Visualising improvement and innovation potential – the case of sustainable building in Dar es Salaam

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Abstract

**Background**

Research shows that building supply chains in many countries could account for as much as 40% of the man made carbon emissions. Most building growth is taking place in Third World countries. Concrete is the most widely used building material. In many countries, as for example in Tanzania concrete blocks are the most widely used building material. Cement is the most expensive component and also has the highest carbon footprint. Earlier research indicates that there is a substantial improvement potential in reduced costs, improved customer value and reduced environmental impact in the building material supply network in Dar es Salaam Tanzania. Even if reasonably simple solutions with good payback for realising the potential exist, change is slow.

**Purpose**

The purpose of this paper is to study how process and product innovations could be visualised with the purpose of driving change towards more sustainable block making processes and products.

**Methodology**

Current processes and products are summarised and compared with benchmarks identified in literature and in practise. Drivers and barriers for change from current to benchmark performance are identified by field studies of block makers including participant observations and interviews. Additionally some performance testing is carried out. These results in combination with previous ones are then visualised using proposed process based sustainability indicators.

**Main results**

Results confirm earlier findings. The identified technical causes are relatively easy to solve. The main barrier for change seems to be lack of drivers and habits preferring proven solutions. The detected potential could be realised in an “Private Public Partnership”.

**Key words**

Process, building material, system model, visualisation, sustainability measurements, Africa

**Type of paper**

Research paper
**Background**

There is a growing need for sustainable change in the sense that more needs to be done using fewer resources. Energy consumption and carbon emissions need to be strongly reduced to extend the energy supply and reduce risks of global warming. Research shows that building supply chains in many countries potentially account for as much as 40% of the man made carbon emissions, most of it coming from the use of buildings, but also with a significant contribution coming from building materials (WBCSD, 2007). Concrete is the most widely used building material and the most commonly used material in the world after water WBCSD (2002). The most expensive component with the highest carbon foot print in concrete is cement. Production of one ton of cement typically generates some 600-1000 kg of carbon dioxide. This means the world cement industry is responsible for some 5% of the total man made carbon emissions (WBCSD, 2009). Most building growth is taking place in developing countries (WBCSD, 2007). In many of these countries, such as Tanzania, concrete blocks are the most widely used building material. This means that there is both economic and environmental incentive to see that cement is used in the most effective way to make best use of resources. Earlier research indicates that there is a substantial improvement potential in reduced costs, improved customer value and reduced environmental impact in the building material supply network in Dar es Salaam Tanzania (Isaksson & Taylor, 2009, Isaksson & al., 2010a, 2010b). But even though reasonably simple solutions with good payback for capturing the potential exist, change seems to be slow. The purpose of this paper is to study how process and product innovations could be clearly visualised in order to use this visualisation as driver for change.

**Theoretical foundation**

The analysis and visualisation of the supply chain is based on the process perspective. This means that focus is on the activities and networks that create value for the customer, instead of having a functional focus (Bergman & Klefsjö, 2010). The customer is defined as “those for whom we want to create value for” (Bergman & Klefsjö, 2010).

**Measuring sustainability**

Eco Efficiency is defined as value per impact (WBCSD, 2000). In this definition, the value is seen as the producer or shareholder value. Impact could be defined as some form of harm and could simplistically be divided into environmental and social harm (Isaksson, 2007), (Isaksson & Steimle, 2009). Value could be enlarged to cover all stakeholders, especially customers, (Isaksson & al, 2010b), (Isaksson & Steimle, 2009). Stakeholder value in the system can be compared with stakeholder impact. To enable a study to be carried out focus could be on the vital few indicators of both value and impact in the studied system. The element of a system could be measured in many different ways. One way of categorisation divides system indicators into drivers, input, output, outcome and resources (Isaksson & Garvare, 2003, Isaksson 2006). For the purpose of assessing performance, focus could initially be on output indicators using the value per impact logic.

**Visualisation using process based system models**

The conceptual model in Figure 1 can be seen as process based system model. The model meets the 9 system criteria of Checkland (1985), (Isaksson, 2006). The intention is that the model could be used to describe the current and the future state of any organisational system, including a supply network or region (Isaksson & Cöster, 2010), (Isaksson, 2011). In Figure 1 the indicator category for output has been simplified to customer value, which could be related to the main environmental harm in the studied system, which is carbon emissions, and the main social harm, taken as price of cement. In a poor country like Tanzania money is a
severely limiting factor, which qualifies it as the main social indicator for sustainability. In Figure 1 the proposed generic main processes are producing and marketing, which can also be viewed as communicating. The support processes of measuring performance and improving are highlighted as particularly interesting for the system studied.

Figure 1. Process based system model for any organization including proposed indicator categories and indicators for output, adapted from Garvare & Isaksson (2003) and Isaksson & al. (2008).

The model in Figure 1 can be used to describe the current state and a targeted future state. It could also be used to describe the change process itself. The change process can also be described as diagnosing, analysing, finding solutions, implementing and fixing into the organization with some controls (Isaksson, 2006).

**Methodology**

The building supply network has been studied in Dar es Salaam, the largest city Tanzania and a good example of a growing urban centre in a developing country. Information has been gathered to enable a description of the block making process. The block making process can be used as an example to visualise existing improvement potential as well as drivers and barriers for realising it. The most common type of block produced in Dar es Salaam is the so-called 6 inch solid block, normally measuring 6*9*18 inches and weighing about 30 kg. The block is mostly made out of cement, sand and water. This block will be used as an example to describe the block making process.

The Dar es Salaam region building supply network is described as a process starting with raw materials and a need for building and ending with using the building until the end of its lifetime, see Figure 2.

The three first stages of a generic improvement process (Isaksson, 2006) are used:

1. Diagnosing the system improvement potential as the difference between benchmark and current performance using value per impact indicators that are defined for the purpose. This includes sampling and testing blocks from the market and sourcing information from Tanzania Bureau of Standards. Block performance is based on
strength, which is expressed as MPa at a given age. To simplify comparison the strength data has been recalculated to 28 days to form a uniform data base – the minor error introduced by this is small compared to other variation.

2. Analysing
   o the technical explanation(s) behind the current performance, based on cement and concrete technology
   o interviewing key persons in the network (focus on block makers, but also the main cement manufacturer TPCC belonging to the international company Heidelberg Cement, cement users and government officials; interviews carried out largely by Idman, Lenhav, Sätterman as part of a Minor Field Study grant leading to a bachelor thesis)
   o the main causes for the improvement potential based on a customised 10 M checklist (adapted from Garvare & Isaksson, 2005 and Isaksson & al. 2010a)

3. Proposing solutions for realising the improvement potential

Note that the generic improvement process is described as a sub-process called: “Improving processes and use of resources”, that is part of the entire network in Figure 2. This process always exists in some form, even if it might have a very low level of maturity.

![Figure 2. The Dar es Salaam building material system.](image)

**Performance indicators**

Process performance can be divided into different process dimensions such as Quality, Cost, Capacity, Environment and social performance, (Garvare & Isaksson, 2005). A diagnosis for improvement potential can be carried out in any or all of these dimensions. Here, focus is on Quality, Cost and Environment. Quality is looked both from a user and valued based perspective, see Garvin in Bergman & Klefsjö (2010).

Quality of blocks could be defined as compressive strength being on target for the chosen type of blocks. From a perspective of making best use of resources we expect performance to be
related to cost. The cost driver is cement and a commonly used indicator among block makers is the number of blocks per bag of cement (50 kg) (Isaksson & al. 2010b). This is the primary value based indicator for the block producers. For the customer the value indicator is a usable block per price of the block. To calculate the system benchmark we propose the value indicator of Strength*Number of blocks. The higher the number in Strength*Blocks for the same block type the better the cement is being used in the process.

The compressive or load bearing strength is the quality indicator tested. This is expressed as Mega Pascal (MPa or N/mm²). The compressive strength is a function of a number of factors including time. Blocks are often measured at 7, 14 and 28 days.

The impact or harm indicators chosen are carbon dioxide (CO₂) emissions and cost of cement.

**Solid block performance**

The current block performance in Dar es Salaam is assessed on blocks tested at the Tanzania Bureau of Standards (TBS).

**Strength performance**

Table I shows test results from TBS of 8 different block makers in Dar es Salaam and the surrounding area. All these blocks have been tested 28 days after the production date, which is the test age specified in the standard by which time the blocks must have reached a minimum compressive strength of 3.5 MPa. But the load bearing capability of a block depends not only on strength but also on design factors such as the load bearing area and whether the block is hollow or solid. The current minimum strength requirement could reflect a wish of having a minimum material strength. Because the local habit is to use a solid 6 inch block the minimum requirement for the material becomes excessive. With a 6 inch block of 3.5 MPa strength the block can carry a load of approximately 20 tonnes. For the builder of a single storey private house this gives a safety margin of more than 20, as the wall and tin roof of such a building will have a maximum pressure of less than 1 ton on any of the blocks. This means that a block with a smaller cross-sectional area, such as a 3 inch block, or a hollow block with the required concrete strength would easily do the job. The relevance of the minimum strength requirement has been discussed with various stakeholders without any firm conclusions being drawn.

The block manufacturing process varies but most mixes are prepared with a mechanical mixer and then compacted with a vibrator. However, mixing standards vary and there are still some who use manual mixing and even manual compaction without vibration.

Table I. Compressive strength results from Tanzania Bureau of Standards reported as 28 day strength using different cements. The averages are based on a minimum 5 blocks.

<table>
<thead>
<tr>
<th>Producer</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement:</td>
<td>Lucky</td>
<td>Lucky</td>
<td>Twiga Extra</td>
<td>Twiga Extra</td>
<td>Twiga Extra</td>
<td>Twiga Extra</td>
<td>Twiga Extra</td>
<td>Twiga Extra</td>
<td>Twiga Extra</td>
</tr>
<tr>
<td>Average (Mpa)</td>
<td>2.6</td>
<td>2.1</td>
<td>2.9</td>
<td>0.8</td>
<td>2.8</td>
<td>3.4</td>
<td>2.5</td>
<td>2.8</td>
<td>2.5</td>
</tr>
</tbody>
</table>
Note: None of the blocks tested here actually meets the minimum standard requirement for the 3.5 MPa class. If the outlier, company 4 in Figure 2 is excluded from average and standard deviation the strength performance would be 2.7 +/- 0.4 MPa.

Figure 3. Results for 28 day strength based on individual random samples from 17 sets of sampling from 14 different block making units collected from block makers and tested at TBS (one set of outlier data has been excluded due to much higher values).

The average and standard deviation for results in Figure 3 are 2.9 +/-1.4 MPa. Although the average results are similar to those presented in Table I, the variation is much higher because of individual samples have been used.

Theoretically a 6 inch block of 1 MPa at 28 days should be more than enough for building a one storey house. However, a block that has only 1 MPa compressive strength at 28 days would only have a strength of 0.3-0.4 MPa at 1 day when it needs to be moved. This would probably lead to problems with excessive breakage during production and moving of the blocks. Blocks are often sold before they reach 28 days age. The minimum acceptable strength level is typically defined by the customer kicking the blocks and dropping a block to see whether it breaks or crumbles. Based on the limited information available it is not possible to establish a minimum strength value with certainty, but 1 MPa as lowest value when the block is sold can serve as a first hypothesis. Based on the data it appears that a large fraction of blocks are produced and sold at this quality level.

The block strength target level also depends on the block strength variation, which in Figure 3 is excessive, although lower variation would be expected within a given production unit. Best practise producers have an s-value of 0.3-0.4 MPa at 2 MPa. As a hypothesis, this means the target value for a 6 inch block intended for building a one story house could be set at 2.2 MPa at 28 days. With an s-value of 0.3 MPa the rate of block failure would be minimal with 4s separating the average target strength and the minimum level of 1MPa.

Cement performance in blocks
Within the group of block producers studied the number of blocks per 50 kg cement bag varies between 22 and 40. The average is 31 blocks per bag. Even though all blocks studied are “6 inch” blocks there are some slight differences in size. Blocks are typically sold for about 1 USD/block. Block performance based on the product of number of blocks per bag and
strength shown in Figure 4 indicates there is a significant variation in how the potential cement strength is used. There is a factor of at least 4 times between the lowest and highest performance levels. There are clear systematic differences in the results from different block makers.

Figure 4. Results for 28 days MPa*Number of blocks per bag based on samples actually collected in the market from different producers.

**Diagnosing the potential for solid 6 inch blocks**

As a starting point we have adopted a benchmark performance level from Figure 4 of 180 MPa*blocks, which combined with a 28 day target of 2.2 MPa would result in a benchmark performance of 80 blocks/bag. The improvement potential in the system is calculated as the difference between best performance and the current performance. The average value from the manufacturers studied is 31 blocks/bag. Comparing this to the proposed benchmark level would mean that less than 40% of the cement building potential is used in the current system. Based on Figure 3 we estimate that 5-10% of the blocks produced are actually lost as breakage due to excessively low strength. If these sub-standard blocks are discounted, the current performance level drops from 31 to 29 blocks/bag of cement.

Table II. Economic potential when performing to benchmark for blocks/bag as specific values and as a potential for the Dar es Salaam region.

<table>
<thead>
<tr>
<th>Indicator type</th>
<th>Current level</th>
<th>Benchmark</th>
<th>Potential</th>
<th>Unit</th>
<th>Current situation in Dar es Salaam</th>
<th>Dar es Salaam benchmark - number</th>
<th>Dar es Salaam potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value (blocks/bag)</td>
<td>29</td>
<td>80</td>
<td>+51</td>
<td>Million blocks</td>
<td>300</td>
<td>828 (with same amount of cement)</td>
<td>+528</td>
</tr>
<tr>
<td>Cement cost per block based on 10 USD/bag</td>
<td>0.34</td>
<td>0.13</td>
<td>-0.22</td>
<td>MUSD (cement in blocks)</td>
<td>103</td>
<td>38 (for the same number of blocks)</td>
<td>-65</td>
</tr>
</tbody>
</table>
Using the benchmark and the estimated number of 6 inch blocks sold, we can calculate a theoretical improvement potential for the region. Local cement sales of 600,000 tpa for blocks are estimated resulting in 300,000,000 “6 inch blocks” (TPCC figures). In Table II the theoretical regional economic improvement potential based on current performance and benchmark has been calculated.

The saving potential is based on cement cost only. At the same level of block production theoretically some 65 MUSD could be saved in block manufacturing. Since building needs are very high, block sales would increase if some of the cost savings were translated into cheaper blocks. Being able to make more blocks per bag of cement also has an important effect on carbon emissions, see Table III.

Table III. Environmental potential in reduced carbon dioxide emissions when improving cement performance in blocks. Based on 750 kg CO₂/ton cement.

<table>
<thead>
<tr>
<th>Indicator type</th>
<th>Current level</th>
<th>Benchmark</th>
<th>Potential</th>
<th>Unit</th>
<th>Current situation in Dar es Salaam</th>
<th>Dar es Salaam benchmark</th>
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<td>+ 51</td>
<td>Million blocks</td>
<td>300</td>
<td>828</td>
<td>+ 528</td>
</tr>
<tr>
<td>kg CO₂/bag of cement</td>
<td>1.29</td>
<td>0.47</td>
<td>- 0.82</td>
<td>Ton CO₂</td>
<td>387931</td>
<td>140625</td>
<td>- 247306</td>
</tr>
</tbody>
</table>

A cautious approximation is that about 50% of the theoretical improvement potential could be realised with a dedicated effort and in a time span of a few years. Even at this level there would be a substantial performance improvement in producing more building value for less money and for less CO₂ emissions.

**Analysis of causes for the existing potential**

Earlier work has showed that the production of blocks does not follow best practises (Isaksson & Taylor, 2009). Several factors such as bad compaction, poor curing and insufficient watering of prepared blocks has been suspected to lead to lower performance in MPa*Blocks.

**Technical causes for the existing improvement potential**

Samples collected in September 2011 by one of the authors have been measured and weighed at TBS enabling a calculation of the density. As density decreases block porosity increases, reducing compressive strength.

Standard mortar used for cement testing and consisting of cement, water and sand has a density of about 2.3 t/m³. Using the regression from Figure 5 this would indicate a benchmark of 185 MPa*Blocks. However if the MPa*Blocks is calculated from the mortar results assuming a mortar strength of 55 MPa at 28 days and adjusting for the size difference the result becomes about 300 MPa*Blocks. Standard mortar is produced and controlled under ideal conditions. The cement content is about 22% compared to 5-8% in the blocks. This allows production of standard mortar at a relatively low water to cement ratio which increases the strength performance, see Figure 6. The conclusion is that the chosen theoretical benchmark of 180MPa*Blocks could be used until further.
MPa*Blocks = 228 * density - 339
$R^2 = 0.63$

Figure 5. MPa*Blocks at 28 days as function of block density.

Based on the correlation in Figure 5, the density fluctuation seems to explain about 60% of the variance in the MPa*Blocks. Site visits have indicated that the main reason for the fluctuations in density is that the vibration time and vibrating equipment varies widely.

During visits and interviews some producers have clear preferences and argue for a particular type of cement. However, the cement quality from all producers, measured as strength at 28 days, varies by less than a factor 1.5 between highest and lowest (Based on 18 cement samples collected from the Dar es Salaam market between July 2011 and February 2012). The MPa*Block varies by a factor 4, which indicates that block manufacturing, and not cement strength variation, is the main problem. The better and the more consistent a block producer is the more important the cement quality becomes.

The early (1 day) strength corresponding to the time when blocks are demoulded and moved is critical. This is often by block makers perceived as a quality indicator. Results from 2 day strength tests (no 1 day data available) indicate a factor of 3.6 between the highest and the lowest value. This is a difference that block makers will register and therefore could affect their choice of cement.

The low content of cement in the blocks makes it difficult to mix with a minimum of water. It has not been possible to measure this because the sand used is often damp and the water added is not accurately measured. This means that more water is added than is really needed which causes the water cement ratio to be higher than ideal. Figure 6 shows that if the water cement ratio increases from 0.5 as in the standard mortar to 0.8 then half of the potential strength of the cement is lost.
At the chosen benchmark of 80 blocks/bag the cement content would drop to about 0.6 kg/block of 30kg or 2% cement only. With less cement less water should be used. The low level of cement makes it practically impossible to mix properly without increasing the water cement ratio. However, by changing the block design to hollow blocks, less sand and water would be needed for the same number of blocks. This means that in order to be able to use the cement potential there should be a change in the type of blocks used making them lighter but with higher cement content.

**Hollow blocks**
The customary concrete block used for building in most parts of the world is a hollow concrete block that is lighter to handle and better insulating while putting less load on foundations. In Dar es Salaam the tradition of using hollow blocks has not yet taken hold and the majority of blocks used are solid blocks.

The Dar es Salaam region is currently (2012) seeing a major construction boom. "Development is construction" says Engineer Danford Semwenda from TPCC. However, using more hollow blocks is not yet a priority. According to Dr. Leonard M. Chamuriho, Estates Manager at University of Dar es Salaam, this is because the market, where “seeing is believing” lacks “pioneers” who can take the use of hollow blocks forward. The impression from almost 20 interviews of people in the business confirms that customers in most cases still prefer solid blocks.

Consequently block makers produce mainly solid blocks and almost no hollow blocks first introduced in the 1980's. Adoptions of improved block making methods and wider use of hollow blocks should improve the housing standards in terms of insulation, labour efficiency and cost. We have identified a single block maker in the Dar es Salaam region that offers hollow concrete blocks of good quality which could be seen as a benchmark. The company RAVI with owners/operators of Turkish origin have invested in the operation based on previous experience in the industry and knowledge obtained in their home country. The enterprise profiles itself with comparatively sophisticated manufacturing technology and
machinery. The director of the company has seen a dramatic increase in demand for their hollow blocks in the two years since they were first added to their product range. The customer base consists mainly of house builders, professional contractors, and other customers building larger projects, who are familiar with the advantages of hollow blocks. The site manager estimates that of his total sales, 80% are hollow blocks. However, he also declares that his customers are mainly of European and Chinese origin. First-time customers tend to ask for solid blocks, but the site manager claims that after selling the advantages of hollow blocks (insulation, price, safety) they often buy the hollow blocks. He further states that hollow blocks are more profitable in comparison to solid ones. The maximal production capacity is approximately 10,000 blocks a day, with a two-shift workforce. With 300 days of full production per year the capacity from his plant would be about 3 million blocks, making it 1% of the Dar es Salaam market.

RAVI is producing 22 solid blocks per 50 kg bag and 33 hollow blocks per bag. The cement raw material cost per solid block is 0.45 USD based on the price 10 USD/bag. These blocks are sold for 1.15 USD, which is above the average market price of 1 USD. However, the company is promoting hollow blocks and selling them for 1 USD. The concrete strength from the company complies with the minimum requirements for concrete strength. The average load bearing capacity of the hollow blocks is about 18 tons which for a standard 6 inch solid block would correspond to about 2.6 MPa. At 2.2 MPa the number of blocks would be 39 per bag. The current production of 33 blocks/bag is slightly above average and with a concrete that corresponds to the minimum requirements, which is seldom the case for other manufacturers. The blocks weigh about 20 kg or two thirds of the solid blocks. This means that for each block 10 kg of sand is saved, which is important since finding good sand becomes more and more difficult and expensive. Substituting the 300 million solid blocks produced with the RAVI type hollow blocks would yearly save 3 million tonnes of sand in Dar es Salaam.

Analysis based on 10Ms
Out of the 10Ms mentioned in Figure 2 the most important missing resource is a proper measurement system. The most apparent reason for the large improvement potential is that there is no realistic and agreed target on what the load bearing strength of a block should be. Also there are no agreed or reliable measurements of system performance. The proposed indicator of MPa*Blocks is a first attempt to highlight this potential.

Another important M is the Market, where habits rule and where the key players will not change unless a particular reason emerges. Some of the interviewees said that if government would order hollow blocks this could change the situation or if there was a serious promotional campaign. The problem here is that nobody owns the issue. Seen from a system perspective there is no Management of the system and there is no Mission (Isaksson & al. 2010a).

There are cultural aspects affecting the use of solid and/or hollow blocks. Traditionally, solid blocks are used for private houses and one- or two-storey buildings. Levels of formal training and education are low and lack of trust in block makers’ knowledge leads to unwillingness to risk eventual shortcomings in quality performance of the blocks. People in general do not trust the quality of the available blocks and therefore base their acquisitions on limited personal knowledge. This results in preference for the traditional product instead of the uncertainty of new innovations. Because the building needs are important, building activity would probably increase if block prices were reduced. Currently cement production in Dar es Salaam is
struggling to keep up with demand and there are also cement imports. Improvements in the
supply network could be of interest for the cement manufacturer especially if services helping
the customer to improve performance could help in creating more loyalty and a competitive
edge against imports and other competitors. TPCC has declared that when their customers are
doing well, they are doing well and that they are interested in supporting the development of
block makers.

The current market preference of 6 inch solid blocks makes it impossible to make best use of
the cement. The theoretical strength potential of cement cannot be achieved since the cement
content becomes too low, which leads to a high water cement ratio and loss of strength. The
current method itself has multiple areas of improvement, which are technically simple. Strong
habits seem to be the main reason for lack of change. Manpower in the block making plants
often consists of day labourers with a low level of education and who are paid per block
produced. This results in clear priority on quantity and not on quality.

**Proposing solutions**

Most stakeholders in the system would gain if the cost of poor quality could be reduced. In
the current situation both users that often are poor and the environment (CO$_2$-emissions) are
losing without anybody gaining. The main cause for the development being slow is that the
potential has not been visualised and that there is no clear owner for the entire system
performance. Local authorities could be seen to have part of the responsibility. It could also
be discussed if TPCC, being part of the major global player Heidelberg Cement, should not
become more engaged as part of their Corporate Social Responsibility. This could possibly be
carried out in the “Private Public Partnership” meaning financial collaboration between the
public and the private sector, which is a common way of doing things in East Africa and
Tanzania (Idman et al. 2012).

**Conclusions**

The earlier indicated improvement potential in block making performance in Dar es Salaam
(Isaksson & al. 2010b) has been confirmed with the proposed performance indicator Strength
times number of blocks per bag (MPa*Blocks). This indicates a factor four difference in
performance between similar types of block producers. There is no commonly accepted target
for the load bearing strength of the blocks which makes optimisation difficult. A proposed
preliminary target of 2.2 MPa for a 6 inch block corresponding with a load bearing strength of
15 tonnes per block has been established. The benchmark in MPa*Blocks has been assessed
to 180 MPa*Blocks. At the target of 2.2 MPa this translates to about 80 blocks per 50 kg bag
of cement as a theoretical best performance. Compared to the current assessed average of 29
Bl/bg there seems to be a huge improvement potential for using the cement more effectively
in both economic and environmental terms. In realistic terms about half of the theoretical
potential should be possible to realise with dedicated efforts over a period of some years.
Apart from the economic benefits the carbon footprint of the blocks could be halved resulting
in yearly reduced emissions of some 100 000 tonnes of CO$_2$. Changing the main product from
solid blocks to hollow blocks would also reduce the consumption of sand used for blocks with
about 3 million tonnes per year at the current level of production of 300 million blocks.

The density variations in tested blocks explain some 60% of the variance of the MPa*Blocks
indicator. The reason for density variations is believed to relate to the use of varying
equipment and use of varying times for compaction in combination with lack of knowledge of
the importance of density. Another probable problem is high water cement ratio due to low
cement content. Cement content can economically only be increased by changing the design,
preferably to hollow blocks. Only one producer, RAVI, focusing on hollow blocks has been identified. The company produces blocks according to standard requirements making good profits, but customers are so far limited to mostly larger and foreign companies. Most producers have little or no control of the quality produced. A simple control would be to weigh the block and use the weight as an indicator of density.

Even if the technical solutions for improving block making performance are relatively simple there are currently no strong drivers for change and no ownership of the indicated improvement potential. Idman et al. (2012) refer to the PPP that stands for ‘Private Public Partnership’ meaning financial collaboration between the public and the private sector, which is a common way of doing things in East Africa and Tanzania. In the case of improved block making this would require that TPCC and Heidelberg Cement take an interest in working with organisations such as the National Housing Cooperation, National Housing and Building Research Agency, Dar es Salaam University, Tanzania Bureau of Standards and a group of chosen block makers. Provided an agreed mission of substituting the economically and environmentally non viable solid blocks with hollow blocks and a clear managerial engagement in this, the change could be carried through with benefits for all parties.

References


