# Experimental investigation of mechanical properties of concrete using different sources of water for mixing and curing concrete

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## Background

The quality of the ingredients used in the production of concrete determines its strength. Mixing and curing water is one of the components required and impurities in the water can reduce concrete strength and induce corrosion of reinforcement, hence water quality is critical. Even though the recommended water for concrete construction is potable, some projects in developing countries utilize sources other than the potable water supply due to its shortage and yet it is not common to test the quality of water. Meanwhile, in Ethiopia, research has not been conducted on the effects of impurities found in mixing and curing water for construction purposes. As a result, a study into the suitability and effect of various water sources on the mechanical characteristics of fresh and hardened concrete strength is required, since different concentrations of impurities could be found due to environmental exposures.

## Project Aim

The primary aim of this study is to find a potential replacement for potable water for concrete production taking into consideration the fact that the item is scarce. To reduce potable water consumption, different sources of water are used as a substitute in concrete mixing and curing. The study includes laboratory tests for cement setting time, workability, compressive strength, splitting tensile strength, and flexure strength of concrete using river water, deep well water, and rainwater.

## Experimental Program

- An experimental tests on the mechanical properties of fresh and hardened concrete were conducted to examine the effect of using different sources of water (potable, river, deep well, and rainwater) for mixing and curing purposes.
- The proportion by weight of all constituents (aggregates, cement, and water) was kept constant in all the mixes.
- Water quality test were examined for various impurities.
- ACI mix design method was used to get the right combination of these constituents for 25 MPa grade concrete.
- A total of 180 concrete samples were cast and tested on the 7th and 28th days of curing age for compressive, splitting tensile, and flexural strengths.
- The test results were compared to the potable water which was used as control.

## Water Impurities

The identified water sources parameters were within the permissible limit of the ASTM C1602 and WHO standard.

| Parameters | Water sources | | | | Requirement | |
|---|---|---|---|---|---|---|
| | Potable | Deep well | Rain | River | ASTM C1602 | WHO |
| Temperature (°C) | 24.5 | 24.7 | 24.4 | 24.8 | - | - |
| pH | 6.6 | 6.5 | 6.4 | 6.75 | - | 6.5-8.5 |
| Salinity (mg/l) | 50 | 100 | 90 | 60 | - | - |
| TDS (mg/l) | 114 | 240 | 150 | 116 | - | 500 |
| TSS (mg/l) | 17.2 | 16.8 | 17.2 | 36.4 | - | - |
| Alkalinity (mg/l) | 58 | 32 | 30 | 62 | <600 | 200 |
| Sulfate (mg/l) | 3 | 6 | 15 | 7 | <3000 | 100 |
| Turbidity (NTU) | 4.73 | 3.83 | 10.42 | 4.48 | - | 5 |
| Hardness (mg/l) | 50 | 82 | 40 | 42 | - | 150 |
| Chloride (mg/l) | 2.5 | 27.5 | 8.75 | 3.75 | - | 250 |

## Concrete Workability

- A slump ranging from 10 to 25 mm is obtained.
- Concrete mix using potable water has improved workability followed by rain and river water.
- The minimum slump value is observed with deep well water having a 10 mm slump.
- All the values fall within class 0-25 mm slump.

| Water sample | Slump (mm) | Water- cement ratio |
|---|---|---|
| Potable water | 25 | 0.53 |
| Rainwater | 15 | 0.53 |
| River water | 13 | 0.53 |
| Deep well water | 10 | 0.53 |

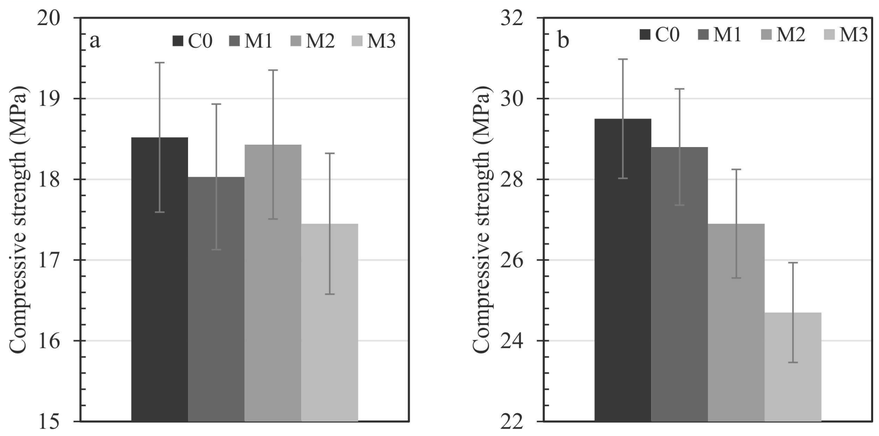
## Compressive Strength

**Mixing Effect** : Potable water was used for curing

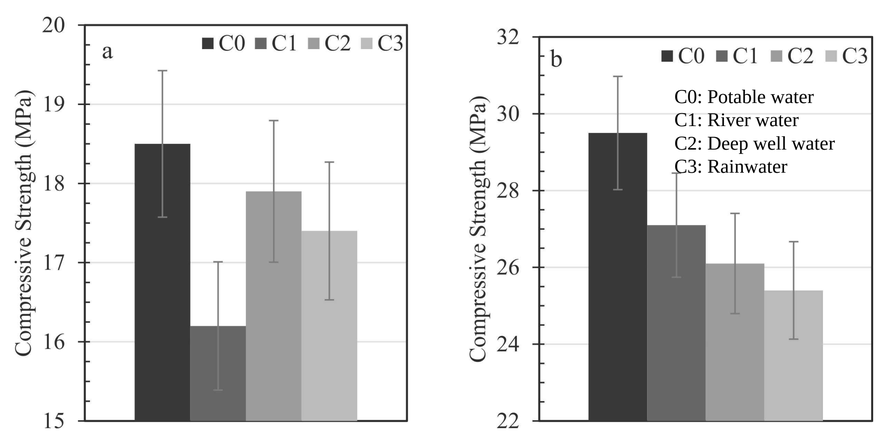
- Concrete cubes cast using potable water (C0) attained higher strength value at the curing age of 7 and 28 days followed by river water (M1), deep well water (M2), and rain water (M3).
- Lower compressive strength observed in the deep well water and rainwater is due to the presence of a high amount of TDS, which is responsible for the reduction in concrete compressive strength.

**Curing Effect** : Potable water was used for mixing

- The identified water sources achieved the minimum requirement of 25 MPa grade of concrete.
- Concrete cured by rainwater changed the color and odor of concrete specimens due to the availability of inorganic material in the water.



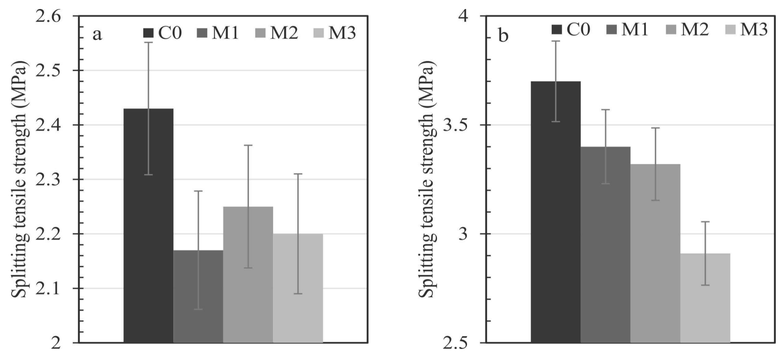

*Compressive strength using identified water for mixing (a) 7th day, (b) 28th day.*




*Compressive strength using identified water for curing (a) 7th day, (b) 28th day.*

## Tensile and Flexural Strength

Concrete mixing and curing utilizing potable water and river water show improved results on the splitting tensile and flexural strength compared with deep well water and rainwater. The effect of different water sources on the compressive, splitting tensile and flexural strength are similar.




| Specimen | Load (kN) | | Flexural strength (MPa) | |
|---|---|---|---|---|
| | 7th day | 28th day | 7th day | 28th day |
| C0 | 17.4 | 24.1 | 5.2 | 7.2 |
| C1 | 17.2 | 23.9 | 5.1 | 7.1 |
| C2 | 13.6 | 23.3 | 4.1 | 7.0 |
| C3 | 13.4 | 21.2 | 4.0 | 6.4 |
| M1 | 13.9 | 23.8 | 4.2 | 7.1 |
| S1 | 10.8 | 20.6 | 3.2 | 6.2 |
| M2 | 16.7 | 21.2 | 5.0 | 6.4 |
| S2 | 12.8 | 18.9 | 3.9 | 5.7 |
| M3 | 13.5 | 20.6 | 4.0 | 6.2 |
| S3 | 12.5 | 18.8 | 3.7 | 5.6 |

## Conclusion

- The properties of concrete using the potable, river, deep well and rainwater sources used for concrete mixings and curing were conducted.
- These water sources show a relative influence on the mechanical properties of concrete.
- The number of impurities observed is within the limits stated in ASTM C 1602.
- The identified sources of water did not affect workability.
- River water can be properly utilized for concrete production.

## Future work

Deep well water contains more amount of chloride compared with the identified water sources. This impurity can lead to corrosion of reinforcement over a long-term duration, hence further study should account corrosion effect.

## Acknowledgement

The authors gratefully recognise Jimma University and the Institution of Structural Engineers for their financial support.