Experimental study on concrete by partial replacement of fine aggregate by textile effluent treatment plant sludge

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Abstract. Chemical sludge produced by textile industries poses a high threat to the environment causing pollution in all stages of its treatment and disposal. In this study sludge from textile dying unit was collected. It has been partially replaced for fine aggregate in concrete up to 20% replacement to find out the possibility of reuse of this hazardous waste in build materials. Manufactured sand made by grinding angular aggregates was used as fine aggregate. Study shows that the samples failed to meet the desired compressive strength required for structural applications. The reason for failure in strength development is to be further experimented by individual analysis of sludge components.

Keywords: chemical sludge, pollution, hazardous waste, fine aggregate, concrete

1. Introduction
Developing industrialization is creating various items and furthermore heaps of waste. The vast majority of this waste makes danger of peril people and the earth. According to USEPA, "Perilous waste will be squander that is unsafe or conceivably hurtful to our wellbeing or nature. The level of peril may shift notwithstanding the amount of the waste produced. By nature, unsafe waste muddles the procedure of gathering, dealing with, treatment and transfer, and, obviously costly and hazard included. Run of the mill case of such squanders incorporate substantial metals, for example, Chromium, Mercury, Nickel, Cyanide, and so forth and oil and oil loaded squanders with poisonous metals. Material industry is one of the most established ventures in India and has a noteworthy nearness in the Indian economy, adding to about 14% of assembling esteem expansion and 1/3rd of the India's gross fare income. According to, yearly risky waste created is assessed to be around 6.23 million tons. Out of this, 49.55 % is recyclable, 6.67 % incinerable and remaining 43.78 % is expendable in verified landfills. Twelve conditions of the nation (Maharashtra, Gujrat, Andhra Pradesh, Tamil Nadu, Odisha, Madhya Pradesh, Assam, Uttar Pradesh, West Bengal, Kerala, Karnataka and Rajasthan) represent 97 % of the aggregate squander age. In Tamil Nadu, huge amounts of compound slop is created for example 55.76 tons/day from Balotra CETP, 130.58 tons/day from Pali CETP, 184.60 tons/day from Tirupur CETP and 90.40 tons/day from Karur CETP are created also, are lying in CETP premises anticipating transfer to landfill. Mindfulness has been made for the sheltered administration of unsafe squander. Be that as it may, it isn't yet placed by and by in the greater part of the conditions of India because of different issues. Notwithstanding appropriation of most costly and propelled strategies, the resultant built up could conceivably be dangerous yet it must be dealt with again through a reasonable innovation. One likewise needs to work toward creating...
different environment—well-disposed and powerful financial innovations for the administration of
dangerous waste in India. Hardening/Stabilization (S/S) is an innovation utilized for treating
mechanical strong squanders containing poisonous constituents to keep their disintegration and
discharge to nature. It had been utilized for a considerable length of time as a last treatment venture
before the transfer of both radioactive and synthetic dangerous waste. A few examiners have
endeavoured S/S innovation for the treatment of various kinds of modern squanders, for the most part
overwhelming metals containing inorganic/natural slope. The interest for development materials is
dependably heightening because of expanding urbanization. In this way, usage of waste materials in
development is the need of hour. It isn't just sets aside extra cash yet additionally diminishes load on
the waning common assets. A few specialists have endeavoured to reuse squander materials into
different kinds of development materials, for example, obstructs from sewage muck utilizing fly fiery
debris, lime and gypsum what's more, Arsenic and Iron slop in block making, sewage and slime
powder in block and tile making, and ooze cinder for light weight totals and. Few writing of portrayal
and reuse of compound slime from material CETPs in India are accessible. Still the endeavours are on
to discover a reasonable financial and condition agreeable answer for the safe reuse of chemical
sludge. We have attempted the experiment with the partial replacement of sand with sludge material.

2. Materials

The textile sludge material for study purpose was obtaine
d from Sri Mahalakshmi textile and dying
unit, Asokapuram locality, Erode district, Tamil Nadu, India. The sludge was collected at sludge
storage facility, where sludge is dried to a certain extent prior to storage and is transported for
treatment and disposal at periodic intervals. Water samples were also obtained from the effluent
treatment plant at three different stages (ETP outlet, RO permeate, sludge mix prior coagulation) for
testing.
The sample sludge was dried at 100°C for 24 hours in a hot air oven and the moisture content
obtained was 36%. The sludge was further dried in room temperature and was ground to fine particles
by manual grinding by trowel. The sludge particles passing 300 micron sieve and retained on 75
micron sieve was taken for study. The sludge that passed 75 micron sieve was not involved in study
purpose due to inconvenience in handling at dry state.
Ordinary Portland cement – 53 grade confirming to IS 12600-2009 is used. OPC grade-53 shows
53N/mm² after 28 days of curing in fresh water. Standard cubes of dimension 150mm x 150mm x
150mm is used for determination of strength with partial replacement of fine aggregate with certain
percentages of sludge material and different curing periods.
Manufactured sand (M sand) is used as a substitute for natural river sand in this study. Particles
passing through 4.75 mm sieve are used. Crushed angular aggregates of size 20mm and 10mm
showing specific gravity 2.79 and 2.74 respectively was used in the study. Water for curing and
mixing confirming to IS 456 was used.

3. Methodology

Specific gravity of the fine aggregate and the sludge which is used in the study was determined by
standard pycnometer. The sludge was analysed by Tamil Nadu pollution control board, District
Environmental Laboratory, Tiruruppur. Standard cubes of 150 mm x 150 mm 150 mm dimension was
casted for M20 concrete to determine strength characters with different percentages of sludge for 7
days and 28 days of curing. The standard cubes were made 5% to 20% sludge as partial replacement
for fine aggregate. Cubes with different sludge percentages were casted and tested at periodic intervals
of curing. The compression test was conducted in a compression testing machine as per IS standards.
For various sludge percentages two samples were made and tested for compressive strength at curing periods of 7 days and 28 days respectively and the average strength of the cubes were obtained.

4. Results
4.1. Characteristics of Sludge

The grade distribution for sludge sample shows that the maximum percentage of sludge particles was retained on 2.36mm sieve. The moisture content of the sludge particles was about 36%, which was determined by drying in a hot air oven for 24 hours.

| S.No | IS Sieve No. | Weight retained | Percentage weight retained | Cumulative percentage weight passing |
|------|--------------|-----------------|---------------------------|-------------------------------------|
| 1    | 4.75         | 0.036           | 3.6                       | 96.4                                |
| 2    | 2.36         | 0.196           | 19.6                      | 76.8                                |
| 3    | 1.18         | 0.157           | 15.7                      | 61.1                                |
| 4    | 0.6          | 0.137           | 13.7                      | 47.4                                |
| 5    | 0.3          | 0.152           | 15.2                      | 32.2                                |
| 6    | 0.15         | 0.157           | 15.7                      | 16.5                                |
| 7    | 0.075        | 0.149           | 14.9                      | 1.6                                 |
| 8    | Pan          | 0.016           | 1.6                       | 0                                   |

Table 1. Grade size distribution of textile effluent sludge

| S.No | Parameters       | Sample LAB code | ETP outlet | RO permeate | Untreated sample |
|------|------------------|-----------------|------------|-------------|-----------------|
| 1    | pH (Number)      | 7.56            | 6.95       | 8.82        |
| 2    | Total suspended solids (mg/l) | 284 | 4 | 280 |
| 3    | Total dissolved solids (mg/l) | 13008 | 368 | 71010 |
| 4    | Chloride(as Cl) (mg/l) | 4615 | 125 | 28842 |
| 5    | Sulphate(as SO4) (mg/l) | 1325 | 7 | 10142 |
| 6    | BOD 3 days at 27degree celsius (mg/l) | 10 | 4 | 54x |
| 7    | COD (mg/l)       | 384             | 16         | 71010       |
| 8    | Oil and Grease (mg/l) | 1 | <1 | 2 |
| 9    | TKN (mg/l)       | 18.48           | <5         | 6.72        |
| 10   | Sulphide (mg/l)  | <1              | <1         | <1          |
| 11   | Phenolic compound (mg/l) | <0.0005 | <0.0005 | <0.0005 |
| 12   | Percent sodium (%) | 97 | 65 | 92 |

The sludge was obtained from different points namely ETP outlet, RO permeate, and untreated sludge sample. The properties shows that the ETP outlet sample shows increased values of dissolved solids, chlorides, oil and grease and phenolic compounds making the sample non portable. The RO permeate
shows improved characters under limits of standards making it portable. Untreated sample is highly contaminated with values more than prescribed limits for portable water making it non-portable. The standards of portable waste as indicated my BIS standards are pH (6.5 – 8.5), dissolved solids (500 mg/l), chlorides (250 mg/l. max), and phenolic compounds (0.001 mg/l. max). the RO permeate alone resides within the limits of standards which makes it most probable for portable consumption. ETP outlet and untreated sludge sample are not suitable for portable consumption.

4.2. Characteristics of M-Sand

The crushed form of angular aggregates was tested for specific gravity by pycnometer shows a specific gravity of 2.49. The grade size distribution of the manufactured sand (M-sand) used in the study purpose showed allowable characters to be used in concrete casting and testing process.

| S.No | IS Sieve No | Weight retained | Percentage weight retained | Cumulative percentage weight passing |
|------|-------------|-----------------|-----------------------------|--------------------------------------|
| 1    | 4.75        | 0.006           | 0.6                         | 99.4                                 |
| 2    | 2.36        | 0.129           | 12.9                        | 86.5                                 |
| 3    | 1.18        | 0.259           | 25.9                        | 60.6                                 |
| 4    | 0.6         | 0.122           | 12.2                        | 48.4                                 |
| 5    | 0.3         | 0.262           | 26.2                        | 22.2                                 |
| 6    | 0.15        | 0.156           | 15.6                        | 6.6                                  |
| 7    | 0.075       | 0.049           | 4.9                         | 1.7                                  |
| 8    | Pan         | 0.017           | 1.7                         | 0                                    |

4.3. Compressive Strength and Structural Applications

The compressive strength observed by testing in a compression testing machine at 7 days and 28 days respectively shows that the 5% replacement samples showed values with minor deviations from nonreplaced samples. The samples with 10%, 15% replacement shows greater deviation and 20% replacement sample shows poor strength development characters. The samples did not achieve desired strength characters at 28 days of curing making it unsuitable for structural applications in building components. The compressive strength result shows that average compressive strength decreases with the increase in the percentage replacement of sludge in the concrete.

| S.No | Percentage replacement % | Comp strength 7 days (N/mm²) | Comp strength 28 days (N/mm²) |
|------|---------------------------|------------------------------|------------------------------|
| 1    | 0                         | 19.21                        | 22.46                        |
| 2    | 5                         | 17.88                        | 19.56                        |
| 3    | 10                        | 9.325                        | 13.44                        |
| 4    | 15                        | 8.66                         | 11.66                        |
| 5    | 20                        | 3.23                         | 9.66                         |
5. CONCLUSION
From this study it is possible to conclude that partial replacement of textile effluent sludge for fine aggregate in concrete is not possible and restricts the usage of this industrial waste as a component in concrete. The sludge material gets finer than cement particles which increases its volume and water demand during mixing which reduces the strength characteristics of the building. Addition of this sludge also delays the setting of concrete. Detailed study on causes for failure in strength gain in concrete due to individual chemical components of sludge is to be carried out as next step of research.

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