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Application of Waste Fishing Nets in Construction

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Abstract - *The threats caused directly or indirectly by influx of marine litter are extensive, having substantial environmental, social and economic impacts. Presence of abandoned fishing nets or ghost nets is a significant global threat to benthic fauna & aqua life such as marine mammals, fishes, birds. They are found in an enormous amount in sea due to their entanglement in rocks or tearing of old nets during fishing. Being non-biodegradable, they remain non-disposed in marine environment for hundreds of years & accumulate in small disintegrated parts. Transition from natural materials to non-biodegradable synthetic materials for manufacturing of fishing nets causes multidimensional & hazardous implications. Being non-biodegradable & possessing fibrous properties waste fishing nets can be used as building material as a sustainable approach. This research aims to analyze implementation of waste fishing nets in construction & reduce compilation of this non-biodegradable waste generated in environment & it's impacts on entire ecosystem.*

Key Words: Marine litter, Non-Biodegradable, Waste Fishing Nets, fibrous properties, building material, Use in construction, sustainable.

1. INTRODUCTION

Coastal areas play a vital role in socio-economic growth of any country as they provide great opportunities for natural resources based economic activities such as fisheries, tourism and Marine transport. The coastal region of India is highly affected by climate changes, developmental activities and urbanization. Survival of primary stakeholders, the fishing communities and preserving the health of coastal ecosystem and biodiversity is a significant challenge.

1.1 Need of Research:

Mumbai is an island city & the coastline of Mumbai has numerous beaches, creeks and estuaries. Central Marine Fisheries Institute of Mumbai (CMFRI) revealed the highest concentration of non-biodegradable marine debris found in the fishing grounds off Mumbai which is 49.11kg per square kilometer.

Gorai, Erangal, Aksa, Marve, Girgaon, Uttan, Juhu, Versova, Chimbai are the major beaches containing the marine litter of different types. Plastic products, Food wrappers, glass bottles and fishing nets are major types of litter found here. Mahim, Worli, Sion, Mazagaon koliwada are the most scrap fishing nets generating places as oldest fisheries communities are residing since long time. Hazardous impacts of waste FN are:

1. Accumulation in and around coastal areas as waste or discarded nets creating pollution
2. Impact on marine life such as marine mammals, fishes, birds due to entanglement & ingestion
3. Threat to human health having seafood as prime food.
4. Ecological imbalance due to destruction of habitat for marine biota
5. Hazards to navigation i.e. for shipping

Use of these discarded nets is currently done for creating Apparels, Jewells, Crafts & Accessories, Surfboard components, Carpets on treatment etc. Applicability of these waste nets in construction can save cost as well as resources & reduce the impacts it causing on earth.

Hence this paper aims on analyzing the use of discarded fishing nets in construction with the help of experimental investigation as a sustainable approach.

Scope will be limited to:

- To study & analyse the physical & mechanical properties of waste fishing net fibres which can be used in construction.
- To propose the ways in which it can be used in construction on experimental investigation.
- This study will be limited to discarded waste fishing nets only & to the coastal region of Mumbai.

1.2 Literature Review

- Jelil, S.N. & Jain, N. (2014): This paper talks about investigation of the quantity and composition of beach litter and its types in the beaches of Mumbai. Based on the field survey, in all the beaches plastic was the major type of litter followed by food wrappers, glass bottles & fishing nets. Since the fisheries communities are the oldest community residing in coastal region, generation of waste fishing nets is most here. Secluded beaches like Uttan and Gorai had a major concern of the presence of abandoned fishing nets.
- Bertelsen, I. M. G., & Ottosen, L. M. (2016): Recycled plastic fibers from waste fishing nets (HDPE) were investigated with respect to their engineering properties

such as tensile strength and Young's modulus. With this screening it is possible to evaluate the applicability of this type of discarded fishing nets as reinforcement in construction materials. This paper discusses how the HDPE fishing net fibers can be implemented in concrete in order to improve its properties.

- Ida Bertelsen Lisbeth M. Ottosen. (2016): This paper discusses about reusing local waste materials from the fishing industry & finding proper application for waste nets in the construction. The methodology for testing is:
  - Physical properties (SEM) & Mechanical properties (tensile test)
  - Durability properties (immersion in 1M NaOH for 28 days)
  - Casting of material samples
  - Mix fibres into material mixture such as mortar, gypsum or clay.
  - Test bonding properties in different materials & evaluate composite materials.
  - Possible applications on results & analysis.

- I M Hanif, M R Noor Syuhaili, M F Hasmori and S M Shahmi (2017): The results obtained from this study shows that by using nylon fiber as additive material can improve the mechanical properties of the cement-based mortar and at the same time produce a good sustainable product that can protects and conserve the marine environment.
- Sigvardsen, Nina Marie; Bonnerup, Amanda Helena; Ottosen, Lisbeth M. (2016): Results show a tendency for beams with NSMR FRP (near surface mounted reinforcement fiber-reinforced polymer) bars to prolong the linear elastic region, thus postponing the formation of cracks.
- Saverio Spadeaa, Ilenia Farinaa, Anna Carrafiellob, Fernando Fraternalia (2015): This paper investigates engineering applications of recycled nylon fibres obtained from waste fishing nets, focusing attention on the use of recycled nylon fibres as tensile reinforcement of cementitious mortars. It deals with compression and bending tests on cementitious mortars reinforced with recycled nylon fibres, and establish comparisons.
- Ganesh Kumar. R., Prasath. K. S., Sudharsan. R. (2019): Waste Nylon fibre in concrete will increase the ductile behaviour of concrete. The compressive strength, split tensile strength, flexural strength of concrete will increase by percentage of nylon fibre i.e. (1%, 2%, 3%.etc.)

1.3 Methodology

Step 1: Research Question
Can waste fishing nets be used in construction?
Step 2: Need of the study, Aim & Objectives, Scope of the Research
Step 3: Literature Review of Research Papers
Step 4: Data Collection & Analysis
Sample Collection Lab Tests
Step 5: Findings
Step 6: Conclusions & Recommendations

2. DATA COLLECTION & ANALYSIS:

Sample Collection:

Experimental investigations were performed on discarded fishing nets to evaluate the Physical and mechanical properties. The samples collected & investigated were fishing nets of the type Knotted Nylon from Gorai beach in Mumbai, after being used for an unknown period of time & discarded. The net type of nylon is among the most used types in coastal region of Mumbai.

Fig -1: Waste FN Fiber Samples Collected from Scrap

Laboratory Tests:

These samples were kept in laboratory for different tests by which the properties and impact of using samples in different grades of concrete [M15 (1:2:4), M20 (1:1.5:3), M25 (Design Mix - 1:1.31:0.71)] was checked in accordance with IS standards. The different tests performed in lab are:

1. SEM Image Test of waste FN fibre:

After collection, the nets were superficially cleaned in fresh water to remove residues and other impurities & dried then. Three different pieces with & without knots were mounted on base with carbon tape to keep it intact. Silicon coating was added on fibre so as to avoid any kind of charging being a polymer. Silicon coating does not change any property of fibre studied in testing.

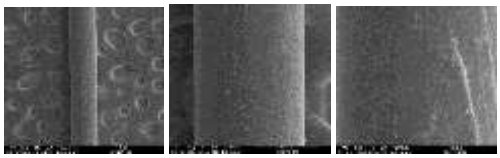

Fig -2: SEM image of waste FN fiber

2. Compressive Strength Test of concrete cubes:

Plain concrete cubes & Fibers added cubes were compared for their respective compressive strengths.

The locally available Ordinary Portland Cement, Coarse & fine Aggregates, Sand, Tap Water & Waste Fishing Net Fibers were used to create the specimens of concrete cubes of size 150 x 150 x 150 mm. The max. size of aggregate used was 20 mm & dia. of fiber was between 0.16-0.28 mm measured by

SEM image testing. Waste fishing net fibers were manually cut in two manners.

1. Fibres of 50 mm length
2. layer of size 150 x 150 mm

Moulds were made clean and oil was applied to make it easy to demould the cubes. Concrete mix was filled in layers & those were compacted with tamping rod of approx. 16 mm dia. & the top surface was levelled with the help of trowel.

Preparation of concrete mix –

1. For preparing plain mix, all materials were put in the drum mixer & then the water was added. The mixer was rotated for five minutes & slump cone test was performed before pouring the mixture into the moulds. Such plain four cubes were casted for each grade of concrete mentioned.
2. Then another four cubes were casted by putting alternate layers of mix & fishing net layer of size 150 x 150 x 20 mm in moulds for each grade of concrete mentioned.
3. The remaining four cubes were casted by putting the fibres of 50 mm length randomly 5% in volume for each grade of concrete mentioned.
4. Hence, total 36 concrete cubes were casted & coded for identifying the types & demoulded after 24 hours. Then they are kept into the curing tank without stacking on each other for 28 days before testing.
5. Compressive strength test was conducted on 3rd, 7th, 14th & 28th day respectively.

Testing of cubes in Compression Testing Machine (CTM):

One by one they were aligned centrally on the base plate of the CTM. The load was applied gradually till the specimen fails. The maximum load was recorded & compressive strength was measured.

Fig -3: C. S. Test Procedure in CTM

Grade of concrete	Type of Mix	C.S. at Curing Days (MPa)			
		3rd	7th	14th	28th
M15	Conventional	6.15	9.85	13.65	22.2
	Crushed Nets	5.85	8.35	12.25	21.2
	Layered Net	6.65	11.25	14.7	23.2
M20	Conventional	8.2	13.15	17.85	27.6
	Crushed Nets	7.45	10.75	16.25	26.6
	Layered Net	7.75	11.45	16.85	27.1
M25	Conventional	10.25	16.35	22.65	34.5
	Crushed Nets	9.15	14.85	19.85	31.6
	Layered Net	9.65	15.40	20.15	32.2

Table -1: Results of C.S. Test

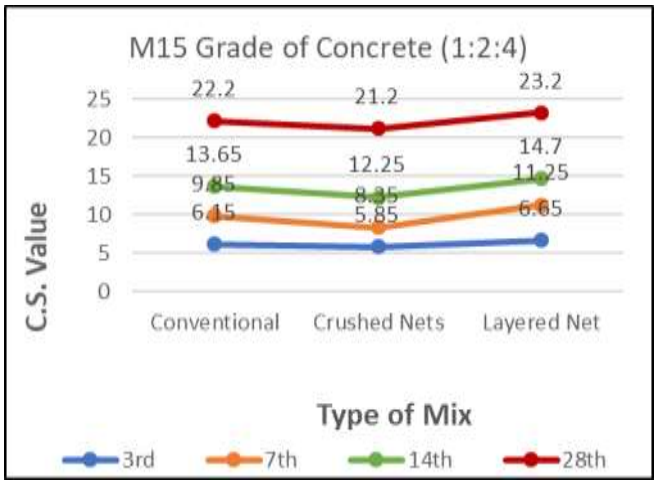

Chart -1: Comparison of all curing days of M15 concrete

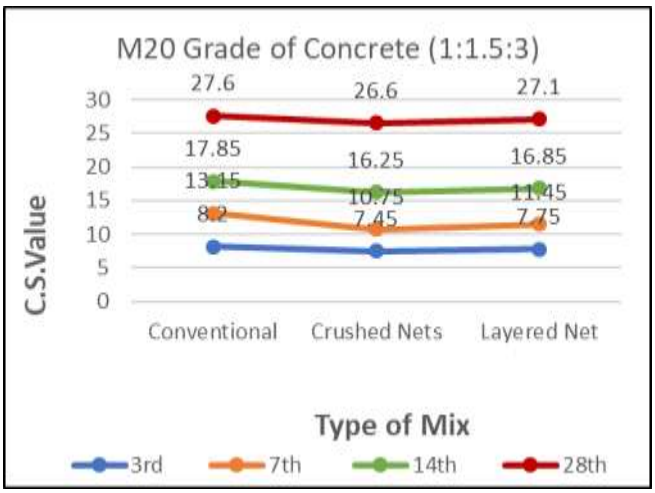

Chart -2: Comparison of all curing days of M20 concrete

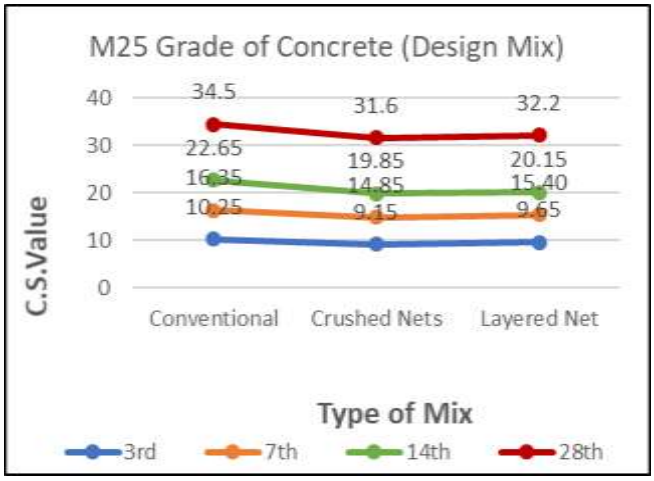

Chart -3: Comparison of all curing days of M25 concrete

3. Flexural Strength Test of concrete beams:

Plain concrete beams & Fibers added beams were compared for their respective flexural strengths.

The locally available Ordinary Portland Cement, Coarse & fine Aggregates, Sand, Tap Water & Waste Fishing Net Fibers were used to create the specimens of concrete beams of size 150 x 150 x 700 mm. The max. size of aggregate used was 20 mm & dia. of fiber was between 0.16-0.28 mm measured by SEM image testing. Waste fishing net fibers were manually cut in two manners.

1. Fibres of 50 mm length
2. layer of size 150 x 150 mm

Moulds were made clean and oil was applied to make it easy to demould the cubes. Concrete mix was filled in layers & those were compacted with tamping rod of approx. 16 mm dia. & the top surface was levelled with the help of trowel.

Preparation of concrete mix –

1. For preparing plain mix, all materials were put in the drum mixer & then the water was added. The mixer was rotated for 5 minutes & slump cone test was performed before pouring the mixture into the moulds. Such plain 4 beams were casted for each grade of concrete mentioned.
2. Then another 4 beams were casted by putting alternate layers of mix & fishing net layer of size 150 x 700 x 20 mm in moulds for each grade of concrete mentioned.
3. The remaining 4 beams were casted by putting the fibres of 50 mm length randomly 5% in volume for each grade of concrete mentioned.
4. Hence, total 36 concrete beams were casted & coded for identifying the types & demoulded after 24 hours. Then they are kept into the curing tank without stacking on each other for 28 days before testing.
5. Flexural strength test was conducted on 3rd, 14th, 21st & 28th day respectively.

Testing of beams in Universal Testing Machine (UTM):

One by one they were aligned on the base plate of the UTM leaving 50 mm on both sides keeping span as 600mm with support of two rollers mounted at distance 200mm. The load was applied gradually n the center till the specimen fails.

The maximum load was recorded, distance at which failure occurs was recorded & flexural strength was measured.

Fig -3: F. S. Test Procedure in UTM

Grade of Concrete	Type of Mix	F.S. at curing days (MPa)			
		3rd Day	14th Day	21st Day	28th Day
M15	Conventional	1.2	1.7	2.10	2.9
	Crushed Nets	0.9	1.4	2.10	2.7
	Layered Net	1.7	2	2.60	3.2
M20	Conventional	1.7	2.4	3.2	3.5
	Crushed Nets	1.4	1.7	2.3	3.1
	Layered Net	2.60	3.10	3.70	4.1
M25	Conventional	2.5	3.1	3.5	3.9
	Crushed Nets	2.1	2.6	3.1	3.5
	Layered Net	3.5	4.1	4.6	4.9

Table -2: Results of F.S. Test

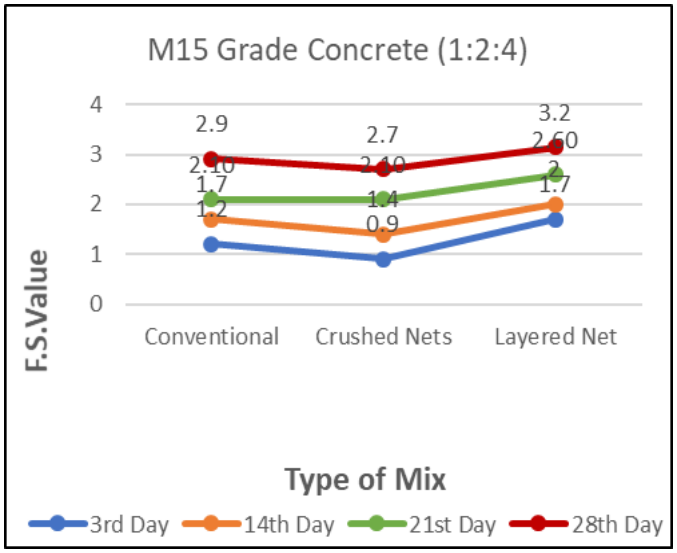

Chart -4: Comparison of all curing days of M15 concrete

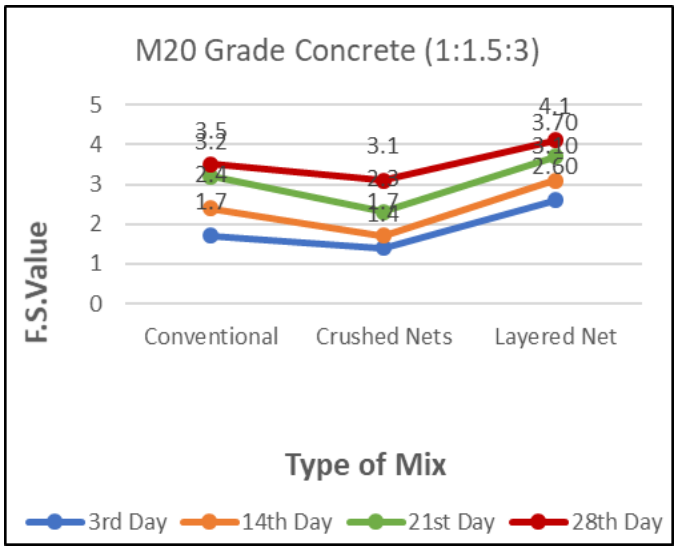

Chart -5: Comparison of all curing days of M20 concrete

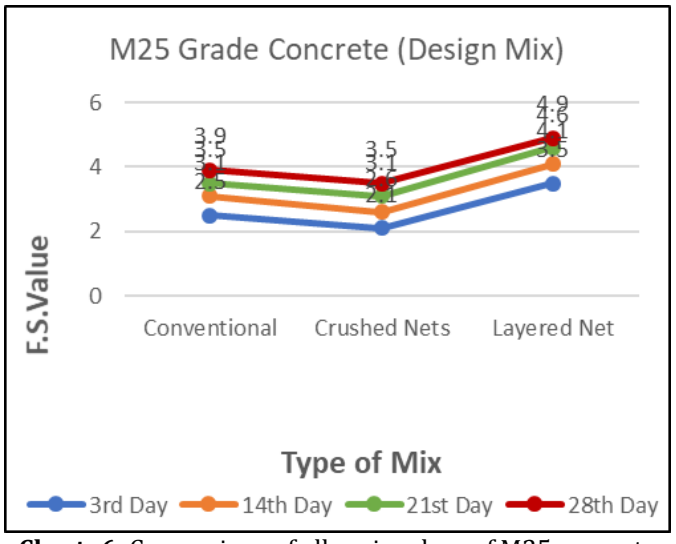

Chart -6: Comparison of all curing days of M25 concrete

3. FINDINGS/OBSERVATIONS

On performing analysis of data obtained from literature review & laboratory tests, following observations are noted:

1. Abandoned waste fishing nets are present in and around coastal region of Mumbai creating a challenge to marine life as well as human life being one of the marine pollutants.
2. As fishing is the major source of income & fishery community is the oldest one in Mumbai coastal region, scrap generation is higher in this area and the rates are cheaper being a waste material.
3. Analysis of SEM images showed that the diameter of the monofilaments was between 16 µm to 28 µm, with the most appearing diameter being 28 µm. There was a clear tendency of the rough surface seen in SEM image.
4. On 3rd, 7th, 14th & 28th day of curing, in comparison with plain concrete there is an increase in CS of M15 grade of concrete when waste fishing net fibres were added in layers whereas it decreases when they were added randomly.
5. M20 & M25 grade of concrete shows decrease in CS when added with fibres in any manner than that of plain concrete.
6. On 3rd, 14th, 21st & 28th day of curing, in comparison with plain concrete there is an increase in FS of all three grades of concrete when waste fishing net fibres were added in layers whereas it decreases when they were added randomly.

4. CONCLUSIONS & RECOMMENDATIONS

Conclusions:

1. Waste fishing net fibres which are present in enormous amount around coastal region of Mumbai are hazardous to marine environment & ecosystem altogether. Since non-biodegradable and synthetic in nature, they are not disposed off in proper manner creating a range of pollution which can be reduced on reusing.
2. Quantity of scrap FN is higher in coastal region and the rates are also cheaper than the existing resources in construction. Hence, the use of waste FN impacts construction cost incurred.
3. Study of physical & mechanical properties leads to the feasibility of application of waste FN fibres in construction on laboratory testing.
4. SEM images suggest rough surface of fibre sample which is effective in interfacial bonding with concrete mix.
5. M15 concrete when mixed with waste fishing net fibres shows improvement in compressive as well as flexural strength.
6. M20 and higher grades of concrete does not show improvements when mixed with waste fishing net

fibres as the results of both Compressive and Flexural strengths are not satisfactory.

Recommendations:

1. It is recommended to use M15 grade of concrete mixed with waste fishing net fibres as it shows a clear tendency of improvement in both compressive and flexural strength on experimental investigation.

2. M20 and higher grade of concrete do not show increase in both compressive and flexural strength on experimental investigation. Hence it is recommended to test & analyse the impact of temperature increase enhancing bonding between fibres and concrete and use as structural element in construction.

3. In case of M20 & higher grade of concrete, mix design can also be proposed in which both waste fishing net fibres and admixtures are mixed collectively in controlled proportion to improve quality of concrete.

4. It is recommended to replace conventional M15 grade of concrete by the one mixed with waste fishing net fibres wherever possible in coastal regions. This will help to reduce abandoned waste fishing nets found around sea disturbing the balance of marine life & entire ecosystem being one of the marine litters as well as the cost of construction & also to save existing construction resources in turn.

5. This study is limited to coastal region as waste fishing net scrap is generated in higher quantity. It is recommended to carry out the same experimental investigation with different other fibres for other areas to use as building material.

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