’re grappling with or ask for help. Furthermore, stories spread. Story telling also helps identify in an organization who possess what kind of knowledge.

11. Lack of investment in information technology
Lack of any form of a computerized KM system constrains knowledge sharing and distribution. Dataware Technologies (2006), point out that Information Technology is crucial to successful KM implementation, but Sena & Shani (1999) and Egbu (2008) note that knowledge sharing need not necessarily involve huge capital investment or IT systems. But all studies indicate that a minimum investment is required to facilitate ease of retrieving and updating the information a firm will eventually deem to be knowledge.

12. Focusing knowledge management efforts only within organizational boundaries
Most organizations begin with internal knowledge-management efforts designed to share knowledge between employees and across the organization. Although these efforts are often valuable, many organizations stop here and don't consider the potential business opportunities associated with sharing knowledge with suppliers and customers.

Research has shown that KM programs that focus beyond an organization’s boundaries on the extended enterprise often provide additional avenues for cost savings, revenue enhancement and customer retention (Fontaine & Lesser, 2002).

Conclusions and Recommendations
Previous studies indicate that most firms practice one form or another of KM, albeit in varying degrees (Oluoch, 2011). Seeing the importance that KM occupies in modern-day business management, this is an area that firms should be encouraged to focus on. As a discipline, KM has steadily gained popularity over the last 20 years as a means of capturing and monitoring ever-developing bodies of intellectual capital, and promoting its leverage (Frappaolo, 2002).

This systematic and deliberate management of knowledge assets is necessary to ensure corporate survival (Carrillo et al., 2004). The important thing in KM is to start the process. Egbu (2008) outlines the steps that have to be taken to make knowledge sharing fruitful in an organization.

The first step is to inculcate a culture of knowledge-sharing and get rid of the ‘blame culture’. Knowledge
sharing comes naturally in a culture where there is trust and people feel 'safe' - where they can express views or admit problems without feeling they'll get victimized.

There's also reciprocity - others will share their experiences and views - and this is the discussion that facilitates knowledge sharing. Trying to implement an initiative such as knowledge interviews, or after action reviews, within a blame culture, is unlikely to succeed. A firm will need to do the following in order to make their knowledge-sharing initiative work:

1. Focus on business-critical knowledge: an organization must establish what kind of knowledge that must be managed to improve a specific aspect of the business.

2. Create senior management support: the backing of top managers is shown to improve the success of KM initiatives. It has to become clear that learning takes place at all levels of the organization and not just at the lower levels.

3. Provide an incentive: the people in the organization need to be given incentives to get involved in the KM initiative; the best incentive is to convince them that sharing knowledge makes their job easier.

4. Develop continuous learning: an organization should allow people time for learning and development, sometimes even within 'working hours'. They should also be encouraged to take the lessons of success and failure from every project they work on. They should also be encouraged to ask questions.

5. Measure performance improvement: after the introduction of a KM initiative, key performance indicators have to be put in place to measure its success. The indicators have to check whether: problems are solved more quickly, more easily, with fewer frustrations. Over time, this success will show itself in the rate of staff retention or increased profits.

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Construction industry in Kenya plays a vital role in achieving social economic development goals, providing shelter, infrastructure and employment. Safety at construction sites is often compromised in a market driven society where concern is for completion of projects at the required quality, at minimum cost and time.

A study was carried out to identify the common accidents in construction sites and to evaluate factors that cause these construction sites in Nairobi County, Kenya. The research adopted a questionnaire survey where a study was carried out in 41 construction sites sampled from all the 9 regions in Nairobi and identified the common accidents in construction sites and factors contributing to the accidents in construction sites. The results show that out of a population of about 6,295 construction workers there were 571 cases of reported injuries of varying severity each year; 391 cases were minor not requiring time off duty, 119 required up to 3 days off, 51 required more than 4 days off duty and 4 were fatal cases.

Therefore, the results show that Kenya experiences about 64 fatalities per 100,000 employees each year which is high compared to UK which experienced 0.44 fatalities per 100,000 employees in 2013, China experienced 3.8 fatalities per 100,000 employees in 2013 while South Africa experienced 25.5 fatalities per 100,000 employees in construction sites. In the study conducted on Nairobi, most injuries in construction sites was as a result of being hit by falling objects (17%), injuries as a result of workers falling from heights (15%) injuries as result of operating motor vehicles or light machines (13%) and...
The main factors that cause these accidents are reluctance to provide resources for safety (12%), lack of training (12%), lack of enforcement of rules and regulations (12%), poor safety consciousness among workers (11%) and lack of strict operational procedures (11%) in construction sites. To reduce accidents in construction sites in Kenya, companies need to provide workers with the necessary Personal Protective Equipment (PPE), which include safety belts, retaining belts, safety ropes, safety harness and catch nets to prevent being hit by falling materials and falling from heights.

In order to improve safety in the construction industry, health and safety should be included right from preparation of contract documents and there is need to provide funding for the regulatory body that oversees safety in construction industry.

Keywords: Safety, occupational safety and health (OSH), construction site, Nairobi, Kenya.

Introduction

Infrastructure development accounted for 8.7 per cent of the total budget for Financial Year 13/14 of the total budget of KES 1.6 Trillion (KNBS, Economic Survey Report, 2013). According to the Economic Survey report, 2013, the construction sector has generated new jobs and has grown by 62% between 2007 and 2013 ahead of other economic sectors.

In 2011, construction industry accounted for 16% of fatal accidents (40 cases reported for 100,000 workers) and 7% of non-fatal cases (DOHSS Annual Report, 2011). Many workers have met their deaths in construction sites while others have become permanently crippled from construction related injuries.

Further, laws on occupational safety and health are not strictly enforced. Safety rules in most construction sites do not exist and if they exist, the regulatory authority is weak in implementing each rule effectively. When accidents occur, they result on both direct and indirect cost. Direct cost includes, medical bills, premium for compensation benefits, liability and property loss. Indirect cost include, time lost while attending burial ceremonies, time lost in investigation, down time...
on damaged equipment and losses arising from site closure. Although regulations in occupational safety and health in Kenya are quite comprehensive, Directorate of Health and Safety (DOHS) do not have the capacity to strictly undertake safety inspection and audit at regular times thus making accidents at construction sites to be alarming.

There is a need to determine why the number of accidents and fatalities in Kenya are still at very high level. It is very important to find any loopholes in enforcing the requirements of Safety Acts or any weaknesses in inspecting and auditing construction sites. In order to address these shortfalls, this research seeks to find out why accidents levels in construction industry are still high despite the legislation passed. This will help establish the strategies by policy makers in seeking to reduce the number of the accidents in construction industry.

To develop a safe construction sites in Kenya, owners, contractors and regulatory agencies are obliged by law to help to provide safe work environment to minimize injuries. The owner cannot have hands-off approach towards safety because construction activity will take place in the owner's property. Architects, Engineers, Project managers and employees also need a tool to integrate safety and health measures in project planning.

It's against this background that it's pertinent to examine the safety of construction sites in Nairobi County in Kenya. This study was undertaken to identify the common accidents in construction sites in Nairobi County, Kenya and to evaluate factors affecting health and safety performance in construction sites in the study area.

**Literature Review**

The difference in accident rates between developed and developing countries is high (Hamalainen et al, 2006). In Sub-Saharan Africa, the fatality and injury rates in construction industry are at 21 and 16,012 per 100,000 workers respectively (CIBD, 2010). These records are higher than the average fatality rate at 4.2 and injury rate of 3,240 per 100,000 in developed countries (CIBD, 2010). According to United Kingdom Health and Safety Executive (HSE) Report 2013/2014, there were 0.44 deaths per 100,000 workers in FY 2013/2014 and 0.56 deaths per 100,000 workers in FY 2012/2013.

In China, there are 3.8 deaths per 100,000 workers in construction industry in 2013 (China Statistical Yearbook, 2013). In South Africa, Smallwood et al, 2013 established there were 25.5 deaths per 100,000 workers in construction industry in South Africa. This shows accidents in construction industry in Kenya are still high going by the annual DOHSS Reports. It has been acknowledged that 25-40% of fatalities in the world’s occupational setting are contributed to construction (ILO, 2005).

It has been further noted that throughout the world, construction is one of the most hazardous industries (Suazo G. A. and Jaselskis E.J. 1993). The major causes of
these accidents are related to the unique nature of construction industry, human behavior, difficult work site conditions and poor safety management, which result in unsafe, work methods and procedures (Koehn et al. 1995).

When construction industry is compared with other labour intensive industries, construction industry has experienced a disproportionately high rate of disability injuries and fatalities (Hinze J. W., 1997). Hughes and Ferret, (2005) identified the common accidents on site to be falling from heights, cutting of limbs due to mishandling heavy equipment, objects falling from height, electric shock from cables, caving in of excavations and lifting of heavy tools and equipment.

They further stated that, workers are also deemed to cause site accidents due to fatigue, lack of discipline, carelessness and distractions. Other causes are attributed to the senior management ignorance, lack of training and poor communication.

Research done by Dedobbeleer and Beland, (1991); Ringen et al., (1995); Gillen et al, (1997); Laitinen et al., (1999); Loosmore and Lee, (2001); Tam et al., (2004); Cheng et al., (2010); Sertyesilisik et al., (2010); Tam and Fung, (2011) identified a number of relevant causes influencing safety performance in the construction industry namely: Poor safety awareness from top leaders, Lack of training, Poor safety awareness of project managers, Reluctance to input resource on safety. Reckless operation of machines, Lack of certified skilled labor, Poor maintenance of equipment, Lack of first aid measures, Lack of rigorous enforcement of safety regulation, Lack of organizational commitment, Low level of education of workers, Poor safety consciousness of workers, Lack of personal protective equipment, Ineffective operation of safety regulation, Lack of technical guidance, Lack of strict operational procedures, Lack of experienced project managers, Shortfall of safety personnel on site, Lack of protection of material during transportation, Lack of protection of material during storage, Lack of teamwork sprit, Fatigue by workers, Shortage of safety management manuals, Lack of innovative technology on safety and Poor information flow.

Pipitsupaphol and Watanabe (2006) did a study in Thailand construction sites and classified causes of accidents as unique nature of the industry, job site conditions, unsafe equipment, unsafe methods, human elements and management elements.

Other factors identified are, failure to use personal protective equipment, improper loading or placement of equipment or supplies, failure to warn co-workers or to secure equipment and improper use of equipment. Whereas many research efforts have been made in identification of causes of accidents in construction industry, research has also been done in construction safety. In 1931, Heinrich suggested that unsafe acts are the cause of a high percentage of accidents.

His study found out that 88% of accidents in construction were caused by people while 10% of accidents were attributed to unsafe conditions. Heinrich was the first researcher to suggest that incidents are symptoms of lack of management commitment to safety.

He summarized that 98% of accidents are preventable by management. Komaki, (1986), reemphasized Heinrich’s theory and suggested that monitoring and providing feedback as attributes of effective management. Research Methods Various methods were employed in this study.

This research commenced by reviewing the relevant literature on previous research through study of academic journals in order to develop in-depth understanding about accidents in construction sites. Based on the literature review, the researcher designed a questionnaire for collecting data. The initial questionnaire was revised based on interviewees’ feedback. The literature review was followed by data collection, data analysis, discussion and conclusion. The questionnaire developed had two main sections; the first section has general information on the construction company, the number of years of existence, their specialization in construction work the company undertakes and the number of employers.
The study also establishes the professional body the company is registered with, classification and the approximate value of the contract currently being undertaken. The second section of the questionnaire evaluates in details health and safety procedures. The study seeks to establish the number of accidents in each construction site for the last three years, common construction site accidents, budget the companies allocate to health and safety and causes of construction site accidents.

The questionnaires were distributed to a sample of construction sites of ongoing projects. While selecting the sample, the researcher considered the main administrative divisions of Nairobi which are Central, Dagoreti, Embakasi, Kasarani, Kibera, Karen, Makadara, Pumwani and Westlands. The nine major administrative regions in Nairobi were used as a sampling frame out of which five regions were selected using cluster sampling. The regions of Nairobi County covered were North, South, East, West and Central Business District. Data was collected between 4th February 2014 and 6th June 2014.

The study area targeted Nairobi County construction sites, which comprised of general building contractors and sub-contractors. The sampling frame consisted of large and medium sized contractors, which have registered with Building and Civil Engineering contractors in Kenya and Kenya Property Developers Association.

The research focused on middle and large contractors in Nairobi County.

The target respondents were persons who are well versed in construction work and in particular accidents at site such as project engineer, site manager, site engineer, safety and health officer, site supervisor, clerk of works and site agents. Respondents were from contractors as classified by the National Construction Authority (NCA) as Class 1, 2, 3 and 4 operating in Nairobi County.

The respondents selected were expected to have extensive working experience in construction industry and were involved in construction at the time of data collection. The validity of the results was dependant on the responses from the sample. The selection of experts on construction sites was deemed to be of utmost importance. The study established the common construction accidents using Likert Scale between 0 and 5 where 0 indicate ‘accidents did not happen’ and 5 ‘frequency of the accidents is high’ so as to create level of importance of each factor.

Common construction accidents which were identified in the introduction of the research were; Hit by falling objects, Falling from heights, Use of light machines with motor, lifting of heavy weights, Operating heavy machines, Toxic or suffocation, collapse of earthwork, electrocution and Fire Explosion. Statistical analysis was conducted using the Statistical Package for Social Science (SPSS) so as to get the mean values of each factor and the ranking of the importance.

The study further seeks to establish the relative importance of the twenty five (25) factors identified by researchers highlighted in the introduction that contribute to the construction site accidents. Using Likert scale between 1 and 5 where 1 ‘the least contributing factor in construction accidents’ and 5 ‘the most contributing factor in construction accidents’ to create a level of importance of each factor.

Further, Statistical analysis was conducted using the Statistical Package for Social Science (SPSS). To determine relative ranking of the factors above, the scores were transformed to important indices based on Formula by Tam et al (2000).

Relative Importance, \[
W = \frac{A}{N}
\]

Where \(W\) = Weightage given to each factor by respondents. \(A = \text{Highest Weight}\). \(N = \text{Total number of respondents concerning that factor}\). The Relative Importance is normalized to fall within 0 to 1 range. The number of questionnaires that were duly filled and returned was 41 representing 68% response. From the 41 questionnaires received, all were filled and usable. Data were checked, edited, coded and analysed.

Data Analysis and Results
(1) Causes of construction site accidents in Nairobi County

The total number of employees in 41 construction sites studied in Nairobi was 6295. The annual number of reported accidents were classified as Minor 1 (injuries not
requiring time off duty); Minor 2 (Injuries requiring up to 3 days off duty); Severe (injuries requiring at least 4 days off duty) (Figure 1).

This shows that Kenya experiences about 64 fatalities per 100,000 employees each year (Figure 2). In the UK, the number of fatal accidents changed from 0.56 per 100,000 employees per year in 2012, to 0.44 fatalities per 100,000 per year in 2014 (UK Health and Safety Executive, 2014). In China, there are 3.8 deaths per 100,000 workers in construction industry in 2013 (China Statistical Yearbook, 2013). South Africa experiences 25.5 construction site

Table 1. Common construction site accidents in Nairobi

<table>
<thead>
<tr>
<th>Type of accident</th>
<th>Significance (%)</th>
<th>Type of accident</th>
<th>Significance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Being hit by falling materials</td>
<td>17</td>
<td>Suffocation</td>
<td>9</td>
</tr>
<tr>
<td>Falling from heights</td>
<td>15</td>
<td>Collapse of earthwork</td>
<td>9</td>
</tr>
<tr>
<td>Injury from motor operated machines</td>
<td>13</td>
<td>Electrocution</td>
<td>8</td>
</tr>
<tr>
<td>Injury from lifting of heavy weights</td>
<td>11</td>
<td>Fire &amp; explosion</td>
<td>8</td>
</tr>
<tr>
<td>Injury from use of heavy machine</td>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Occurrence of accidents in Kenya

Figure 2. Comparison of fatal accidents per 100,000 employees per year in various countries.
fatalities per 100,000 workers per year (Smallwood et al., 2013). Therefore, Compared to developed countries Kenya experiences a very large number of fatalities (about 64 deaths per 100,000 construction workers per year).

According to Table 1, the five most significant causes of injuries in Kenya’s construction sites include being hit by falling objects (17%); falling from heights (15%); motor operated machines (13%); lifting of heavy weights (11%); and the use of heavy machines (10%). Various researchers have also found falling from heights, being struck by falling items and electric shock to be responsible for construction site fatalities (Reese and Edison, 2006; Hinze and Russel, 1995).

Florence et al. (2008) found that in Singapore falling from heights was responsible for 55% of fatalities while being hit by falling objects caused 37.5% of the fatalities.

Figure 2. Number of Fatalities Resulting from Construction Site Accidents Tam et al (2004) working in China, and Florence et al. (2008) working in the United States found the most significant cause of accidents in construction sites to include falling from heights (37-50%), electrocution (5-13%), hit by falling objects (12-21%), collapse of earthwork in China (9%) and injuries due to use of heavy machine in China (9%).

This shows a slightly different scenario where falling from heights is the most significant cause of accidents. This be because of the higher level of development and hence more construction of high rise buildings.

Ayman Ahmed (2010) established that most construction site accidents in South Africa were occurred as a result of falling from heights (28.18%), hit by falling objects (22.85%), electrocution (19.57%) injuries from motor operated machines like motor vehicles and concrete mixers (18.51%).

It may be concluded that being hit by falling objects and falling from heights contributes towards about 32% of all construction site accidents. Therefore construction companies need to provide workers with the necessary Personal Protective Equipment (PPE), which include safety belts, retaining belts, safety ropes, and safety harness and catch nets to prevent being hit by falling materials and falling from heights.

Furthermore, workers need to be continuously trained on the importance of using PPE.

(2) Factors contributing to construction site accidents in Nairobi County

As is evident in Table 2, the ten most significant factors affecting safety in construction sites include Reluctance to invest in safety (12%); Lack of training (12%); Lack of enforcement of safety regulation (12%); Poor safety consciousness of workers (11%); Lack of strict operational procedures (11%); Poor safety awareness from top leaders (11%); Lack of personal protective equipment (10%); Lack of management support (9%); Ineffective operation of safety regulation (9%); and Shortfall of safety personnel on site (9%).

Table 2. Causes of construction site accidents in Nairobi

<table>
<thead>
<tr>
<th>Type of accident</th>
<th>Significance (%)</th>
<th>Type of accident</th>
<th>Significance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reluctance to invest in safety</td>
<td>12.0</td>
<td>Lack of technical guidance</td>
<td>9.6</td>
</tr>
<tr>
<td>Lack of training</td>
<td>11.9</td>
<td>Lack of experienced project managers</td>
<td>9.6</td>
</tr>
<tr>
<td>Lack of enforcement of safety regulation</td>
<td>11.7</td>
<td>Lack of certified skilled labor</td>
<td>9.4</td>
</tr>
<tr>
<td>Poor safety consciousness of workers</td>
<td>11.2</td>
<td>Low level of education of workers</td>
<td>8.8</td>
</tr>
<tr>
<td>Lack of strict operational procedures</td>
<td>11.1</td>
<td>Poor maintenance of equipment</td>
<td>8.7</td>
</tr>
<tr>
<td>Poor safety awareness from top leaders</td>
<td>10.9</td>
<td>Lack of first aid measures</td>
<td>8.6</td>
</tr>
<tr>
<td>Lack of personal protective equipment</td>
<td>10.7</td>
<td>Lack of teamwork spirit</td>
<td>8.5</td>
</tr>
<tr>
<td>Lack of organizational commitment</td>
<td>10.3</td>
<td>Lack of innovative technology on safety measures</td>
<td>8.2</td>
</tr>
<tr>
<td>Reckless operation of machines</td>
<td>10.2</td>
<td>Poor information flow</td>
<td>7.8</td>
</tr>
<tr>
<td>Poor safety awareness from top leaders</td>
<td>10.2</td>
<td>Fatigue by workers</td>
<td>6.9</td>
</tr>
<tr>
<td>Shortfall of safety personnel on site</td>
<td>9.8</td>
<td>Shortage of Safety management manuals</td>
<td>6.3</td>
</tr>
<tr>
<td>Ineffective operation of safety regulation</td>
<td>9.6</td>
<td>Lack of protection of material during transportation</td>
<td>6.1</td>
</tr>
<tr>
<td>Lack of protection of material during storage</td>
<td>5.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
protective equipment (11%); Lack of organizational commitment (10%); Lack of competence in Machine operation (10%) and Poor safety awareness from top leaders (10%).

Effective safety training reduces the number of construction site accidents (O’Toole, 2002). This study showed that lack of training in health and safety contributes about 12% towards construction site accidents.

Kenya has very few certified safety trainers (DOSHS, 2011). Health and safety training should be offered as a separate subject within Construction Management, Civil Engineering, Project Management and Architectural programs.

Lack of enforcement of safety regulation by DOSH contributed 12% of the accidents. DOSH has inadequate staffing compared with increased workload has continued to affect the smooth running while discharging their duties (DOSHS, 2011). Work Injury Benefits processing take a lot of officers and support staff time leaving them with little time to perform other official duties as specified in their performance contracts.

This has been largely attributed to the inability of the Directorate to attract and retain qualified personnel. Another challenge faced by field officers was lack of transport to cover all workplaces within their jurisdiction. This resulted in officers not reaching all areas that fall under them and in most cases inspections carried out concentrated within a small area within Nairobi’s Industrial Area.

In the US, Irrizary and Abraham (2006) identified that lack of awareness of dangers in the construction industry, lack of safe behavior and lack of safety training as the factors influencing accident occurrence in construction.

This could also be the case in Kenya where 61% of surveyed companies had projects valued at over KES 500 Million (Figure 3); and yet 63% of the construction companies budgeted less than KES 0.5 Million per year (Figure 4) to cater for health and safety. Most of the construction sites visited lacked safety policy and written documents that enforces safety in the construction site.

According to MacCollum 1995, project managers have a safety responsibility to prepare project safety plan, identify potential hazards at the site, prepare a written safety plan and insist on reporting of injuries, death and property damage as a result of accidents. The construction industry in Kenya does not seem to have a clear policy and a regulatory body that deals with accidents in construction sites.

**Conclusion**

This study concludes that compared to developed countries Kenya still experiences a large number of fatalities (about 64 deaths per 100,000 construction workers...
per year). Being hit by falling objects and falling from heights contributes towards about 32% of all construction site accidents.

Majority of the construction companies do not have specific budget for health and safety and allocate less than 1% of the project budget to health and safety. This could be because the construction industry does not seem to have a clear policy.

**Recommendations**

Construction companies need to provide workers with the necessary Personal Protective Equipment (PPE), which include safety belts, retaining belts, safety ropes, and safety harness and catch nets to prevent being hit by falling materials and falling from heights. Furthermore, workers need to be continuously trained on the importance of using PPE. Funding for the regulatory body needs to be improved. In order to improve safety in the construction industry, health and safety should be included right from preparation of contract documents.

All employees from top management should undergo proper job related health and safety training. This can be done through customized or tailored courses, workshops, seminars, conferences or field demonstrations. Universities and technical colleges that teach Civil Engineering should also introduce safety training from undergraduate level.

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Module I  KCSE Mean Grade C-
• Certificate   Mean Grade D (Plain)
• Minimum Entry Requirement;

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Road Construction
• Refrigeration & Air Conditioning
• Pastries
• Motor Vehicle Mechanic
• Certified Information Communication Technologist

Metal Work Processes & Technology
• Certified Public Accountant (CPA)

Technology
• Food Preparation & Culinary Arts
• Relevant Diploma
• Minimum Entry Requirement for Diploma

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• Bachelor of Science in Geomatic and Geospatial Information Systems
• Bachelor of Science in Geospatial Information Science (4 years)

June 2010
Risk Management in Civil Engineering and Construction Projects
Alexander Khamala Opicho, Email: aopicho@yahoo.com or opichoalexander@gmail.com

Risk is any deviant outcome with quantifiable negative consequences on the project progress. In civil engineering, eventuality of risk can be economically disastrous or capable to occasion death depending on the peril and hazard level of the risk occurring. It has been a regular experience in the Kenyan urban building and construction sector. Often, it has been occurring only where the otherwise of the expected project process is the experience. This paper uses phenomenological approach to explore the nature and meaning of engineering project risks, factors that account for engineering project risk, process of engineering risk management, methods of engineering risk control and the expected future management practices that can help as strategy against occurrences of engineering project risks.

Key words:
Risk, engineering project, peril, plan, event

Introduction
The Oxford English Dictionary cites the earliest use of the word risk in English in the spelling of risqué from its Arabic original as: Exposure to the possibility of loss, injury, or other adverse or unwelcome circumstance; it is also a chance or situation involving such a possibility. In the world of engineering project management, Bartolt (2010) defines a risk as an uncertain event or condition that, if it occurs, has an effect on at least one project objective. Risk is also the probability of something happening multiplied by the resulting cost or benefit if it does.

This is more properly known as the ‘Expectation Value’ or ‘Risk Factor’ and is used to compare levels of risk. Project risk in engineering is the probability or threat of quantifiable damage, injury, liability, loss, or any other negative occurrence that is caused by external or internal vulnerabilities, and that may be avoided through preemptive action. The human resource management definition of risk is expressed as a product of the consequence and probability of a hazardous event or phenomenon.

For example, the risk of developing cancer is estimated as the incremental probability of developing cancer over a lifetime as a result of exposure to potential carcinogens cancer-causing substances at the workplace or in a given occupation. Types of engineering risks Mar (2013) in an online Journal Management Simplifiable, identifies 22 types of engineering project risks. These are discussed as below:
(1) Executive Support risk:
Wavering, inconsistent or weak executive commitment is often a project's biggest risk. This can be difficult but not impossible to document. Ask for specific commitments. Where you are denied you can document it as a risk.

(2) Scope risk:
The quality of your estimates, dependencies and scope management make a risk if an estimate is just a guess, that's a risk. Be sensitive to the comfort level of estimates. If your team is unsure about a particular estimate, you can document this as a risk.

(3) Change Management risk:
A continuous flow of complex change requests can escalate the complexity of your project and throw it off course. Change requests may lead to a perception that a project has failed because they continually add budget and time to the project. If requirements are missing items that are expected to come later, that's a risk.

(4) Stakeholders risk:
Stakeholders with a negative attitude towards a project may intentionally throw up roadblocks every step of the way. If you anticipate conflict or a lack of cooperation between stakeholders, document it as a risk.

(5) Resources & Team risk:
Resource issues such as turnover and learning curves are common project risks. There's always a risk that your key experts will leave. If your team are inexperienced or need to acquire new skills, that's another risk.

(6) Design risk:
The feasibility and flexibility of architecture and design is key to your project's success. Low quality design is a risk. You might want to highlight the design of complex or experimental components as separate risks.

(7) Technical risk:
The risk that components of your technology stack will be low quality. There are dozens of quality factors for technical components like stability, availability, scalability, usability, security and extensibility. It's a good idea to identify specific risks in components, for example, the risk that a component will have a security flaw.

(8) Integration risk:
Whatever you're delivering needs to integrate with the processes, systems, organizations, culture and knowledge of the environment. Integration risks are common.

If you need to integrate your project into a business process there's a risk that the process will be disrupted. This may represent a significant business impact. In 1999, a ERP implementation at Hershey's disrupted manufacturing and distribution operations. The company was unable to process $100 million in orders. Quarterly profits dropped 19 percent.

(9) Communication risk:
Invalid stakeholder expectations are a consolidation of fundamental project risk. If the stakeholders think you're building an orange but you're building an apple — your project will fail. If stakeholders become disengaged like ignore project communications. That's a risk.

(10) Requirements risk:
Garbage in, garbage out. If requirements aren't feasible or are detached from business realities, your project may fail. Look at the feasibility, quality and completeness of requirements to identify risks. Look at whether requirements are possible to integrate with organizations, processes and systems.

(11) Decision Quality risk:
Slow, low quality or ambiguous decisions are common risks.

(12) Feasibility risk:
Risk identification is a critical time to consider the feasibility of the project. Ask the key members of your team to do their own sanity checks. List any doubts about feasibility as risks.

(13) Procurement risk:
The procurement process is ripe with risks. For example, there's a risk that you won't find an acceptable proposal to an RFP. There's also a

Evaluating the risk for probability of occurrence and the severity or the potential loss to the project is the next step in the risk management process.
risk that your vendors won’t deliver to the terms of their contracts.

(14) **Quality risk:**
Quality and risk management are intertwined. You’ll expect to have defects in your project. However, there’s a risk that quality won’t meet basic levels. Significant rework may trigger project failure. Identify quality related risks for process inputs and outputs. Identify quality risks for infrastructure, work packages, components and products.

(15) **Authority risk:**
Project teams often lack authority to complete project work. In many cases, teams are expected to influence to achieve project objectives. This reflects business realities. For example, your project may cross-organizational boundaries. It’s rare that a project team doesn’t depend upon influence. It’s a useful exercise to think of risks in terms of a lack of authority, if you need to influence to secure infrastructure, cooperation or inputs. There’s always a chance the answer will be no.

(16) **Approvals and Red Tape:**
If you anticipate that red tape like financial approvals will slow down your project — add this as a risk.

(17) **Organizational risk:**
Organizational change restructuring, mergers, acquisitions will throw your project off track. Think about the minimum stability that your products require launching. List potential organizational changes as risks.

(18) **External risk:**
External forces such as laws, regulations and markets. If your project touches compliance-sensitive processes, regulatory change is a risk.

(19) **Secondary Risks:**
Secondary risks are often overlooked aspect of risk. Secondary risks are the result of risk mitigation and transfers. Let’s say you transfer a risk to a vendor with a fixed price contract. The contract itself represents a counterparty risk. You’ve replaced a series of project execution risks with a series of procurement risks.

(20) **User Acceptance risk:**
There’s always a chance that users will reject your product. You can build a product that matches requirements (on time and to budget). However, if users reject the product the project will be considered a failure. (21) **Cultural risks:** Corporate or project culture risk.

(22) **Commercial or marketing risk:**
If you’re building a commercial product for market, like new product development, there’s always a chance the product will be a commercial failure. This should be documented as a project risk.

Human factors as an influence on the engineering risks In the fieldwork done for this paper, in the month of July 2015, a sample of 20 civil engineering projects in Eldoret town were purposefully sampled for the purpose of data collection.

Supervisors, consultants and technicians were interviewed on the perspectives of causes of engineering risks. It was averagely deduced that human factors are the dominant risk factors in any engineering process.

This falls in tune with the position of the previous studies which posited that, one of the growing areas of focus in risk management is the field of human factors where behavioral and organizational psychology underpin our understanding of risk based decision making.

For instance, a contemporary analysis can have it that an extremely disturbing like an attack by Al Shabaab hijacking, or moral hazards may be ignored in analysis despite the fact it has occurred and has a nonzero probability. Or, an event that everyone agrees is inevitable may be ruled out of analysis due to greed or an unwillingness to admit that it is believed to be inevitable.

These human tendencies for error and wishful thinking often affect even the most rigorous applications of the scientific method and are a major concern of the philosophy of science.

Risk management process Hillson (2003) enumerates the major elements in the process of managing project risk as:

- describing the processes for
identifying project risk, describing the processes for evaluating risk, and describing the processes for mitigating risk.

(1) Risk identification:
He goes further to argue that, managing risks on projects is a process that includes risk assessment and a mitigation strategy for those risks. Risk assessment includes both the identification of potential risk and the evaluation of the potential impact of the risk. A risk mitigation plan is designed to eliminate or minimize the impact of the risk events—occurrences that have a negative impact on the project. Identifying risk is both a creative and a disciplined process.

The creative process includes brainstorming sessions where the team is asked to create a list of everything that could go wrong. All ideas are welcome at this stage with the evaluation of the ideas coming later. On risk identification, Alison argues that, this is a more disciplined process that involves using checklists of potential risks and evaluating the likelihood that those events might happen on the project.

Some companies and industries develop risk checklists based on experience from past projects. These checklists can be helpful to the project manager and project team in identifying both specific risks on the checklist and expanding the thinking of the team. The past experience of the project team, project experience within the company, and experts in the industry can be valuable resources for identifying potential risk on a project.

Alison makes further efforts to point out that, potential risks sources to be indentified are; Technical, Cost, Schedule, Client, Contractual, Weather, Financial, Political, Environmental and People. The most peculiar is people category that can be subdivided into risks associated with the people. Examples of people risks include the risk of not finding the skills needed to execute the project or the sudden unavailability of key people on the project. David Hillson uses the same framework as the work breakdown structure (WBS) for developing a risk breakdown structure (RBS).

(2) Risk evaluation:
Alison further argues that, after the potential risks have been identified, the project team then evaluates the risk based on the probability that the risk event will occur and the potential loss associated with the event. Not all risks are equal. Some risk events are more likely to happen than others, and the cost of a risk event can vary greatly.

Evaluating the risk for probability of occurrence and the severity or the potential loss to the project is the next step in the risk management process. He further notes that, having criteria to determine high impact risks can help narrow the focus on a few critical risks that require mitigation.

For example, suppose high-impact risks are those that could increase the project costs by 5% of the conceptual budget or 2% of the detailed budget. Only a few potential risk events met these criteria.

These are the critical few potential
Risk events that the project management team should focus on when developing a project risk mitigation or management plan. Risk evaluation is about developing an understanding of which potential risks have the greatest possibility of occurring and can have the greatest negative impact on the project.

These become the critical few. Risk evaluation often occurs in a workshop setting. Building on the identification of the risks, each risk event is analyzed to determine the likelihood of occurring and the potential cost if it did occur. The likelihood and impact are both rated as high, medium, or low.

A risk mitigation plan addresses the items that have high ratings on both factors—likelihood and impact. Risk analysis of equipment delivery is given by Parker (2013). He comes out beautifully on this matter by arguing that a project team analyzed the risk of some important equipment not arriving to the project on time.

The team identified three pieces of equipment that were critical to the project and would significantly increase the costs of the project if they were late in arriving. One of the vendors, who were selected to deliver an important piece of equipment, had a history of being late on other projects. The vendor was good and often took on more work than it could deliver on time.

This risk event, the identified equipment arriving late, was rated as high likelihood with a high impact. The other two pieces of equipment were potentially a high impact on the project but with a low probability of occurring.

Not all project managers conduct a formal risk assessment on the project. One reason, as found by David Parker and Alison Mobey in their (2013) phenomenological study of project managers, was a low understanding of the tools and benefits of a structured analysis of project risks.

The lack of formal risk management tools was also seen as a barrier to implementing a risk management program. Additionally, the project manager’s personality and management style play into risk preparation levels. Some project managers are more proactive and will develop elaborate risk management programs for their projects.

Other managers are reactive and are more confident in their ability to handle unexpected events when they occur. Yet others are risk averse, and prefer to be optimistic and not consider risks or avoid taking risks whenever possible. They further argued that, on projects with a low complexity profile, the project manager may informally track items that may be considered risk items.

They also pointed out that on more complex projects, the project management team may develop a list of items perceived to be higher risk and track them during project reviews. On projects with greater complexity, the process for
evaluating risk is more formal with a risk assessment meeting or series of meetings during the life of the project to assess risks at different phases of the project.

On highly complex projects, an outside expert may be included in the risk assessment process, and the risk assessment plan may take a more prominent place in the project execution plan. Parker and Mobey further discussed that on complex projects, statistical models are sometimes used to evaluate risk because there are too many different possible combinations of risks to calculate them one at a time.

They gave one example of the statistical model used on projects is the Monte Carlo simulation, which simulates a possible range of outcomes by trying many different combinations of risks based on their likelihood.

The output from a Monte Carlo simulation provides the project team with the probability of an event occurring within a range and for combinations of events. For example, the typical output from a Monte Carlo simulation may reflect that there is a chance that one of the three important pieces of equipment will be late and that the weather will also be unusually bad after the equipment arrives.

(3) Risk mitigation:

Parker (2013) discussed further that after the risk has been identified and evaluated, the project team develops a risk mitigation plan, which is a plan to reduce the impact of an unexpected event.

He further pointed out that the project team mitigates risks in the following ways: risk avoidance, risk sharing, risk reduction and risk transfer. Going by practical experience of this paper in the field at different engineering sites in Eldoret town, it can be argued that each of these mitigation techniques can be an effective tool in reducing individual risks and the risk profile of the project.

The risk mitigation plan captures the risk mitigation approach for each identified risk event and the actions the project management team will take to reduce or eliminate the risk.

A rudimentary explanation of the above listed mitigation approaches are given below: -

(i) Risk avoidance usually involves developing an alternative strategy that has a higher probability of success but usually at a higher cost associated with accomplishing a project task.

A common risk avoidance technique is to use proven and existing technologies rather than adopt new techniques, even though the new techniques may show promise of better performance or lower costs.

A project team may choose a vendor with a proven track record over a new vendor that is providing significant price incentives to avoid the risk of working with a new vendor. The project team that requires drug testing for team members is practicing risk avoidance by avoiding damage done by someone under the influence of drugs.

Many organizations that work on international projects will reduce political, legal, labor, and others risk types associated with international projects by developing a joint venture with a company located in that country.

Partnering with another company to share the risk associated with a portion of the project is advantageous when the other company has expertise and experience the project team does not have. If the risk event does occur, then the partnering company absorbs some or all of the negative impact of the event. The company will also derive some of the profit or benefit gained by a successful project.

On international projects, companies will often purchase the guarantee of a currency rate to reduce the risk associated with fluctuations in the currency exchange rate.

A project manager may hire an expert to review the technical plans or the cost estimate on a project to increase the confidence in that plan and reduce the project risk.

Assigning highly skilled project personnel to manage the high-risk activities is another risk reduction method.

Experts managing a high-risk activity can often predict problems and find solutions that prevent the activities from having a negative impact on the project. Some companies reduce risk by forbidding key executives or technology experts to ride on the
same airplane.

The purchase of insurance on certain items is a risk transfer method. The risk is transferred from the project to the insurance company.

A construction project in the Caribbean may purchase hurricane insurance that would cover the cost of a hurricane damaging the construction site. The purchase of insurance is usually in areas outside the control of the project team. Weather, political unrest, and labor strikes are examples of events that can significantly impact the project and that are outside the control of the project team.

Contingency plan for risk management The contingency project risk plan is very important organizational device of project risk management. It balances the investment of the mitigation against the benefit for the project.

It requires the project team to develop an alternative method for accomplishing a project goal when a risk event has been identified that may frustrate the accomplishment of the project goal. These plans are collectively called contingency plans.

For example the risk of a truck drivers' strike may be mitigated with a contingency plan that uses a train to transport the needed equipment for the project. If a fundamental or critical piece of equipment is late, the impact on the schedule can be mitigated by making necessary changes it to accommodate a late equipment delivery.

Similarly the contingency plan can have the contingency funds. These are the funds set aside by the project team to address unforeseen events that cause the project costs to increase. Engineering Projects with a high-risk profile will typically have a large contingency budget. Although the amount of contingency allocated in the project budget is a function of the risks identified in the risk analysis process.

It has to be noted that, contingency is typically managed as one line item in the project budget. During the expedition of this study, most of the engineering projects that were underway in the month of July 2015 in Eldoret town had a delicate experience that some project managers had only allocated the contingency budget to the items in the budget that have high risk rather than developing one line item in the budget for contingencies.

The line approach to the contingency fund is more encouraged. This approach allows the project team to track the use of contingency against the risk plan. This approach also allocates the responsibility to manage the risk budget to the managers responsible for those line items.

The availability of contingency funds in the line item budget may also increase the use of contingency funds to solve problems rather than finding alternative, less costly solutions. Most project managers, especially on more complex projects, will manage contingency funds at the project level, with approval of the project manager required before contingency funds can be used.

Mathematics of risk management

Mathematics is a very important perspective of engineering project risk management. Surprisingly, a part from the rudiments of engineering and project management being so strict with risk control, mathematics practitioners are insensitive to this virtue.

This study did not identify any active project supervisor that was actively aware of the engineering math in relation to risk control. Though one project manager, Engineer Malaba Keya (PM for Moi University pension scheme project) displayed awareness and use of risk mathematics in controlling the project risks.

The theory of project risk management points out that project managers and supervisors must be competent in applying the following mathematical models as devices of risk control: binomial expansion (also known as Bernoulli expansion based on Jakob Bernoulli), Poisson distribution based Simon Dennis Poisson, normal distribution based on the Gaussian Curve of Von Gauss, and the Descartes' relationship theory.

Conclusion Risk management is a creative process that involves identifying, evaluating, and mitigating the impact of the risk event. Risk management can be very formal, with defined work processes, or informal, with no defined processes or methods. Formal risk evaluation includes
the use of checklists, brainstorming, and expert input.

A risk breakdown structure (RBS) can follow the work breakdown structure (WBS) to identify risk by activity. Risk evaluation prioritizes the identified risks by the likelihood and the potential impact if the event happens.

Risk mitigation is the development and deployment of a plan to avoid, transfer, share, and reduce project risk. Contingency planning is the development of alternative plans to respond to the occurrence of a risk event. From this study two main conclusions may be made.

Firstly, human factors are the dominant risk factors in any engineering process; behavioral and organizational psychology underpins our understanding of risk-based decision-making. Secondly, one area of weakness of project management practitioners is the application of the mathematical models in risk control.

Therefore, behavioral and organizational psychology and engineering mathematics are areas that the training and practice of project managers should focus better to enhance risk management effectiveness in construction projects.

References


Mar, A. (2015); *Types of engineering Project risks and their related management*, online Journal of project Management.
### PLANNING COMMITTEE MEMBERS

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