# Effect Of Wastewater On Properties Of Portland Pozolana Cement

G. Reddy Babu

*Department of Civil Engineering, Vishnu Institute of Technology, Bhimavaram-534202, West Godavari District, A P, India*

greddybabu66@gmail.com

***Abstract:*** This paper presents the effect of wastewaters on properties of Portland pozzolana cement (PPC) . Fourteen water treatment plants were found out in the Narasaraopet municipality region in Guntur district, Andhra Pradesh, India. Approximately, from each plant, between 3500 and 4000 L/day of potable water is selling to consumers. All plants are extracting ground water and treating through Reverse Osmosis (RO) process. During water treatment, plants are discharging approximately 1,00,000 L/day as wastewater in side drains in Narasaraopet municipality. Physical and chemical analysis was carried out on fourteen plants wastewater and distilled water as per producer described in APHA. In the present work, based on the concentrations of constituent's in wastewater, four typical plants i.e., Narasaraopeta Engineering College (NECWW), Patan Khasim Charitable Trust (PKTWW), Mahmadh Khasim Charitable Trust (MKTWW) and Amara (ARWW) were considered. The performance of four plants wastewater on physical properties i.e., setting times, compressive strength, and flexural strength of Portland pozzolana Cement (PPC) were performed in laboratories and compared same with reference specimens i.e., made with Distilled Water (DW) as mixing water. No significant change was observed in initial and finial setting time but setting times of selected wastewaters were retarded as compared to that of reference water. Almost, no change was observed in 90 days compressive and flexural strengths in four plants wastewaters specimens compared to that of reference water specimens. XRD technique was employed to find out main hydration compounds formed in the process.

Keywords: waste water, PPC, setting time, compressive strength, flexural strength

## 1. INTRODUCTION

Ever since concrete began to be used as a construction material, potable water has been using as the mixing water in concrete due to the chemical composition is well known. The literature search indicates that, not much research work has carried out on the quality of mixing water in concrete and there are no detailed guide lines [1 - 3]for the use of water in concrete. The building code requirements of different countries generally contain broad guidelines on mixing and curing water. Most of the codes consider potable water to be satisfactory for both mixing and curing of concrete and stipulate permissible limits for solids and aggressive chemicals. .However, In recent years, attention has been focused on the potential for various aspects of wastewater reuse, although previous research has been performed on the use of wastewater that are producing from the water treatment plants and industries for making concrete and reported that no adverse effects on concrete properties in fresh and hardened state [6-16]. Also [1,17] stated that the compressive strength of the cubes made of water with unknown chemical composition not to be less than 90% of cubes made with potable water. There is a note in BS 3148 – 1980which states that non potable water that results in a strength reduction of up to 20% can be acceptable compared to that of cubes made with potable water, but the mixture proportions should be adjusted appropriately. However, limit of a chemical in mixing water of concrete given by various codes is tabulated in table .1

Therefore, throughout Andhra Pradesh 71 municipalities and 13 municipal corporations were existed. From these municipalities, small to large scale water treatment plants might have been setup. As a result of water treatment plants, huge volume of ground water is wasted as wastewater. Hence, present work is taken up on the effect of wastewaters on properties of PPC from water treatment plants located in residential buildings, Narasaraopeta municipality, Andhra Pradesh, as mixing water in cement.

# 2. MATERIALS AND METHODS

*2.1. Cement*

Portland Pozzolana cement was used. The physical properties of cement are given in Table: 2.

*2.2 Sand*

The ennor sand was used. Table 3 gives its physical properties. The cement to fine aggregate ratio was maintained at 1:3 by weight in the mortar mixes.

*2.3 Water*

Distilled water was used in reference specimens and wastewaters from typical four water treatment plants were used in test specimens. The physical and chemical properties of distilled and fourteen plants wastewater are given in Table: 4.

Table:1 Tolerable limits of impurities in mixing water of concrete ( all values in mg/L, except pH)

| Constituent | Tolerable Limit | Reference |
|---|---|---|
| pH | 3 | [18,19] |
| | >5 | [20,21] |
| | 6 | [1] |
| | 6-8 | [22] |
| | 7-9 | [2] |
| Total solids | 50000 | [3] |
| | 5000-10000 | [23] |
| | 4000 | [19] |
| Suspended solids | 2000 | [23,24,1] |
| Dissolved solids | 50000 | [26] |
| | 2000 | [24,1,2] |
| | <6000 | [27] |
| Organic solids | 200 | [1] |
| Inorganic solids | 3000 | [1] |
| Total Alkalinity(as $CaCO_3$) | 500 | [2] |
| | 1000 | [28,25] |

| Constituent | Tolerable Limit | Reference |
|---|---|---|
| Sodium Carbonates and Bicarbonates | 2000 | [20,21,23] |
| Carbonate | 1000 | [25] |
| Bicarbonate | 400 | [25] |
| Chlorides for plain concrete | 360 | [32] |
| | 500 | [20,21,24] |
| | 2000 | [1] |
| | 4500 | [33] |
| Chlorides for Reinforced concrete | 500 | [8,1,34] |
| | 1000 | [35, 33] |

Table 2: Properties of Cement

| Property | Result |
|---|---|
| Specific gravity | 3.25 |
| Fineness, $m^2/kg$ | 34.5 |
| Initial setting time, minutes | 170 |
| Final setting time, minutes | 260 |
| Compressive strength ,$N/mm^2$ | |
| 3 days | 31.55 |
| 7 days | 40.60 |
| 28 days | 58.44 |
| 90 days | 64.28 |
| Flexural strength ,$N/mm^2$ | |
| 3 days | 3.90 |
| 7 days | 5.50 |
| 28 days | 6.65 |
| 90 days | 7.50 |

Table 3: Properties of Sand

| PROPERTIES | RESULTS |
|---|---|
| Specific gravity | 2.65 |
| Bulk density, $kN/m^3$ | 15.90 |
| Fineness modulus | 2.72 |
| Grading | Percentage |
| Passing in 2mm sieve | 100% |
| Retained on 2mm sieve | 100% |
| Particles size 2mm to 1 mm | 33.33% |
| Particle size lee than 1 mm to 500µ | 33.33% |
| Particle size lee than 500 µ mm to 90µ | 33.33% |
| Absorption in 24 hours | 0.8% |
| Shape of grains | Sub angular |

Table 4: Physical and chemical properties of various plants wastewaters

| NAME OF PLANT | PH | ALKALINITY AS $CaCO_3$(mg/L) | | | ACIDITY AS $CaCO_3$ (mg/L) | | SOLID(mg/L) | | | CHLORIDES (mg/L) | SULPHATESmg/L |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $OH^-$ | $CO_3^{-2}$ | $HCO_3^-$ | Mineral acidity | $CO_2$ acidity | Total solids | Organic solids | Inorganic solids | | |
| DW | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| NEC | 7.13 | 0 | 0 | 560 | 0 | 80.0 | 502.13 | 17.13 | 485 | 175 | 22 |
| MKT | 6.93 | 0 | 0 | 464 | 0 | 81.0 | 320.93 | 16.93 | 304 | 140 | 20 |
| PKT | 7.16 | 0 | 0 | 545 | 0 | 79.0 | 437.16 | 17.16 | 420 | 160 | 23.5 |
| AR | 7.05 | 0 | 0 | 520 | 0 | 82.5 | 402.05 | 17.05 | 385 | 145 | 27.8 |
| SMS | 6.82 | 0 | 0 | 300.5 | 0 | 91.5 | 219.2 | 19.2 | 200 | 150.34 | 17 |
| RL | 6.01 | 0 | 0 | 410.9 | 0 | 92.5 | 270.2 | 20.2 | 250 | 130.56 | 16 |
| Varun | 6.61 | 0 | 0 | 425.4 | 0 | 90.6 | 227 | 32.0 | 195 | 160.45 | 08 |
| BST | 6.55 | 0 | 0 | 300.23 | 0 | 95.9 | 230 | 25 | 205 | 170.59 | 05 |
| KC | 6.81 | 0 | 0 | 423.25 | 0 | 95.2 | 244 | 24 | 220 | 172.53 | 11 |
| PRT | 6.45 | 0 | 0 | 416.45 | 0 | 97.1 | 281 | 31 | 250 | 144.59 | 13 |
| VGT | 6.64 | 0 | 0 | 413.45 | 0 | 96.9 | 248 | 28 | 220 | 140.58 | 10.5 |
| MGT | 6.35 | 0 | 0 | 400.29 | 0 | 98.5 | 236 | 20 | 216 | 139.49 | 9.5 |
| VCT | 6.35 | 0 | 0 | 355.93 | 0 | 54.9 | 242 | 20 | 222 | 152.93 | 11.9 |
| RR | 6.53 | 0 | 0 | 419.2 | 0 | 46.3 | 171 | 21.0 | 150 | 148.63 | 12.5 |

*2.4Methods*

Distilled water, wastewaters of water treatment plants were analysed as per procedure lay down in [36]. The quantity of cement, sand, and mixing water for each specimen were 200 g, 600g, and (P/4 + 3), where P denotes the percentage of water required to produce a paste of standard consistency. Fifteen samples were prepared and tested for initial and final setting time using Vicat's apparatus. Sixty mortar cubes with 50 $cm^2$cross sectional area and same number of square prisms of 10X2.5X2.5 cm were cast for compressive and flexural strengths. Tests were performed at 3 days, 7 days, 28 days and 90 days for compressive and flexural strengths. The compacted specimens in moulds were maintained at a controlled temperature of $27^0 \pm 2^0$ and at 90 percent relative humidity for 24 hours by keeping the moulds under gunny bags wetted by the same mixing waters of the specimens. After 24 hours, all specimens were subjected to immersion curing and curing was continued remaining 27 days.

*2.5 Powdered X-Ray Diffraction (XRD)*

Powdered XRD technique was used to investigate crystalline compounds in 28 days hydrate cement specimen powder [37]. The reference and test cement specimens (NECWW) were grinded to a fine powder and a flat specimen was prepared on a glass surface using an adhesive for XRD measurement. The diffracted intensities were recorded using monochromatic Copper Kα radiation.

## 3. RESULTS AND DISCUISSION

*3.1 Setting time*

*3.1.1 Initial setting time*

Effect of NECWW, PKTWW, MKTWW and ARWW on initial and final setting times of PPC is shown in Fig. 3.1.

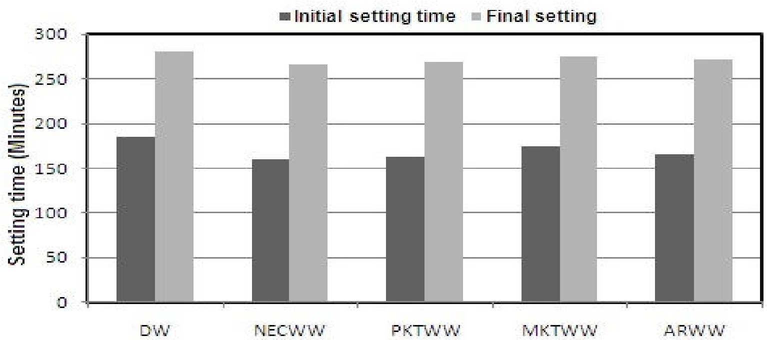

Fig 3.1 Effect of wastewaters on setting times of PPC

The effect of NECWW, PKTWW, MKTWW and ARWW on initial setting time of PPC is insignificant when compared to that of DW. Initial setting time of DW, NECWW, PKTWW, MKTWW and ARWW are 185,159,162,175,165 minutes respectively. The initial setting times are retarded by 26,23,10,and 20 minutes compared to that of DW.

*3.1.2 Final setting time*

The effect of NECWW, PKTWW, MKTWW and ARWW on final setting time of PPC is shown in Fig 3.1. Final setting time of DW, NECWW, PKTWW, MKTWW and ARWW are 280,265,269,275and 271 minutes respectively. The final setting times are retarded by 15,11,5 and 9 minutes when compared to that of DW.

*3.3 Compressive strength of PPC*

Effect of DW, NECWW, PKTWW, MKTWW and ARWW on compressive strength of PPC is shown in Fig 3.2.

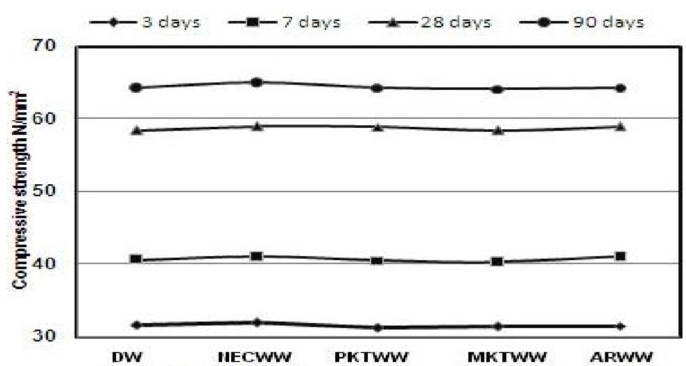

Fig 3.2 Effect of wastewaters on compressive strength

It reveals that the 3 days compressive strength of DW, NECWW, PKTWW, MKTWW and ARWW is 31.55, 32, 31.25, 31.4, 31.5 N/mm$^2$, for 7 days is 40.6, 41.0, 40.5, 40.3, 41.0 N/mm$^2$, for 28 days is 58.44, 59.0, 58.9, 58.4, 59 N/mm$^2$, and for 90 days is 64.28, 65, 64.30, 64.15, 64.30 N/mm$^2$ respectively. The change in 3, 7, 28, and 90 days compressive strengths of test specimens made with NECWW, PKTWW, MKTWW and ARWW almost same as that of reference specimens made with DW.

*3.4 Flexural Strength*

Effect of DW, NECWW, PKTWW, MKTWW and ARWW on flexural strength of PPC for 3 days, 7 days, 28 days and 90 days is shown in Fig 3.3.

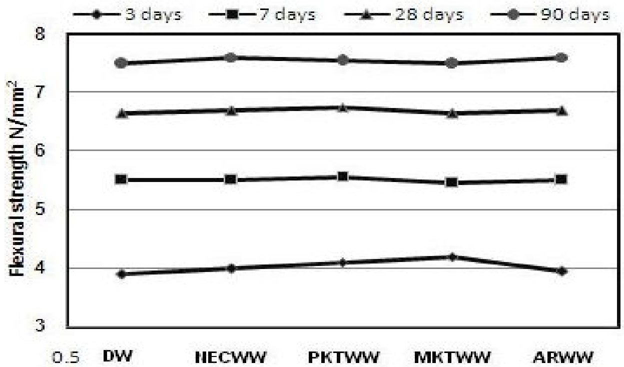

Fig 3.3 Effect of wastewater on flexural strength

It makes kwon that the 3 days flexural strength of DW, NECWW, PKTWW, MKTWW and ARWW is 3.9, 4.0, 4.1, 4.2, 3.95 , for 7 days is 5.5, 5.5, 5.55, 5.45, 5.5, for 28 days is 6.65, 6.7, 6.75, 6.65, 6.70 N/mm$^2$, for 90 days is 7.5, 7.6, 7.55, 7.5, 7.6 N/mm$^2$ respectively. The change in 3, 7, 5, 7.60and 90 days flexural strengths of test specimens made with NECWW, PKTWW, MKTWW, ARWW almost same as that of reference specimens made with DW.

*3.5 XRD Analysis*

XRD of reference (DW) and test sample (NECWW) cured for 28 days is shown in Fig. 3.4. It can be seen that both reference and test samples XRD patterns are almost same. The compounds identified in reference sample are $C_3S$, $C_2S$, CSH, and CH and in test sample are $C_3S$, $C_2S$, CSH, CH, $CaCO_3$. Wastewater analysis revealed that among all properties, bicarbonates concentration is more. Due to bicarbonates in test sample the new compound i,e., $CaCO_3$ is formed, which is responsible for the retardation in setting times.

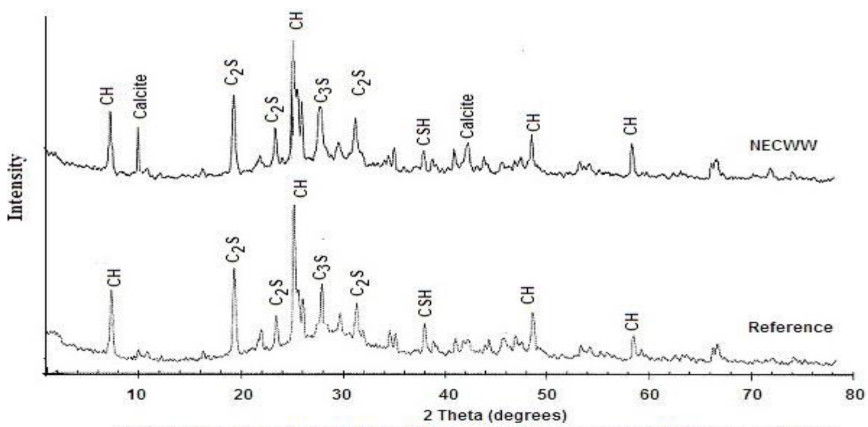

Fig 3.4 XRD pattrens of the hydrate PPC powder reference and NECWW at age of 28 days

# 3. CONCLUSION

The following conclusions are drawn on the basis of the results obtained in this paper

- Setting times of test specimens are retarded when compared to that of reference specimens but retardation in setting times is insignificant
- Compressive and flexural strengths of test samples are almost same as that of reference samples
- In the XRD analysis, new compound other than regular compounds in hydrate cement is appeared $CaCO_3$.
- These wastewaters may be recommended to use in cement mortar.

## ACKNOWLEDGEMENT

Author (Dr G Reddy Babu) deeply thank Principal & Director (Dr.D. SuryaNarayana) of Vishnu Institute of Technology, Bhimavaram, Waste GodaraviDist, A.P, India, to his great support to complete this paper successfully.

## REFERENCES

1. IS 456- 2000. Plain and reinforced concrete-code of practice, New Delhi: Bureau of Indian Standards.
2. BS 3148-1980.Method for test for water for making concrete. London: British standard institute.
3. ASTM C94 – 1992. Standard specification for ready-mixed concrete, American society for testing and materials, Philadelphia.
4. G.E. Troxell, H.E. Dams, J.W. Kelly, Composition properties of concrete 2nd Edition McGraw Hill, Inc. New York, N.J, 1968.
5. J.J. Waddell, Concrete construction handbook, 2nd Ed. McGraw Hill, Inc., New York, N.Y, 1974.
6. J.H. Tay, WK. Yip, Use of reclaimed water for cement mixing. J. Environ. Engg 1987: 113:5: 1156-60.
7. O.Z. Cebeci, A.M. Saatci. Domestic sewage as mixing water in concrete, ACI Material Journal 1989: 86:503 -506.
8. O.A. El-Nawawy, S. Ahmed, Use of treated effluent in concrete mixing in an arid climate. Cement Concrete Composites 1991; 13:2:137-41.
9. J. Borger, RL. Carrasquillo, DW. Fowler, Use of recycled wash water and returned plastic concrete in the production of fresh concrete. AdvCem Based Mater 1994; 1:267-74
10. A.R. Chini, L.C. Muszyasti, P.S. Ellis, Recycling process water in ready-mixed concrete operations. Final report submitted to the Florida Department of Transportation, University of Florida, Gainsville,February 1999:134.
11. Su. Nan, Wu. Yeong-Hwa, Mar. Chung-Yo, Effect of magnetic water on engineering properties of concrete containing granulated blast furnace slag,Cement and Concrete Research, 2000:599-605
12. Nan Su, buquan Miao, Fu-Shung Liu, Effect of wash water and underground water on properties of concrete, cement concrete research 2002: 32:777-782.
13. Ibrahim Al-Ghusain, Mohammad J Terro, Use of treated wastewater for concrete mixing in Kuwait, Kuwait J. Sci. Engg 2003: 30:1: 213–227.
14. AS. Al-Harthy, R. Taha, J. Abu-Ashour, K. Al-jabri, S. Al-Oraimi, Effect of water quality on the strength of flowable fill mixtures, Cement and concrete Composites 2005: 27; 33-39.
15. B. Chatveera, P. Lertwattanaruk, N. Makul, Effect of sludge water from ready -mix concrete plant on properties and durability of concrete. Cement and concrete composites 2006: 28:441-450.
16. I.V. Ramana Reddy, N.R.S Prasad Reddy, G. Reddy Babu, B. Kotaiah and P. Chiranjeevi, Effect of biological contaminated water on cement mortar properties, The Indian Concrete Journal 2006: 80:13-19.
17. AASHTO T 26-79. Standard method of test for quality of water to be used in concrete.
18. J.H. Tay, WK. Yip, Use of reclaimed water for cement mixing. J. Environ. Engg 1987: 113:5: 1156-60.
19. G.R. White, Concrete technology, Von Nostrand Reinhold, New York,N.Y 1977.
20. AS 1379, Specification and supply of concrete Standards Australia, 2007
21. NZS 3121, Specification for Water and Aggregate for Concrete,New Zealand Standards 2002
22. A.M. Neville, Properties of concrete, fourth ed., Longman Group, England,1995:182-184.
23. H.H.Steinour, Concrete mix water –how impure can it be? J.PCA Res.Dev.Lab.1960:2:3: 32-50
24. Construction Industry Research and Information Association,The CIRIA Guide to Concrete Construction in the Gulf Region,CIRIA,London,1984
25. S. Mindess, JF. Young. Concrete.PrenticeHall,New Jercy,1981.
26. SANS 51008, Mixing water for concrete, South African National Standards 2006
27. D.A.Abrams, In Experimental Studies of Concrete; Structural Materials Research Laboratory, Lewis Institute: Chicago 1925.
28. A.M. Neville, Properties of Concrete 3rd Ed,. Pitman, London, 1981.
29. M. Fintel, Handbook of concrete Engineering.2nd Edition, Van Nostrand Reinhold Co., New York, p.179.
30. I. Soroka, Portland cement paste and concrete. 2nd Ed., MacMillan press, London, England 1979.

31. EN 1008, Mixing water for concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete, 2002.
32. F.K. Kong, R.H. Evans, E. Cohen, F. Roll, Handbook of structural concrete. Pitman Advanced Publishing programme, London, 1983.
33. R. Taha, A S. Al-Harthy, KS. Al-Jabri, Use of production and brackish water in concrete. Proceedings International Engineering Conference on Hot Arid Regions (IECHAR), Al-Ahsa, Kingdom of Saudi Arabia, 2010: 127-132.
34. Chineese Institute of Civil and Hydraulic Engineering, Construction Codes of Concrete Engineering, Science and Tech.Pub.,Taipei,1999.
35. J J Waddell, Practical Quality Control for Concrete,McGraw-Hill Book Co.,New York ,1962:396

Standard Methods for the Examination of Water and Wastewater: APHA, AWWA, WEF, Washington, Dc, USA.1998.

37. T. Knudsen, Quantitative analysis of the compound composition of cement and cement clinker by X-ray diffraction, American ceramic society bulletin, 1976, Vol. 55, No.12, Pp. 1052-1055.