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The Case Study on Cubes Compressive Strength Variations for Different Water Sources in Dares Salaam City, Tanzania

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Authors' contributions

This work was carried out in collaboration between all authors. Author LS designed the study, performed the statistical analysis, wrote the protocol, managed data analysis and wrote the first draft of the manuscript. Author MZ managed the water sample collection for the study. Author YK managed the literature searches. All authors read and approved the final manuscript.

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Case Study

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ABSTRACT

In this study the concrete compressive strength variations for different water sources in Dares Salaam city is presented. Concrete cubes were casted and cured for 7, 14 and 28 days using public fresh water and water samples collected from different borehole sources in Dar es Salaam city. The selected parameters (pH, chlorine content, sulphate content, TDS level and Electrical Conductivity) were analyzed in the laboratory for all water samples. The concrete was mixed with mixing ratio of 1:2:4. The concrete cube size measuring 150×150×150 mm in dimension was used. The results of the compressive strength of cubes showed that there was increase in strength at 7 days, 14 days and 28 days for cubes casted from Kawe, Riverside, Mabibo external, Makumbusho boreholes samples and public fresh water sample. Also results showed that pH, chlorine content (CL^-), sulphates (SO_4^{2-}) and Total dissolved solids (TDS) contribute to lower the compressive strength of the concrete when are in higher side and contribute to increase the compressive strength when are in lower side.

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1. INTRODUCTION

Water is essential constituent in concrete production, it react chemically and facilitates hydration reaction by reacting with cement and resulting into hardening and setting of cement paste necessary for strength development on a concrete and durability. The concentration of impurities in water should be limited to ensure that desired strength of concrete is achieved. Amount of soluble and insoluble matters, sulphates and chloride content should be controlled in water.

Water that is slightly acidic is harmless, but presence of humic or other organic acids may result on affecting the hardening of concrete. Acid solutions attack cement mortars or concrete by dissolving part of the cement and progressively weaken the material by removing cementing constituents forming soft and mushy mass [1]. Water with pH value less than 12.5 reduces the alkalinity of the pore fluid and will eventually lead to removal of the cement materials [2]. Water containing fewer amounts of salts does not reduce the concrete strength; hence this water can be used for casting. If reinforcement is needed to be provided, then the structures should be provided with large cover to protect it from corrosion [3]. And according to BS 3148: Methods of test for water for making concrete, the permissible limit of total dissolved solids (TDS) is 2000 mg/l [4,5].

Water being used for construction in Dar es Salaam city is from different borehole sources, however the quality of this water is not yet known. In this study the fresh water sample was collected from public fresh water taps and the remaining sample were collected from different borehole sources in Dar es Salaam city and their levels of the selected parameters (pH, chlorine content, sulphate content, TDS and Electrical Conductivity) were analyzed in the laboratory. The cubes were casted from these water sources and tested for compressive strength.

2. MATERIALS AND METHODOLOGY

2.1 Materials

2.1.1 Cement

Ordinary Portland Cement (OPC) grade 33 was used.

2.1.2 Coarse aggregate

Crushed stone aggregate of maximum size 20 mm was used.

2.1.3 Sand

Local sand which is mainly used for construction activities in the city was used in this investigation.

2.1.4 Water

Clean portable water free from suspended particles from public fresh water was used to mixing and curing of concrete cubes casted. Other cubes were casted and cured using water from different borehole in Dar es Salaam city.

2.2 Methodology

2.2.1 Laboratory analysis

The water samples were collected from different areas in the city as shown in Table 1.

Table 1. Sample collection areas

S/N	Name of the area	Coordinates
1	Public fresh water	Public water tap
2	Mabibo external borehole	(6°48’12.3”S, 39°12’37.2”E)
3	Kawe borehole	(6°43’36.54”S, 39°13’47.23”E)
4	Riverside borehole	(6°48’10.14”S, 39°12’14.8”E)
5	Makumbusho borehole	(6°46’54.86”S, 39°14’47.91”E)

Water samples collected were analyzed in the laboratory to determine the level of pH, chlorine content (CL^-), sulphates (SO_4^{2-}), Total dissolved solids (TDS) and Electrical Conductivity. The results from the laboratory analysis of each water sample are presented in Table 2. The chemical limitations for water used for concrete mixtures [6] areas follows; chlorine content (CL^-) should not exceed 500 mg/l [7], for sulphates (SO_4^{2-}) should not exceed 3000 mg/l, Total dissolved solids (TDS) should not exceed 50,000 mg/l [8].

2.2.2 Experimental system

To investigate the concrete compressive strength variations for different water sources, concrete cubes were made, in which some concrete cubes were casted and cured with public fresh water and the remaining cubes were casted and cured with the water samples collected. The concrete was mixed with mixing ratio of 1:2:4. The concrete cube size measuring 150×150×150 mm in dimension was used. Concrete was properly placed beneath and along the sides of the mould with the help of trowel and the concrete cube moulds were filled to one third of their height and compacted 25 times. The cube moulds were later filled to two third of their height and finally filled completely. In each of the layer, the concrete cubes were compacted 25 times respectively. The concrete cubes were casted and cured for 7, 14 and 28 days.

2.2.3 Workability

Slump test was performed separately for concrete made from each water sample to check the concrete workability during casting of cubes. The slump was maintained from 80 mm to 150 mm.

2.3 Compressive Strength

The quantity of cement, aggregate and water for all cubes prepared were the same. The concrete cube moulds were lubricated with oil before placing mixed concrete in it. The concrete cubes were cured for 7, 14 and 28 days in water having similar quality as used in the preparation of mix. After curing the concrete cubes were tested in compression testing machine and the maximum test load in kN were recorded. The average compressive strength was estimated using the formula; Compressive strength= $\frac{Load}{Area}$

3. TEST RESULTS

Test results of the cubes were prepared from public fresh water and water from boreholes. The results indicated that, there is significant increase in the compressive strength of all concrete cubes at 7, 14 and 28 days.

Table 2. Results from the laboratory analysis of water samples

Parameters	Public fresh water	External borehole	Kawe borehole	Riverside borehole	Makumbusho borehole
pH	8.19	6.15	8.32	8.28	7.10
Chlorides (CL-)(mg/l)	213.1	1396.97	3384.8	1833.2	780.08
Sulphates (SO42) (mg/l)	6.7	57	120	96	8.7
TDS (mg/L)	117.9	2530	6130	3320	1413
Electrical Conductivity (Salinity), μS/cm	240	3330	1700	1530	2800

Table 3. Showing the compressive strength at the age of 7 days

S/N	Name of the area	Cube Size W ×D×H (mm)	Mass of cubes (g)	Test Load, kN	Cube strength N/mm^2
1	Kawe	150X150X150	8248	288	12.8
2	Riverside	150X150X150	8419	292	12.97
3	Mabibo external	150X150X150	8288	312	13.86
4	Makumbusho	150X150X150	8325	328	14.5
5	Public fresh water	150X150X150	8373	345	15.3

Table 4. Showing the compressive strength at the age of 14 days

S/N	Name of the area	Cube Size W ×D×H (mm)	Mass of cubes (g)	Test Load, kN	Cube strength N/mm^2
1	Kawe	150X150X150	8254	400	17.7
2	Riverside	150X150X150	8250	412	18.3
3	Mabibo external	150X150X150	8255	450	20
4	Makumbusho	150X150X150	8311	454	20.01
5	Public fresh water	150X150X150	8372	478	21.24

Table 5. Showing the compressive strength at the age of 28 days

S/N	Name of the area	Cube size W ×D×H (mm)	Mass of cubes (g)	Test load, kN	Cube strength N/mm^2
1	Kawe	150X150X150	8259	585	26
2	Riverside	150X150X150	8250	588	26.13
3	Mabibo external	150X150X150	8260	592	26.3
4	Makumbusho	150X150X150	8314	598	26.5
5	Public fresh water	150X150X150	8379	624	27.7

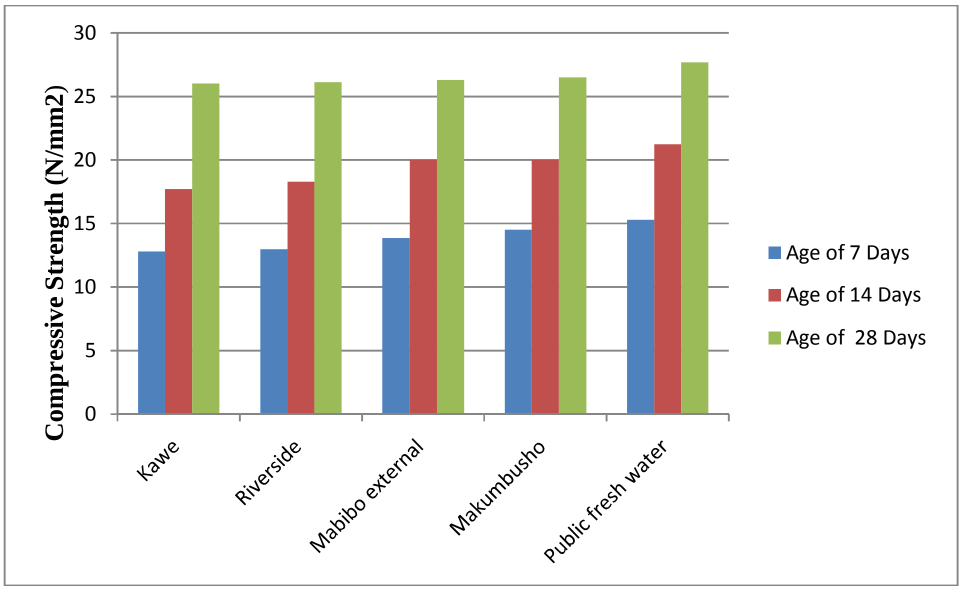

Fig. 1. Showing the variation on compressive strength at the age of 7, 14 and 14 days

The results of variation on compressive strength at the age of 7 days, 14 and 14 days are shown in Fig. 1.

4. DISCUSSION

The results show that there is appreciable increase in strength at 7, 14 days and 28 days for concrete cubes casted from Kawe, Riverside, Mabibo external, Makumbusho boreholes samples and public fresh water. It has observed that Kawe cubes have lowest strength of12.8, 17.7 and 26 at the age of 7, 14 and 28 days respectively compare to other cubes. Also the results show that cubes casted from public fresh water have highest strength of 15.3, 21.24 and 27.7 N/mm^2 at the age of 7, 14 and 28 days respectively compare to other cubes. All the compressive strength has reached the minimum value of 15 N/mm^2 for the age of 28 days [9].

5. CONCLUSION

1. From the laboratory analysis results of water samples, Kawe has the highest value of pH, chlorine content (CL$^-$), sulphates (SO_4^{2-}) and Total dissolved solids (TDS), these parameters contribute to lower the compressive strength of the cubes at the age of 7, 14 and 28 days.
2. From the laboratory analysis results of water samples, there is decrease of pH, chlorine content (CL$^-$), sulphates (SO_4^{2-}) and Total dissolved solids (TDS) for samples collected from Riverside, Mabibo external and Makumbusho. Decrease of these parameters contributes to increase the compressive strength of the cubes at the age of 7, 14 and 28 days respectively.
3. From the laboratory analysis results of water samples, public fresh water sample has the lowest value of chlorine content (CL$^-$), sulphates (SO_4^{2-}) and Total dissolved solids (TDS), these parameters contribute to the higher compressive strength of the cubes at the age of 7, 14 and 28 days.

4. From the laboratory analysis of water samples, Electrical Conductivity (Salinity) increases from 240 for public fresh water, 1530 for Riverside, 1700 for Kawe, 2800 for Makumbusho and 3330 for Mabibo eternal. The cubes compressive strength increases from the lowest Kawe, Riverside, Mabibo external, Makumbusho and public fresh water which was the highest. The increase sequence of Electrical Conductivity (Salinity) does not reflect the decrease sequence of compressive strength of cubes, therefore Electrical Conductivity (Salinity) seems to have very small effect to the compressive strength of cubes at the age of 7, 14 and 28 days.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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