

An Examination of Possible Usage of Mumbai Creek Sand for Making Concrete – A Review

Sandeep D. Kadam¹, P. M. Devikrishna², Subrato Chowdhury³

¹M E student; Department of Civil Engineering - Structure, Saraswati College of Engineering - Kharghar, Navi Mumbai-410405, Maharashtra, India
Email: kadam268@gmail.com

² Professor, Department of Civil Engineering, Saraswati College of Engineering - Kharghar, Navi Mumbai-410405, Maharashtra, India
Email: devikrishna.pm@gmail.com

³ Head – R and D, Cement Business, Aditya Birla Group, Ahura Centre, Andheri (E), Mumbai- 400093, Maharashtra, India
Email: subrato.chowdhury@adityabirla.com

Abstract: This paper present literature review on replacement of natural sand by sea sand and/or sea water in Portland cement concrete. Progressively shrinking availability of river sand has posed a bigger challenge towards the usage of concrete in the infrastructural development in our Country. Towards mitigation of this problem a study is initiated to review the research work done usage of sea sand and/or sea water for concrete. The findings of the various research works on usage of sea sand/sea water indicated that it is possible to produce durable concrete using sea sand provided adequate precautions are taken to enhance resistance to deterioration of the concrete like increasing the density of concrete microstructure using appropriate combination binder, chemical admixtures and using non-corrosive reinforcement. And the characteristics of unwashed creek sand being more or less similar to the sea sand, there is great opportunity to use it as a partial or complete replacement for the scarce river sand without affecting the durability of the structures.

Key Words: River Sand, Creek Sand, Sea Sand, Sea Water, Binder, Compressive Strength, Rapid Chloride Ion Permeability

INTRODUCTION

Geological transformations and the physical movement of the river body have been transporting the sand from it's bed from upstream to the downstream. Different dams, barrages, etc which are essentially required to improve the irrigation

capabilities for cultivation & green energy generation as well has also resulted in blocking sand transformations to plains. Moreover, availability of sand mines in India is very insignificant compared to the consumption. A comprehensive understanding tells us that alternative to sea sand should be identified to maintain the uninterrupted growth of infrastructural projects. For Maharashtra having quite a sizable coast line, Mumbai in particular having huge quantum of sea sand/creek sand and these could be a potential material to replace normal river sand.

Scarcity of land and other resources is a reality, particularly in a small country like India. The rapid infrastructural developments in metropolitan & satellite cities in India demand huge quantum of aggregates. Mumbai's requirement of sand is around 15000 trucks per day; whereas, availability is only 400-500 trucks. Maharashtra requires close to 50000 sand trucks for construction purpose daily [13].

The characteristics of creek sand is understood to be similar to sea sand as it is always soaked & drained in the water transported from sea to creek. The usage of creek sand for the city of Mumbai is a unique opportunity. Sea water/sand is commonly known as a possible chloride bearing material, similarly creek sand as well. If we can use chloride contaminated materials like sea-water for curing and mixing, sea dredged aggregates, chloride enriched cement, and then it would be a great way forward to support sustainability initiative.

LITERATURE REVIEW

Use of Sea Sand Globally

In 2005 marine sand and gravel accounted for 8% of total primary aggregate sales in England & Wales, but more significantly for 19% of total sand & gravel sales in England and 46% in Wales. Clean and durable nature of marine sand and gravel makes it an excellent concrete aggregates. Examples of construction projects using marine aggregates:-

Arsenal AFC Emirates Stadium, Portsmouth Channel Tunnel Rail Link, Queens Alexandra Hospital, Cosham, Hampshire, Liver pool Paradise street development area, Portsmouth Terminal Five [9].

Sands obtained from seashore or dredged from the sea or river estuaries have been used in the UK over a long period. Currently, in the UK, about 20 per cent of natural gravel and sand requirement is sea dredged with submersible pumps making it possible to win the material from depths up to 50 m [10]. Also material from marine deposits around the coasts of Great Britain has been used in concrete production for several decades [11]. In China, where coastal areas are rich in sea sand, sea sands are already in wide use in local concrete construction due to convenience in mining and transportation, mature technology, and lower costs; the cost of sea sand is only 50-70 per cent of imported freshwater sand [12].

Many researchers have worked and reported in scientific journals on the usage of high chloride bearing materials such as sea water, sea sand in concrete making and its impact on durability of concrete. Chloride attack has been one of the major contributors towards concrete durability problems worldwide. It should be noted that chloride may be a contributing factor, but it is not the only factor. Many structures are standing tall in areas of high chloride concentration for a significantly long time and have shown no durability problem or corrosion problem. Huntington Lighthouse of USA (concrete structure built in 1912) and Murudeshwara Temple are few of the examples. Pore system and microstructure of hardened concrete play a significant role in corrosion. Moreover sufficient amount of oxygen and moisture should also be present. Corrosion is seldom seen in desert regions, because the concrete matrix does not contain sufficient amount of moisture, although other contributing factors are present. But it requires a

proper understanding of how “chloride” described by Verbeck(1975) as “unique and specific destroyer” can be used in concreting with minimum harm. The main chloride transport mechanisms are:

- Diffusion (driven by concentration difference)
- Permeation (driven by pressure difference)
- Migration (driven by voltage difference)

The amount of chloride transport is highly dependent on the pore-structure and the denseness of the concrete and therefore mainly varies with the w/c -ratio, cement content, pozzolana content, presence of micro-cracks and curing conditions.

Chloride ingress can be measured by various measurements. ASTM C: 1202-91 describes a rapid chloride penetration test where the total amount of chloride passing through the sample under a potential gives a measure of permeability of concrete.

Yildirim and Ilica (2010) studied the effect of cement types on the resistance of concrete against chloride penetration for a given compressive strength class. They used Ordinary Portland cement, sulphate resisting cement, granulated blast furnace cement and puzzolonic cement for making samples. RCPT results showed that blast furnace slag cement has the highest resistance to chloride permeability, while OPC and SRC showed the lowest. This validated the results of Ellis *et al.* (1991) who concluded that when fly ash, blast furnace slag or silica fume is added it significantly reduces the penetrability of concrete and increase its resistivity.

S. Premkumar and A. Ambika (2014) have found that concrete made using 100% beach sand as fine aggregates achieved better compressive and split tensile strength compared to river sand using Sulphate Resisting Portland cement compared to OPC.

The study conducted by D. A. R. Dolage et al 2013, revealed that offshore sand obtained from 2 to 7 km away from the Western coast of Sri Lanka, soon after dredging, can be used as an alternative to river sand, since the offshore sand dredged from places about 2- 7 km away from the shore is having a

chloride content well below the allowable limits. However, some offshore sand may require washing in order to remove organic matter that could not be physically separated by sieving, and other contaminants.

Nobuaki Otsuki et al. (2011) have investigated the possibility of using sea water for concrete making. The results of their investigation showed that "the difference of durability between the concrete mixed with fresh water and mixed with sea water is not so much, but the difference between the concrete with OPC and BFS cement is very large. Also, the BFS cement concrete mixed with sea water showed better durability than the OPC concrete mixed with fresh water. Authors, in this paper, explored the following possibilities;

- (1) Mixed with pozzolanic materials (Blast furnace slag powder (BFS), etc.) expecting to fix the free chloride ion.
- (2) Mixed with corrosion inhibitor.
- (3) Reinforced with stainless steel or corrosion resistant reinforcement.

The study was done for a period of 20 years. The authors have concluded that the countermeasures of using sea water as mixing water are as follows;

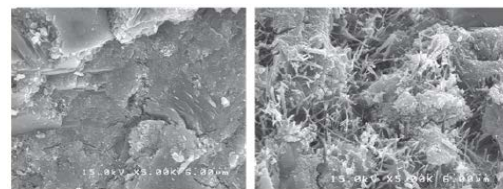
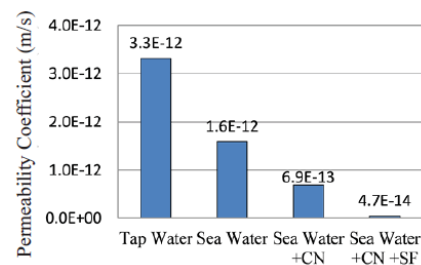
- 1) Use BFS cement or other blended cement instead of OPC
- 2) Use corrosion inhibitor.
- 3) Reinforced with stainless steel or corrosion resistant reinforcement

Preeti Tiwari et al. (2014) studied the effect of sea water on compressive strength of 1:3 cement mortar. The test result showed that the compressive strength of cubes which were cast and cured with salt water is slightly higher than the cubes casted and cured with fresh water. This trend is observed for testing of cubes at different ages of curing.

Md. Moinul Islam et al. (2012) have studied the effect of sea water as mixing & curing water on the compressive strength of concrete. The results of the study had shown that higher grade concretes have shown better resistance to deterioration compared to lower grade concrete. Also, concrete made with sea water but cured in plain water has shown better resistance to deterioration compared to sea water

concrete exposed to sea water curing. Sea water affects the gain in strength of concrete when used for mixing and curing. It increases the early strength gaining but ultimately the strength decreases. Sea water affects the rate of gain in strength of concrete when used for mixing. The strength of concrete made by using sea water is observed to be decreased by about 10% at 180 days.

K. Katano et al. studies the performance of concrete made using unwashed sea sand & sea water with different combinations of cementitious material using OPC, granulated blast furnace cement (GGBS), fly ash (FA), Silica Fumes (SF) and a special admixture containing Calcium Nitrate (CN) to produce high density & hard concrete. They found that the internal organizations of that concrete was denser compared with normal concrete, and it was clear that the water-tightness, early strength, and long-term strength of sea water and unwashed sea sand concrete were increased by adding mixture materials such as ground granulated blast-furnace slag, silica fume, fly ash and special admixture containing calcium nitrate. Reinforced concrete structures that used a non-corrosive reinforcing bar were durable in the long term. The permeability coefficient of sea water and unwashed sea sand concrete (total chloride ion content: around 4.5 kg/m³) becomes small compared with that of concrete made using tap water, as a result of density of its microstructures.



(a) Tap Water (b) Sea Water + CN + SF
Photo 1. SEM Images of Mortars

Fig. 1 Permeability Coefficient of Concrete

Photo 1 shows SEM images of mortars comparing microstructures of concrete mixed using tap water and concrete made with sea water as mixing water, CN, and SF. Many needle crystals of ettringite are formed in the pores of concrete mixed using sea water. It is inferred that these crystals filling large voids densify the microstructure.

Fig. 1 shows the permeability coefficient of concrete made using 50% OPC and 50% GGBS as the binder. Whereas the permeability coefficient of concrete mixed using tap water is 3.3×10^{-12} m/sec, those of concrete mixed using seawater, such concrete containing CN, and such concrete containing both CN and SF are approximately 1/2, 1/4, and 1/70, respectively. Thus the use of seawater, CN, and SF in combination is found to significantly improve the watertightness of concrete.

SUMMARY

Based on the above discussion following findings can be summarized;

- 1) Sea water or sea sand can be successfully used for production of concrete provided adequate precautions are taken to enhance resistance to deterioration of the concrete like increasing the density of concrete microstructure using appropriate binder composition, using non-corrosive reinforcement, etc.
- 2) Creek sand having almost similar characteristics compared to sea sand can be easily used for concrete making even without washing by using appropriate binder composition to achieve denser microstructure.
- 3) Unwashed creek sand can also be used for the structures under mild exposure conditions.
- 4) A long term study needs to be initiated to examine the plastic, hardened state performance & durability of concrete made using creek sand.

REFERENCES

[1] G. J. Verbeck. (1975) "Mechanisms of corrosion in concrete, Corrosion of Metals in Concrete", SP-49 American Concrete Institute, pp. 21-38.
[2] D. A. R. Dolage, M. G. S. Dias and C. T. Ariyawansa. Offshore Sand as a Fine Aggregate

for Concrete Production, British Journal of Applied Science & Technology 3(4): 813-825, 2013.
[3] S. Premkumar and A. Ambika, "Replacement of Beach Sand to River Sand in Cement Concrete, International Journal of Applied Environmental Sciences ISSN 0973-6077 Volume 9, pp. 1199-1208, Number 2014.
[4] H. Yildirim, T. Ilica and O. Sengul, "Effect of cement type on the resistance of concrete against chloride penetration", Construction and Building Materials, V-25, pp. 1282-1288, 2010.
[5] N. Otsuki, D. Furuya, T. Saito and Y. Tadokoro, "Possibility of Sea Water as Mixing Water in Concrete", 36th Conference on Our World in Concrete & Structures, Singapore 14 - 16 August 2011.
[6] P. Tiwari, R. Chandak, R. K. Yadav, "Effect of Salt Water on Compressive Strength of Mortar", International Journal of Emerging Trends in Engineering and Development Issue 4, Vol.2, ISSN 2249-6149, March 2014.
[7] Md. Moinul Islam, Md. Saiful Islam, Md. Al-Amin and Md. Mydul Islam, "Suitability of sea water on curing and compressive strength of structural concrete", Journal of Civil Engineering (IEB), 40 (1) 37-45, 2012.
[8] K. Katano, N. Takeda, Y. Ishizeki, and K. Iriya, "Properties and Application of Concrete Made with Sea Water and Un-washed Sea Sand", 3rd International Conference on Sustainable Construction Material & Technologies, Available: <http://www.claisse.info/proceedings.htm>
[9] D. E. Highley, L. E. Hitherrington, T. J. Brown, D. J. Harrison and G O Jenkin, "The strategic importance of marine aggregate industry to the UK", British Geological Survey Research Report OR/07/019.
[10] Neville AM, Properties of Concrete, 4th ed. India: Pearson; 1995.
[11] Newman K. Aspects of workability, strength, shrinkage and creep, sea dredged aggregates for concrete, Proceedings of a Symposium, Sand and Gravel Association of Great Britain, Buckinghamshire; 1968.
[12] Y. Huiguang, L. Yan, L. Henglin, G. Quan, "Durability of sea sand containing concrete: Effects of chloride ion penetration", Mining

Science and Technology (China),2011;21:123-127.

- [13]H M Vakharia, “Sands of Time” article in Construction World, July 2011 issue. Available on <http://www.constructionworld.in/News.aspx>

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