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RESEARCH ARTICLE

EVALUATION OF TRAINING ON THE PRODUCTION OF FIBRE REINFORCED SOIL BLOCKS

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ABSTRACT

Impacting the skills required in producing soil blocks to building block manufacturers is important to ensure that high quality blocks are produced. This study evaluates the opinions of block manufacturers who were trained on the manufacturing process of fibre reinforced soil blocks. The study used a questionnaire to survey the views of the participants of workshop training organised for adobe block manufacturers in Ghana. It was found that: the cost of the fibre reinforced soil blocks houses will be affordable for those in the low-income bracket, the manufacturing of fibre reinforced soil blocks has little effect on the environment, and fibre reinforced soil blocks are useful to the society and can be used to produce durable houses. Furthermore, the process of producing the fibre reinforced blocks will be somehow difficult due to the manual process of preparing particularly the fibres. It was also found that the fibre reinforced soil blocks will be more useful in the rural areas where earthen construction is common. It is recommended that governments of developing countries should promote the use of fibre reinforced soil blocks in order to reduce housing deficit.

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INTRODUCTION

Soil blocks are precast units made with soil/earth for building houses. The blocks are usually compressed in a mould with a damp raw soil/earth that has suitable proportion of particle sizes to improve the properties. For further enhancement of the properties of the soil blocks, binders (cement and lime) and fibres (natural and synthetic) are added. A number of studies have enhanced the properties of soil blocks using binders and fibres as described in a study by Danso *et al*. (2015a). Reinforcing soil blocks with fibres can be traced back in the ancient Egypt, where straw was used to enhance the strength of the blocks. Current studies have also used different type of fibres in reinforcing the soil blocks for construction purposes as shown in Table 1. Different types of fibres have different properties and behave similarly in wet and damp conditions, however they possess the properties that are acceptable to be used as reinforcement in soil blocks (Danso, 2017a). As different fibres have different properties, when using any type of fibre for reinforcing soil blocks, it is important to consider these critical factors: (1) the fibre aspect ratio; (2) the optimum fibre content; (3) the fibre-soil matrix bonding mechanism; (4) the rate of compaction pressure; and (5) the manufacturing process.

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Fibre aspect ratio is the ratio of length to diameter of a fibre and is usually expresses as a single number greater than 1. The fibre aspect ratio of some selected fibres has been studied by Danso *et al*. (2015c) and Yalley (2012). The results suggest that different fibres produce blocks with optimum strength at different aspect ratios, however, the fibre aspect ratio should be equal to or greater than 100. Previous studies (Danso *et al*. 2015e, Yalley, 2012) have established different fibre contents that produced the optimum strength of soil blocks manufactured with different fibres. Studies conducted by Ibraim *et al*. (2006), Danso *et al*. (2017b), Maeda and Ibraim (2008) and Luz *et al*. (2007) described the interfacial bond that exist between fibres and soil matrix of fibre reinforced soil specimens. The influence of compacting rate on the properties of compressed earth blocks have also been studied (Danso, 2016). The process of manufacturing fibre reinforced soil blocks are very important to make block makers produce the blocks to the required specification. Though studies explain how the fibre reinforced soil blocks are manufactured, they don't go further to impact the skills required in producing the blocks to the stakeholders (block makers) who are responsible in manufacturing the blocks in communities where they are used. This study therefore evaluates the views of stakeholders who were trained on the manufacturing process of fibre reinforced soil blocks that were produced in the study by Danso *et al*. (2015b). The study surveyed the views of the participants of the training on the benefits of the fibre reinforced soil blocks and the organisation of the workshop.

MATERIALS AND METHODS

Focus group workshop training was organised for adobe block makers in Ghana because they are the main people who are involved in producing soil blocks mostly in rural areas. Two training sessions were organised, one for those in Southern Ghana and the other in the Northern Ghana. A snow-ball approach was used to contact and invite the adobe block manufacturers for the training, because the researcher did not know their locations; so those identified earlier provided the snow-ball nucleus which spread until majority of the adobe block manufacturers were contacted. In all, one hundred and eleven (111) adobe block manufacturers were contacted and invited to attend the workshop training, 62 and 49 from Southern and Northern sectors respectively. 49 and 38 attended the workshop training respectively from Southern and Northern sectors, making a total of 87 attendants representing about 78%. The first training was held on 2nd February 2015 at Accra for the Southern sector and the other was held on 6th February 2015 at Kumasi for the Northern sector. Resources provided for the training include (1) writing pads, (2) pens and pencils, (3) technical guide on the production of fibre reinforced soil blocks, (4) samples of fibre enhanced soil blocks, and (5) posters on the production of fibre reinforced soil blocks. During the workshop, the participants discussed the benefits of fibre enhanced soil blocks, the process involved in preparing the fibres, sieving of soil, mixing of the materials, moulding and drying of the blocks. Participants were allowed to ask questions and answers provided.

A feedback form was given to each participant to rate their agreement or disagreement on the usefulness and benefits of the fibre reinforced soil blocks and organisation of the workshop training with a five-point Likert scale. The Likert scale used was from strongly disagree (1) to strongly agree (5). The participants were also asked to provide general suggestions and comments for improvement. At the end of the training, the feedback forms were distributed to all the participants to complete, out of which at total of 81 feedback forms were completed and returned (47 and 34 respectively from Southern and Northern sectors). Content validity was established by a panel of two expert. Construct validity was also ensured by critically developing the indicators within established theoretical framework. Cronbach alpha reliability test for the items was above the recommended 0.7 (Straub *et al*., 2004), with a reliability coefficient of all the 13 items measuring a composite value of 0.73. Therefore the scales could be considered reliable. The computed mean ratings were compared with the theoretical mean rating (assuming normal distribution of responses above neutral) of 3.0, in order to determine the participants' agreement to the items.

RESULTS AND DISCUSSION

Descriptive analysis of the participants' responses is presented in Table 2. The responses are discussed under three main headings: (1) benefits of the fibre reinforced soil blocks, (2) organisation of the workshop, and (3) suggestions and recommendations for improvement.

Benefits of the Fibre Enhanced Soil Blocks

Cost

It can be seen from Table 2 that the participants ranked C1 first (1st) with mean ± Standard deviation of 4.40 ± 0.86 which is between agreed and strongly agreed. This shows that 'fibre reinforced soil blocks can be used to produce low-cost houses' was agreed by the respondents as the highest benefit of the fibre reinforced soil blocks. C2 and C3 are all within the first five ranked items, implying that the cost of the fibre reinforced soil blocks will be affordable for those in the low-income bracket. Some respondents' comments are quoted below: *"The research will help to produce low cost housing and should be introduced in the country" "The raw materials used are cheap and abundant in Ghana"* As the cost of construction materials constitutes between 60% and 70% of a building (Danso and Menu, 2013), the reduction of the materials cost will invariably reduce the cost of the entire building project. This will contribute to affordable housing due to the low-cost of the material (Zami and Lee, 2011). Another important contribution to the low-cost is the production of the blocks at the site where the construction work takes place, as compared to conventional building materials such as cement and steel bars which are imported or manufactured in urban towns and have to be transported to other parts of a country at long distances, and invariably increase the cost of housing (Fernandes *et al*., 2007).

Environmental

The participants ranked E1 'using fibre reinforced soil blocks will help produce cool room temperature houses' second (2nd) with mean ± Standard deviation value of 4.37 ± 0.97 which is also between agreed and strongly agreed. Soil blocks provides a cool room temperature due to its good thermal insulation properties (Arumala and Gondal, 2007, Danso, 2013). E2 'using fibre reinforced soil blocks will help reduce pollution of the environment' obtained Mean value of 4.10 which also shows participants' agreement to the item. This is supported by the fact that improper disposal of agricultural waste such as burning can give rise to ammonia and methane emissions that can lead to acidification and contribute GHG (European Environmental Agency, 2006). This means the incorporation of the agricultural waste fibres in blocks will have positive effect on both internal and external housing environments. Furthermore, manufacturing of fibre reinforced soil blocks has little effect on the environment as compare to cement and sandcrete blocks production, which contribute high carbon emission and pollute the environment.

Usefulness

U1 'I find the fibre reinforced soil blocks useful for building houses' was ranked third (3rd) by the respondents with mean ± Standard deviation value of 4.31 ± 0.68 which is also between agreed and strongly agreed. The respondents therefore consider the fibre enhanced soil blocks to be used to address inadequate housing problem in the society as U2 was rated above 4.0 (agree). The respondents rated U3 and U4 items 4.0 (agree), meaning they find the fibre reinforced soil blocks useful to the society and can be used to produce durable houses. This is important because the main reason for reinforcing the soil blocks is to improve the engineering properties for better resistance to load and weathering (Minke, 2009; Danso, 2015). However, U5 'producing fibre reinforced soil blocks will be easy' was ranked 13th (the least), which means the respondents find the process of producing the block may be difficult compared with the blocks without fibres. Considering the manual process of preparing particularly the fibres, they felt it will be difficult and time consuming.

This is supported by some of the suggestion the participants made that: *"The manual means of preparing the fibres will be time consuming, so it will help if mechanical means can be used to save time"*.

Some respondents also gave these suggestions as quoted below: *"The fibre enhanced soil blocks will be more useful in the rural areas" "You must try to implement this research work to help our rural communities especially the three Northern Regions"* This suggests that some of the respondents were of the opinion that the fibre reinforced soil blocks will be more useful in the rural areas where earthen construction is common. Therefore, introducing the technique in rural communities will be more accepted than the urban communities where conventional building materials for building houses dominate.

Organisation of the Workshop

The respondents agreed to the item O1 'I am satisfied with the general organisation of the workshop' with Mean ± Standard deviation of 4.14 ± 0.77. This means that the participants generally agreed that the workshop training was satisfactory organised. Similar rating was given by the respondents to items O2 and O3 'delivery of the workshop was satisfactory' and 'resources provided for the workshop were helpful' respectively. It suggests that the resources such as note pads, pens and pencils, technical guide on the production of fibre reinforced soil blocks, posters, among others were helpful to the delivery of the workshop training. This is consistent with the findings of the study by Danso *et al*. (2012) which majority of the respondents rated high the resources used for the in-service training. Though the participant felt the organisation and the resources provided were good, some of them provided suggestion as quoted below: *"The delivery of the workshop was good, but next time try and used overhead projector instead of posters"* This means although the posters were good, the use of projector could sustain the interest of the participants in the workshop training with the changing of slides, which will show different viewing characteristics.

Suggestions and Recommendations for Improvement

The respondents made the following additional comments and suggestions

- Addition of binders like cement and POP in the reinforced soil blocks will help to make it more durable
- The fibres must be improved and package like cement to make it available in market for people to buy and used for construction of their houses
- The technique is a good idea and must be encouraged
- Further research must be done to test the fire resistance of the fibre reinforced soil blocks
- I believe if the demand for the fibres increased, the farmers will not leave the waste but will sell them, which will increase the cost of the fibres
- The compression machine used for making the blocks should be made available in the rural communities for use, so that they will not continue to use the wooden moulds
- This idea should be extended to technical and vocational school to help train the students
- Very good research and I have learnt a new idea from the workshop
- The blocks might have good thermal properties as well
- Additives can be added to check insert or termite attack
- Government intervention is needed to promote the idea
- Other wastes must be researched to be used to reinforced the soil blocks

From the comments, it can be seen that the participants commended the idea of reinforcing soil blocks with fibres. In view of this, some suggested that the idea should be included in the curriculum of technical and vocational schools to inculcate the technique in the students, and also to seek government intervention in promoting the blocks. Some participants also suggested the introduction of other additive for controlling termites and rodents, and some binders to increase durability properties of the fibre reinforced soil blocks. Improvement of the fibres in the form of bagging or packaging (like cement) was also suggested, so that the fibres will readily be available in the market for people. Contrarily, others expressed that if the demand for the fibre increase, it might lead to increase cost, just as in the case of cement. In addition, some suggested the need for further research work in using other waste materials and fire resistance and thermal properties tests.

Summary of Findings and Conclusion

The study evaluated the opinion of blocks manufacturers who were trained on the manufacturing process of fibre reinforced soil blocks. It was found that

- The cost of the fibre reinforced soil blocks houses will be affordable for those in the low-income bracket, due to the abundance and low-cost of the raw materials.
- The manufacturing of fibre reinforced soil blocks has little effect on the environment as compare to cement and sandcrete blocks production, which contribute high carbon emission and pollute the environment.
- The fibre reinforced soil blocks are useful to the society and can be used to produce durable houses. This is relevant because the main reason for reinforcing the soil blocks is to improve the engineering properties for better resistance to load and weathering.
- The process of producing the fibre reinforced blocks is difficult as compared with the blocks without fibres. The mechanical process of preparing particularly the fibres could be difficult and time consuming.
- The fibre reinforced soil blocks will be more useful in the rural areas where earthen construction is common. Therefore, introducing the technique in rural communities will be more accepted than the urban communities where conventional building materials for building houses dominate.
- The organisation and the resources provided for the training were deemed to be good. However, the use of other resources such as projector for presentation would be preferred.

From the forgoing, it can be concluded that the training provided for block manufacturers has enlighten them on the manufacturing process and benefits of using fibre reinforced soil blocks. It has further elicited feedback that can be used to help in the adoption of the fibre reinforced soil blocks, especially in the low-income communities where earthen construction is common.

The study therefore recommend that government of developing countries should promote the fibre reinforced soil blocks, and incorporate the technique in the curriculum of technical and vocational schools. Researchers should also extend the study by adding other binders to further increase the durability properties of the blocks and also test the resistance of the blocks against fire.

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