The Effects of Different Types of Concrete Compositions on Benthic Organisms under an Ecodock

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Abstract

Coastal Infrastructures are increasing in abundance as more people look to live on the water. Coastal Infrastructures are typically made out of Portland cement. Portland cement is considered detrimental to marine organisms due to the high pH and surface alkalinity. This project will be studying the effects of different types of compositions of concrete and their capability of recruiting organisms in a horizontal placement. It was hypothesized if different innovative concrete matrices varying in composition and texture were used to test for marine life recruitment on the ecodock, it would prove to be better than Portland cement in regards to being more biodiverse. Four sets consisting of six different concrete matrices were hung horizontally under the ecodock located on pier 101 on Governors Island. Organism recruitment was quantified by using a quadrat for percent cover and by counting. Biodiversity was measured by using the Shannon Weaver Index. Matrice 5 proved to be the most biodiverse out of all the concrete types. Texture had a recruitment rate of 1.05, which was slightly higher than the 1.00 of the smooth side. However, it was not statistically different due to the low number of replicates.

Introduction

More people are increasing their dependence on water, leading to them living near or close to water (Kummu 2011). With the increasing population, the construction industry is increasing on the coast (Perkol-Finkel 2014). Coastal infrastructures like breakwaters, seawalls, and piers are often used to prevent erosion while at the same time supporting an increasing human population (Bulleri 2010). Some coastal infrastructures could be detrimental to marine organisms in the area. This is because the natural coastline is decreasing (Perkol-Finkel 2014). By getting rid of the natural coastline, natural substrates for organisms are destroyed. When the natural substrate becomes replaced by breakwaters with unnatural physical and chemical parameters, organisms can't survive (Abdus-Samad 2013). In the past many people have tried different techniques to protect marine organisms while at the same time supporting the increasing population (Bulleri 2010). If different innovative concrete matrices varying in composition and texture are used to test for marine life recruitment on the ecodock, that could replace Portland cement, then the biodiversity of the area will rise due to the presence of a more natural substrate (in regards to chemical and physical parameters) being present.

Background Information

Studies have recently shown that there has been an increase of the population choosing to live by water (Kummu 2011). As of 2012 two-thirds of the people in the world already live by water (Perkol-Finkel 2012). It is projected that by 2025, 75% of the population will live on or near water (Bulleri 2010). Due to the increase in people on the coast and the replacement of the organisms' habitat with infrastructure, it is assumed that the water quality or biodiversity will decline.

Bivalves, tunicates, and other sessile organisms in the New York Harbor area have slowly declined due to pollution, over-exploitation, and disease (EPA 2012). Improved water quality (EPA 2012) in the area has led to resurgence of some these organisms but they need an efficient substrate to survive on (Bulleri 2010). Portland cement is the most commonly used cement in construction and has been used in the past on piers. Portland cement cannot serve as an efficient substrate for marine organisms to colonize due to the fact that it has a high surface alkalinity and pH not natural to the ocean (Abdus-Samad 2013). Since it is so unhospitable to organisms, they either depart in search of a better ecosystem or die off. Overall, this lowers this biodiversity in the area. ECOncrete, the alternative to Portland, has a lower pH and surface alkalinity (Abdus-Samad 2013). Given that, ECOncrete is friendlier to organisms searching for a habitat to latch onto.

Physical appearance of a substrate also has an effect on how and what colonizes (Bulleri 2010). ECOncrete units tested had one smooth and one textured side. When testing ECOncrete in a vertical placement, the textured side generally had more recruitment. When the six month period was reached, recruitment on the textured side averaged eighty percent and about seventy- four percent for the smooth side. Textured substrates typically had more recruitment of colonial and solitary tunicates and Sabellidae. Bivalves and barnacles maintained a steady colonization rate throughout deployment (Abdus-Samad 2013). Furthermore, colonial tunicate recruitment did vary, but it averaged overall about 54%. Also, even more organisms were found than expected (Abdus-Samad 2013).

Matrix	Water cement/Ratio	pH	Average Compression Strength (Mpa)	Weight (Kg/m^3)	Water Pressure Penetration Resistance (mm)	Chloride Penetration Resistance (Coulombs)
M1	0.3	9-10	32.5	2300-2500	<20	<1500
M2	0.3	9.5-10.5	48.5	2300-2500	<20	<1000
M3	0.3	9.5-10.5	39.3	2300-2500	<20	<1000
M4	0.3	9-10	31.1	1400-1800	NR	NR
M5	0.3	9-10	31.9	1400-1800	NR	NR
Portland	0.30-0.25	12.5-13.5	32	2300-2500	<20	>2000

NR- Not relevant for high air content concrete

Table 1- Physical Parameters for the different concrete types compared to Portland cement. (Abdus-Samad 2013)

17		**18**		**19**		**20**	
204	Portland	284	M5	113	M2	205	Portland
286	M5	203	Portland	246	M4	280	M5
161	M3	153	M3	201	Portland	165	M3
91	M1	110	M2	166	M3	244	M4
111	M2	239	M4	267	M5	128	M2
238	M4	66	M1	65	M1	82	M1

Table 2- Each tile on every set is different. This shows the tile number and which matrice it corresponds to.

<u>Project Design Chart</u>

Scientific Problem:	Is it possible to create a suitable artificial substrate for organisms?
Objectives:	• Monitor organism recruitment on ECOncrete • Determine which texture and concrete type of ECOncrete is suitable for organisms • Determine which orientation of ECOncrete is suitable for organisms
Null Hypothesis:	ECOncrete will not prove to be a suitable substrate and not replace Portland cement.

Proposed Variables		**Proposed Controls**	**Proposed Constants**
Independent	*Dependent*	Portland cement	Orientation of sets (horizontal) Location- under ecodock
Textured vs. non-textured Different composition types	Biodiversity Percent cover Diversity in Species		

Possible Outcomes
• No recruitment • Textured side of ECOncrete will generally receive 80-85% of recruitment

How Data Will Be Represented
Data will be collected and then averaged out between all three sets and then graphed using a line graph.

List and Explain Statistics You Will Use to Support Results
Biodiversity indices will be used to explain the differences in recruitment between the textured and smooth sides.

Assumptions
• Concrete will be used in the future on coastal infrastructure • Biodiversity will increase in the area • Infrastructures will increase in strength

Limitations
Factors that can influence the results are water quality of the surrounding area, closeness to the surface, movement of water, and the orientation of the sets. These all limit what recruits and what comes off the tiles.

Locality

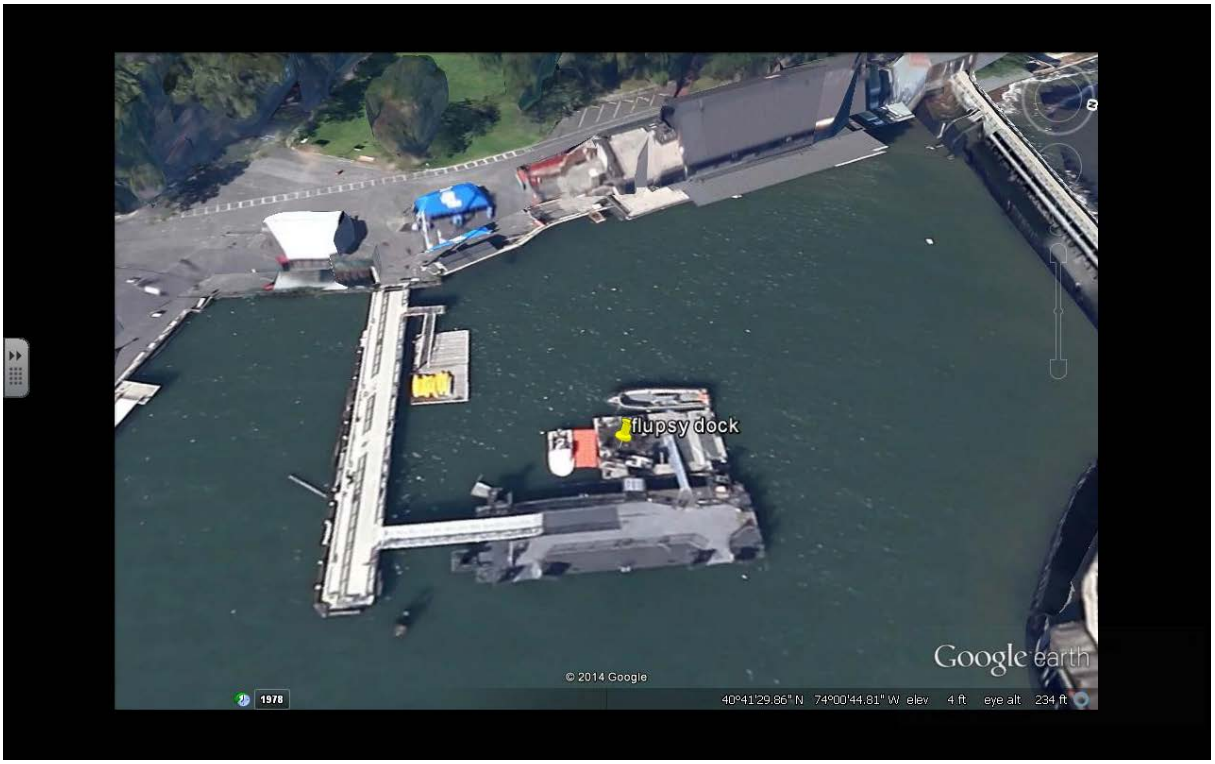

Figure 1- shows Pier 101 on Governors Island. The experiment was conducted under the flupsy dock Latitude: 40. 691412, Longitude: -74. 02106

Materials

Materials	**Quantity**	**Function**
Microscope (Levenhuk 25649 3S NG microscope;200x magnification)	3	to view invertebrates
Box of gloves	1	to protect hands

Clipboard	1	to hold data sheets
Knife	1	To cut rope
Spool of rope	1	To tie tiles to pier
Camera (Pentax X90)	1	To take pictures of data
Garbage bag	1	To cover tiles
Cart	1	To hold materials
15x15 cm grid	1	To measure percent cover
Tape	1	To mark up rope
Digital Dissection Scope (Amscope)	1	Viewing and photographing organisms taken from ECOncrete sets
Data sheets		To write down data and information
Spectrometer	1	chlorophyll
Scraper	2	To scrape off organisms when testing for overall recruitment
Petri dishes	6	To hold organisms
Tweezers and needles	4	Examining invertebrates
Alcohol (ethyl alcohol pure 1:4)		Storing samples of organisms
Lifejacket	Depends on how many people	Personal floatation device

	are on the dock	
Magnifying glass	4	Viewing organisms
Laptop	1	To process data
50 ml test tube	5	To store organisms for microscopy.
Carabineers	8	To attach set ropes to.
Jar	2	To store alcohol concentration

Figure 2- ECOncrete tiles before deployment. The textured side is shown. The tiles vary in composition.

Procedures

Preparation

- Lay out all the four plots and take pictures of plot tag and tag on each tile.
- Take a picture of the tiles on their textured and smooth side.

ECOncrete Deployment

- Put on lifejacket and begin recording with camera and make way to dock with ECOncrete in buckets.
- Lay out ECOncrete sets and have one person on each end of the rope.
- Carrying the sets, make way to the edge of the dock.
- On one end tie extra rope with a sheep bend so it would be easier to position the sets.
- With scissors cut the rope to length needed and deploy set into water.
- With the top end of the rope, position the set so the rough side is facing the oyster cages.
- Tie set to cleat/hole (snap shackles can be used to make removal easier).

ECOncrete Sampling

- Take buckets down to the dock, untie ECOncrete sets and carefully place in buckets.
- Fill one bucket with water and pour into cart and place sets into the cart.
- Take picture of each tile on smooth and rough side.

- On textured side record the number of organisms on the data sheet. The organisms will be measured using a percent cover method with quadrat. Other organisms will be quantified based on abundance.
- On smooth side record the number of organisms with data sheet. Same method used on the textured side will be used on the smooth side.
- Return sets back to dock and pour water out of cart.

Sampling Organisms

- Take a jar and fill ¾ with Alcohol
- Place Organism inside jar
- Identification is done using a field lab guide and Digital Dissection Scope

Analyzing Data

- Data for general percent cover and tunicate percent cover will be averaged out on a line graph and graphed on excel.
- Data for barnacles will be graphed on a bar graph on excel.

Results

When the ECOncrete tiles were first sampled, there was little to no recruitment. Most of the recruitment was that of turf algae. When the tiles were sampled again in September, there was a clear increase in invertebrate recruitment.

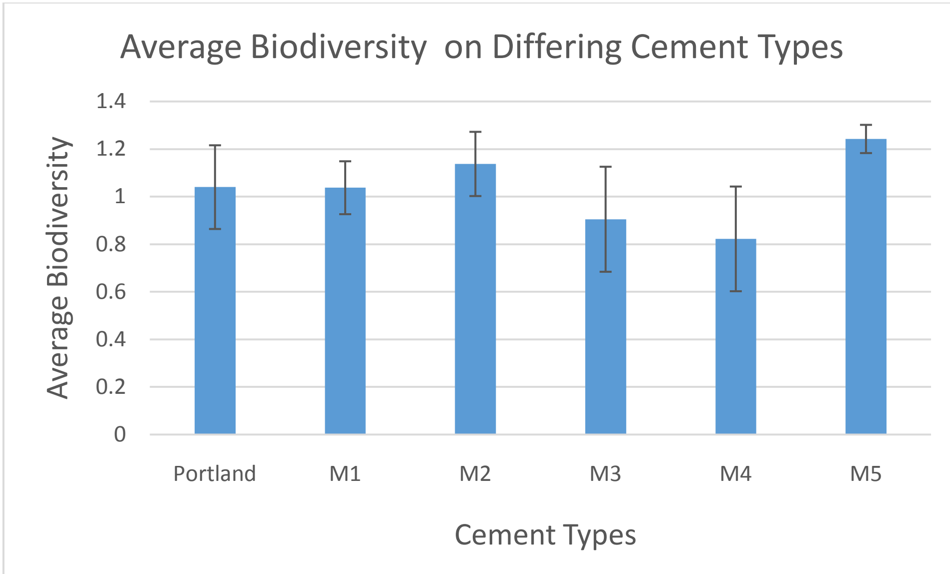

Figure 3- Average Biodiversity on Different Cement Types shows the average biodiversity for all six cement types. Also displayed is the standard error of the cement types. M5 has the smallest standard error and the highest biodiversity average.

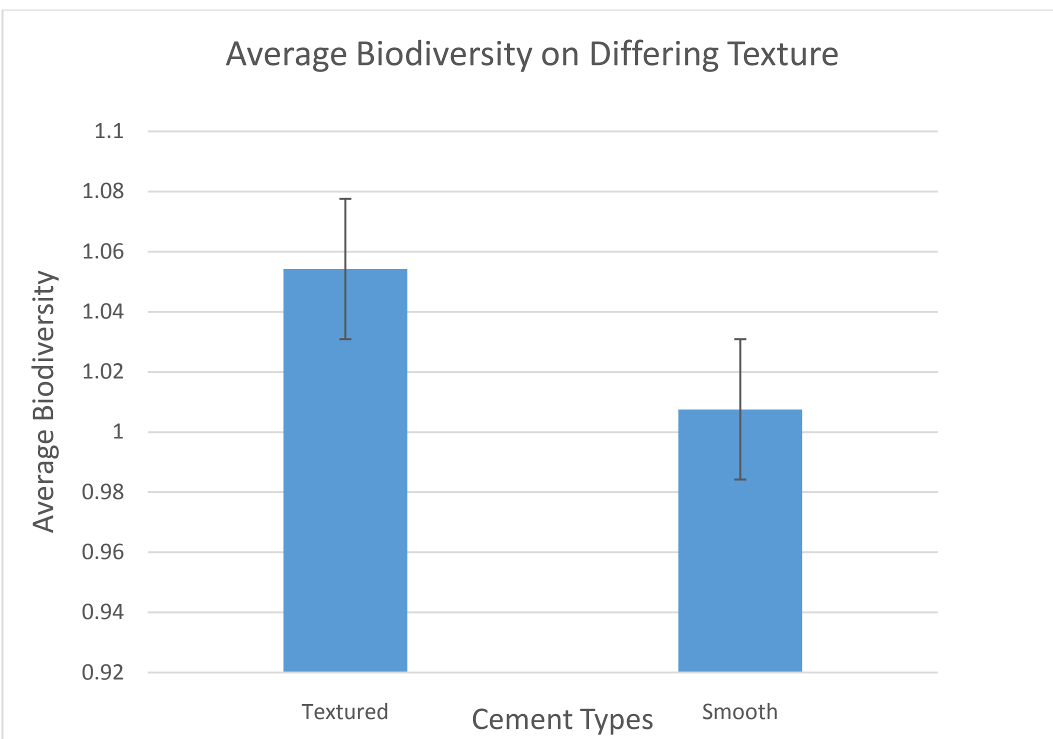

Figure 4- Average Biodiversity on Different Textures shows the average recruitment amongst textured and smooth cement types. In addition to that, standard error is displayed. The textured and smooth cement types did not differ by much in average recruitment.

Figure 5- pictured is the textured side of tile 128. The organisms present on this tile are *Botryllus schlosseri, , Eupleura caudate* and *Semibalanus balanoides.*

Figure 6- Pictured is the smooth side of tile 128. On this tile, there is a higher percent cover however, the same organisms are present.

<u>Organisms Found</u>

- Colonial and solitary tunicates (*Botryllus schlosseri* and *Molgula* respectively)
- Barnacles (*Semibalanus balanoides)*
- Crabs
- polychaete worms
- Whelks (*Eupleura caudata* and *Urosalpinx cinerea*)
- Hydrozoa
- Anemones

Analysis

M5 had the highest biodiversity recruitment followed by Portland cement. M5 was significantly more diverse than the other matrices M5 and Portland cement are very different in regards to chemical parameters. There is no explanation for this closeness in recruitment due to the lack in data and the low number of replicates. The textured side of ECOncrete had a significantly higher recruitment than that of the smooth side. In previous experiments, M5 and texture has proven to have more benthic recruitment (Abdus-Samad 2013).

Conclusion

Ideally, when testing ECOncrete, there are four replicates of each set. However, only two were able to be tested and that altered the results. Even though M5 and Portland cement were the closest in average biodiversity recruitment, Portland cement had a bigger standard error. Therefore, in that sense, M5 is the better concrete type for organisms. This can be supported from past experiments in which M5 had the most recruitment and four replicates. However, the biodiversity count can't be directly due to concrete type because it could be due to a variety of ingredients or concrete texture. Suggestions for further research would be testing more so more data is received. Another suggestion would be making others more aware of the placement of the ECOncrete sets so more accurate data is received.

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