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INFLUENCE OF FORMWORK MATERIALS ON THE SURFACE QUALITY OF REINFORCED CONCRETE STRUCTURES

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ABSTRACT

Formworks made from different materials are used for concrete works to hold the concrete in place until it hardens sufficiently to form the desired shape. It has been a practice to specify the type of formwork to be used basing on the availability of formwork materials, cost, safety during construction and sometimes on the surface quality of the finished product without considering the formwork influence on the surface strength and durability of concrete.

In this manuscript, investigation results on the influence of formwork materials on the quality of surface concrete are presented. It has been established that the rate of water absorption of formwork materials among other factors has an influence on the concrete strength. Further, it is being recommended to use formworks which can absorb water from the concrete surface so as to increase the strength of concrete at the surface and hence the durability of concrete structural members.

Key words: *Formwork, reinforced concrete, durability, water/cement ratio, compressive strength*

1.0 INTRODUCTION

Reinforced concrete is one of the most widely used building material for construction of structural members of buildings and other structures in many countries including Tanzania due to its strength, durability, reasonable cost and other favorable properties. In order for concrete to be poured for casting and formation of the desired shape of a structural element/member as well as curing, provisional shuttering, which is also called concrete formwork is required.

Concrete formwork serves as a mould to produce concrete elements/members having a desired size and configuration. It is usually erected for this purpose and then removed after the concrete has cured to a satisfactory strength. In some cases, concrete formwork may be left in place to become part of the permanent structure.

For satisfactory performance, formwork must be adequately strong and stiff to carry the loads produced by the concrete, the workers placing and finishing the concrete, and any equipment or materials supported by the forms. In Tanzania, as a practice, the selection of materials to be used for formwork is done by the Quantity Surveyor/Cost Estimators based on the availability, cost, safety during construction and sometimes on the surface aesthetics required in the finished product.

Although it is considered that the quality and durability of reinforced concrete is dependent on the quality and quantity of concrete ingredients such as cement, water, aggregates, as well as on the placement and curing, but of recent there are views that the type of formwork materials and the time when the forms can be struck off also seem to influence the quality and durability of reinforced concrete.

The concept of using permeable formwork which remove excess water from cast concrete has been developed with the objective of eliminating voids on the surface of the concrete and to increase the strength and durability of the concrete surface immediately behind the formwork (Malone, 1999).

Therefore, in this manuscript, the results on the investigation of the influence of formwork materials widely used for concrete works in Tanzania on the surface quality of concrete are discussed.

2.0 TYPES OF FORMWORK MATERIALS

In Tanzania, soft wood timber, plywood, hard wood and steel materials are normally used for concrete formworks. In Figure 1 below is a site in Dar es Salaam where timber (soft wood) formwork was used for concrete construction works.

Figure 1 A construction site in Dar es Salaam using softwood formworks

Timber and plywood formworks are normally fabricated at the site. It is easy to produce these formworks but time consuming for larger structures. It is still used extensively where the labour costs are lower than the costs for procuring re-usable formwork. It is also the most flexible type of formwork, so even where other systems are in use, complicated sections may use it. Marine plywood is also widely used especially where good surface finish is required.

Steel formwork or engineered formwork systems are built out of prefabricated modules with a metal frame(usually steel or aluminium). This formwork has two major advantages compared to timber formwork. These are speed of construction(modular systems pin, clip or screw together quickly) and lower life-cycle costs. Figure 2 shows some steel formwork.

Fig. 2 Steel formworks

3.0 INVESTIGATION AND RESULTS

Investigation of the influence of formwork materials on the quality of concrete was performed by comparing four types of formwork materials. These were softwood timber (cypress), hardwood timber (mninga), plywood and steel.

Before fabricating the formwork, samples of these materials (except steel) were taken and their moisture contents and water absorption determined. The obtained results are shown in Table 1. It has to be noted that wood is considered to be dry if the moisture content is less or equal to 19% and saturated if it is greater than 28%.

Using formworks fabricated from the above mentioned materials, concrete beams of dimensions 150 x 150 x 750 mm and columns of 230 x 230 x 1000 mm were casted Concrete was placed and uniformly compacted.. Concrete ratio used was 1:2:4 with a water/cement ratio of 0.48.

Table 1 Moisture content and water absorption of formwork materials

S/n	Type of material	Moisture content (%)	Water absorption(%)
1	Softwood timber	12.76	32.73
2	Hardwood timber	8.08	9.17
3	Plywood	13.77	27.61

The formwork for beams and columns were stripped off after 24 hours which is the minimum recommended time (Shetty, 2006). After curing for 28 days, concrete cores were drilled and their densities and water absorption determined. The compressive strengths along the drilled cores were also determined. The results of the densities and water absorption determined are shown in Table 2.

Table 2 Densities and water absorption of concrete cores

S/n	Formwork material	Concrete samples	
		Density (kg/m^3)	Water absorption (%)
1	Softwood Timber	2270	1.16
2	Hardwood Timber	2205	1.21
3	Plywood	2209	1.18
4	Steel	2163	1.59

The estimated compressive strengths of the concrete along the drilled cores at the centre and the surface (outer zone) of concrete were determined using the rebound hammer. The average estimated compressive strengths results are shown in Table 3.

Table 3 Rebound hammer test results

S/n	Formwork material	Estimated compressive strength (N/mm^2)	
		Surface	Inner (Centre)
1	Softwood Timber	38.5	42.2
2	Hardwood Timber	38.4	41.6
3	Plywood	38.5	41.8
4	Steel	38.3	40.3

The drilled concrete cores were crushed to determine their compressive strengths and the results are shown in Table 4.

Table 4 Concrete compressive strengths

S/n	Type of material	Compressive strengths (N/mm^2)
1	Softwood timber	23.6
2	Hardwood timber	22.9
3	Plywood	23.1
4	Steel	22.5

4.0 DISCUSSIONS OF THE RESULTS

Basing on the investigation results presented in section 3.1 above, the following have been observed:

(i) The concrete uniformity characterizing the estimated compressive strength varies along a section of a concrete member increasing from the surface (outer zone) towards the centre (inner zone). The lower estimated concrete compressive strength at the surface is due to the fact that during compaction there is a tendency of water and entrapped air in concrete to migrate towards the surface of concrete (near the formwork) where compaction is not carried out intensively hence increasing the w/c ratio at the surface (outer zone) and reducing the same in the inner zone which result to more pores at the surface and reduced compressive strength (Rubaratuka, 2008).

(ii) The concrete compressive strength obtained by testing the drilled concrete cores is greater for concrete of softwood formwork and lower for concrete of steel formwork.

These results are related to the water absorption and density of concrete cores whereby lower water absorption signifies less voids and greater density and hence higher compressive strength and vice versa.

(iii) Water absorption of formwork material seems to have an influence on concrete compressive strength. The greater the water absorption of formwork material the greater the concrete density and compressive strength. This is due to the fact some water and the entrapped air that migrate to the interface of concrete and formwork is absorbed by the formwork material or allowed to escape.

5.0 CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

From the results and observations in section three above, following are the conclusions::

(i) Formwork material has an influence on the compressive strength and durability of concrete.

The surface strength vary with the rate of water absorption of formworks.

(ii) There is a need to reduce/absorb excess water at the concrete surface in order to ensure concrete uniformity and improve the concrete compressive strength at the surface and hence concrete durability.

5.2 Recommendation

There is a need to undertake further investigation on the influence of formwork materials on the quality of concrete by considering the time taken

to strike off formworks on sites which is normally greater than the recommended minimum time..

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