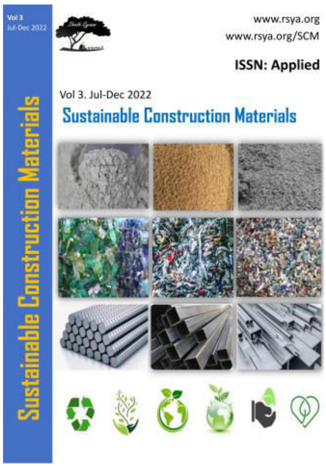

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A Review on Utilization of Water Other Than Potable Water in Concrete

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Abstract. The emergence of increasing population has caused a requirement of rapid infrastructure development which requires huge amount of fresh water. The world is already facing water crises and as reports of UNICEF, around 700 million people will suffer due to scarcity of water by the end of year 2030. In such situation, it is necessary to reduce the use of fresh water in construction industries by replacing fresh water with sea water, domestic and industrial waste water. This article aims to provide the short review to create knowhow of the utilization of water other than fresh water in the construction on the basis of previous researches. In this article, the effect of sea water and recycled waste water on the mechanical and durability properties has been discussed and it was found that use of high amount of salt present in sea water reduces the compressive strength but it can be countered by using admixtures and special types of cements and the use of sea water and recycled waste water in the cement concrete requires high degree of supervision.

Keywords- Sea water, domestic waste water, industrial waste water, concrete, compressive strength

1. INTRODUCTION

India is the second largest country in the world after China in terms of population[1] and accounts for approximately 17.68% of world population[1]. Although, India has a lot of rivers and lake of fresh water but those not enough for whole population[2]. The main reason is that the India is a developing country and water is shared in domestic and commercial usage[2]. It is not an easy task to meet the water demands of such huge population. The growing population, along with an unfavorable climatic environment, has an impact on available resources, particularly pure drinking water, which is inaccessible in some regions of the world[3]. Since, the resources are limited and population is still growing, it is necessary to avoid using fresh water in the industries such as construction so that fresh water can be supplied to people for drinking purpose. The construction industry serves as the backbone to infrastructure development. The concrete is a mixture of coarse aggregate, fine aggregate, cement and water[4], [5]. The water plays a pivotal role in the hydration of cement by which cement works as binder in the cement concrete[6]. The properties of cement concrete such as durability, reliability, long service life, and economic in terms of cost make concrete as the most desired construction material[7]. The present study aims to discuss the various characteristics of water, and their effect on the properties of cement concrete on the basis of previous researches.

2. LITERATURE SURVEY

This section describes the characteristics of water such sea water, domestic and industrial waste water which cannot be used for drinking purpose without any treatment or purification. In this section, the properties of sea water and waste water has been discussed as well as with their acceptable limits of impurities.

2.1 Sea water

Of the total water available on earth, about 96.5% water is sea water[8]. Sea water has salty taste and its salinity is approximately 3.5%[9] that means there will 35g of salt in 1 liter of water. However the sea water is not saline throughout in the world[9]. Kaushik et. al. suggested the acceptable limits for impurities in sea water by weight of water which are shown in table 1.

Table 1. Permissible limits of impurities[10]

Substance	Permissible limit (in %)
Organic substance	0.02
Inorganic substance	0.30
Sulphates in terms of $CaCO_3$	0.04
Chlorides of alkalis in terms of $CaCl_2$	0.2 for Plain concrete 0.05 for RCC

Seawater has a disadvantage in that it alters the engineering characteristics of cement such as permeability and setting time, however the use of various supplemental cementitious materials and natural pozzolans is efficient in reaching the desired effects[3], [10]. As per a study by Mori et. al., the compressive strength of concrete made with sea water will be more or less same as that of standard concrete after a decade [3]. This decrease in strength can be counter by using the pozzolanic material in concrete which will reduce the permeability and porosity of concrete and hence increase the strength of concrete[3].

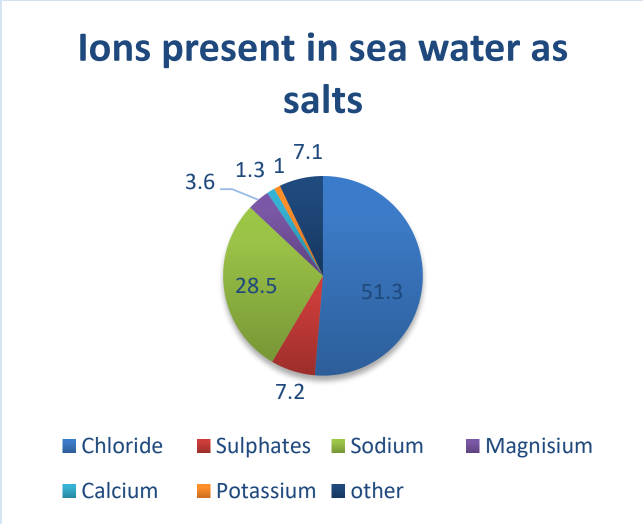

Fig. 1 Ions present in sea water as salt (in %)[3]

As per IS 456-2000, the pH of water to be used in the concrete should be limited to 6[11] hence the seea water should be tested for harmful and deleterious substances (as shown in fig. 1) that might induce sulphate attacks, corrosion, and acid attacks, among other things, as a result of the presence of undesired substances in it. The presence of chloride ions in sea water causes efflorescence and corrosion, which are two of the most serious issues that may occur in any building. Until the steel bar is completely corroded, the corrosion will continue to occur. The structure of a building is made up of steel bars embedded in concrete as a source of strength, thus the choice of sea water should be considered carefully. the studies suggested to avoid use of sea water in concrete[12] and as per studies, the decrease in strength vanishes as increase in strength in 10-20 years age of concrete[13].

Table 2. Effect of salts of sea water on compressive strength of concrete[13]

Salts of sea water (in %)	**Reduction in compressive strength (in %)**
5% Sodium Chloride	25-30
Carbon di Oxide	15-20
1% Sulphate	3.9-4
0.5% Sulphate	9-10

If we talk about setting time of cement, it is also influenced by the quality of water. When fresh water is used in cement the normal setting times comes in range between 30 min to 600 min[11]. The initial setting time should not be less than 30 min and the final setting should time more 10 hours[11]. As per studies, the sea water reduces the setting time by 32%, however, it can be countered by using retarding admixtures[14]. As per standard textbook for building material by SK Duggal, special types of cement should be used in marine or saline environments and the coastal region which are prone to sulphate attacks[6]. These special cements such as portland slag cement, sulphate resisting portland cement, high alumina cement provides better performance than ordinary portland cement. Researchers suggest that low water-cement ration as 0.26 with admixtures such as fly ash, blast furnace slag can reduce the chances of corrosion in steel bars[15].

2.2 Industrial and domestic waste water

Waste water are the sorts of water originating from numerous sources including human activities such as water from food preparation sink, Bathing, washing clothes, water from dish washer, sinks and drains, laundries, water from car washing stations, water form textile mills, water form cold storages etc. In India, where water crises are already high, there rises a concern that the waste water should be recycles and reused in the each and every applicable field which does require the use of fresh drinking water. As per a study, the sewage waste water cannot be used directly to concrete due to presence to harmful substances[16]. It should be treated first then used in the concrete by adopting cheap but safe procedure because it will not be economic for concreting if the cost of processing to treat waste water. If the process is cheap and efficient then it will provide the maximum benefit to municipality and construction industry[16].

Since the waste water is available in huge amount, many researches have been done on the use of waste water in the construction[16]–[20] and it was reported that use of recycles water imposed no adverse effect on the mechanical properties on the cement concrete[16]. As per IS 456, compressive strength of cement concrete should not be decreased by maximum 10% when using waste material in the cement concrete[11]. This is why to create knowhow about the properties of waste water, the permissible limits of various chemical and physical parameters of waste water are shown in table 3.

Table 3. Permissible limits of physical and chemical parameters

Parameter	Max. permissible limit	References
Appearance	Colorless	[11]
Odor	Odorless	[11]
Turbidity	None	[11]
Hardness	600 mg/l	[11]
pH	6.5-8.5	[11]
	>3	[19]
	7-9	[21]
Total solids	50000 mg/l	[22]
	5000-10000 mg/l	[3]
	4000 mg/l	[3]
	2000 mg/l	[11]
Dissolved solids	50000 mg/l	[3]
	2000 mg/l	[11]
Suspended solids	2000 mg/l	[11]
Inorganic solids	3000 mg/l	[11]
Alkalinity	600 mg/l	[11]
	1000 mg/l	[23]
Carbonates	1000 mg/l	[11]
Bi-carbonates	400 mg/l	[11]
Chlorides	2000 mg/l for plain concrete 500 mg/l (For RCC)	[11]

2.3 Brackish water

When sea water is mixed with fresh water then it is known as brackish water which have TDS (total dissolved solids) content between that of fresh and sea water[24]–[26]. Most continents have natural brackish water, especially brackish groundwater, in amounts almost equal to or greater than fresh groundwater and surface waters[24]. The brackish water is also generated from industries such as oil production firms, due to its huge availability several researches have been done on the use of brackish water in cement concrete [27]–[30] and it was reported that compressive strength of concrete made using brackish water can meet the desired requirement[31]. It was suggested by researchers that the brackish water should be checked for BOD, COD as well as their chemical and physical properties and these should be under permissible limits as describe table 3[29], [31], [32]. And it is general recommendation that the samples should be tested for mechanical and durability properties before incorporating such concrete in actual construction because it recommended to avoid the use of such water in the construction of structures of great importance e.g., high rise buildings, hospitals etc.

3. CONCLUSION

Although, the sea water and recycled waste water can be used in cement concrete as the impurities and solid substances present in such water can reduce the setting time and causing early gain of strength. this will not only reduce the voids but also enhance the strength of concrete. But there are several challenges in utilization of sea water and recycled water such as surrounding environment, geographical location, temperature and humidity conditions, availability of extra resources such as special cements and admixtures and these factors are necessarily to considers before utilizing the sea water and recycled water. At last, this short review has following conclusions.

- The recycled waste water can make the concrete more compact by lowering the workability due to presence of fine impurities and reduction in water content.
- The fine impurities present in recycled waste water will reduce the voids and this can decrease water absorption, the chances of chemical attack. Hence, concrete may become more durable.
- If compressive strength of concrete obtained using waste water comes around 90% of that with fresh water, then it is acceptable as per IS 456 recommendations.
- The sea water can be used in plain concrete works but should be avoided in the RCC works.
- Special cements such as high alumina cement, sulphate resistance cement etc. should be used while making concrete with sea water.
- Recycled water can be used in the RCC work only after testing for permissible limits of chemical and physical properties of water.
- Very high degree of supervision is recommended for using sea water and recycled waste water.
- The use of sea water and recycled waste water can save a lot of fresh water which will reduce the water crises up to some extent.

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