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Incorporation of Contaminated Sediment into Environmentally Safe Concrete

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Honors Project – Incorporation of Contaminated Sediment into Environmentally Safe Concrete

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Abstract Summary:

The research performed through this project provided some interesting results on how the different properties of the contaminated sediment can impact the strength of the new concrete.

Average three, seven, and fourteen-day strengths increased when comparing to the baseline mix developed for the experiment. Increases in strengths were notices in the ten and twenty-five percent soil replacement mixes. The largest increase was approximately thirty-three percent greater than the baseline average.

The results from the forty percent replacement test showed a significant decrease in strengths when comparing against the baseline mix. A loss of about thirty percent was observed between the average strengths of the two mixes. These results show the amount of substituted soil reaches a peak strength around a thirty-two percent replacement.

When testing mixes that contained a substitution of fifty and seventy-five percent soil replacements, seven-day strengths were able to achieve around fifty percent of the seven-day baseline strength. The results from concrete made with one-hundred percent soil-sand replacement only achieved about fifteen percent of the seven-day baseline strengths. Tests using high percentages of substituted soil show that the concrete can still achieve strengths high enough to out-match typical low strength mixes.

In all, this research shows that the contaminated sediment can provide a boost to concrete strength when used in low quantities or, if used in large quantities, can achieve strengths exceeding the requirements for industry grade controlled low strength material.

Introduction

Dredge materials are sediment that consist sand, silt, and clays that are transported down rivers and streams and eventually deposit in low flow regions of the river or above riverbanks in fields. While traveling downstream, these materials may encounter contaminants of concern, like heavy metals and organic compounds, that bind to the sediment. Sediment that is deposited in Federal Navigation Channels are traditionally dredge periodically to maintain commerce by the U.S. Army Corps of Engineers (USACE). The USACE is then tasked to dispose of the dredge materials by the most inexpensive option available, which is open lake placement. Open lake placement is when a barge containing dredge material is taken from the navigation channel and released into open water mile offshore. Site selection is highly dependent on if the sediment will potentially damage/harm the benthic zone. Sometimes, some of the sediment is has concentrations of COCs that exceeds the aquatic life criteria and needs to be disposed of in a confined disposal facility (CDF). Material can be deposited in a CDF until it meets/exceeds its capacity.

USACE has constructed three CDFs for the Cuyahoga River has been placing dredge materials since the seventies. The Cuyahoga River is dredge twice annually in May and November with all 250,000 cubic yards of sediment being hydraulically place in the last remaining CDF. Cuyahoga River sediment contains concentrations of COCs too high for open lake placement and the final CDF is approaching capacity. While the Port of Cleveland (POC) has initiated a beneficial use program for sediment being harvested from the CDF, more material is deposited every year than harvested due to COCs or the material has no real market value. For example, sand that has been hydraulically separated from the contaminated silts and clays can be directly used for construction projects/construction materials; however, 65% of the dredge material deposited in the POC CDF has very little use due to its physical/chemical properties. Therefore, finding a way to treat the material and find a value-added beneficial use for the fine sediment material would be a great benefit to POC and other ports facing a similar issue.

Decontamination of sediment can be achieved by two methodologies according to Ohio Environmental Protection Agency (OEPA). Depending on the COCs, the sediment can be washed with a chelation agent and water to remove heavy metals and organic compounds can be chemical/biologically degraded. The second method is to encapsulate material immobilizing the COCs and preventing the contaminants for leaching into the environment. Encapsulation with cementitious materials prevents COCs from leaching out of the solid matrix and into the environment.

The main goal of the testing is to find a way to take an environmentally problematic substance and turn it into an environmentally beneficial and profitable product. This research could, if successful, could fuel the beginnings of a new section of industry, creating more jobs for the area and helping to increase local revenue flow. Products created by using this methodology would be environmentally friendly and serve as a way to make current work being performed in removing this material more purposeful and allow an environmentally harmful substance to be successfully contained.

Incorporating this material into a concrete mixture could potentially be used as a way to give this material value and to ensure that the contamination within the soil/sediment can be contained so that no harm will come to the local environment. One production goal behind this research is making concrete that has the compressive strengths needed to be used in a non-structural fashion. The main production aspect of this would be to serve as a formable material for landscape features. These could

range from brick work, to concrete tiles, to even medium strength mixes for sidewalks and driveways. Expansions on this initial research are also possible and with the addition of this material and other repurposed waste materials, the concrete industry could see a shift to being more environmentally sustainable as a whole.

Methodology

The first step in this process was to determine a baseline measurement that all future results could be compared to. In order to achieve this, testing began with a simple seven-part concrete mix. The idea behind this was to have the concrete consist of one-part Portland cement, three parts fine aggregate and three parts coarse aggregate. Construction sand would be used for the fine aggregate and number eight limestone would serve for the coarse aggregate.

These materials were chosen because they represent the industry standard and were readily available in large quantities for consistent testing. All aggregates were considered to be "wet", given the conditions of how they were being stored and to remove the need to determine water for saturated surface dry conditions. All mixes were based off of a water to cement ratio of 0.45 was used. This was to ensure that mixes would be standardized, and the consistency would be very flowable as to create a more practical pouring effect.

In order to measure the correct quantities of material, initial testing used a standard volume needed to make eight 3x6 inch concrete cylinders. A factor of 1.05 was added to the volume in order to ensure that excess material would be present so that a shortage would not occur. Once the total volume was decided, the material component volumes were calculated based on the seven-part proportions and then the mass required was determined by using the specific gravity of the materials.

Table One: Standard Volumes for Batch Sizes

Volumes	Cubic Inches (in^3)
One Cylinder	42.3
Eight Cylinders	338.4
Modifier (1.05)	-
Total Volume	355.32

Table Two: Material Specific Gravities

Specific Gravities	
Portland Cement	3.20
Limestone #8	2.70
Construction Sand	2.65
Contaminated Soil	-
Water	1.00

Baseline Mix			10% Soil Replacement		
Components	Total Volume (in^3)	Total Weight (g)	Components	Total Volume (in^3)	Total Weight (g)
Portland Cement	50.76	2662.4	Portland Cement	50.76	2662.4
Limestone #8	152.28	6739.2	Limestone #8	152.28	6739.2
Construction Sand	152.28	6614.4	Construction Sand	137.05	5953.0
Contaminated Soil	-	-	Contaminated Soil	-	661.4
Water	73.14	1198.1	Water	73.14	1198.1

Table Three: Concrete Mix Component Volumes and Weights for Baseline and 10% Replacement Mix

Along with the creation and batching the baseline mix, the first trial of the substitution mix was created. This followed the same procedure as the baseline with the only change being that ten percent of the construction sand would be replaced with the contaminated soil material. This replacement was done based purely on weight of material so the batch weights would be consistent and a decrease in material volume would not occur.

The contaminated soil needed to be refined so that large pieces of dried mud like substance would not create chunks of un-mixed material. The soil was spread out of a flat area on top of a plastic sheet, as to not loose any material, and then repeatedly crushed and broken by a fifty-pound rolling weight. Once the material was fine enough to pass through a number eight sieving pan, it was collected and stored for future use. A quick sieve analysis of the crushed material showed that the majority of the usable material fell between the size of one hundred and lower, while approximately a third fell between the sizes of thirty and one hundred and the remainder retained an aggregate size of between eight and thirty.

Table Four: Sieve Analysis of Contaminated Soil

Sieve Size	Amount Passing (g)	Amount Retained (g)	Percent Passing (%)	Percent Retained (%)
4	1000	0	100	0
8	1000	0	100	0
16	878.6	121.4	87.86	12.14
32	729.4	149.2	72.94	14.92
50	650.5	78.9	65.05	7.89
100	431.8	218.7	43.18	21.87
200	122.4	309.4	12.24	30.94
Pan	0	122.4	0	12.24

The first batch trials produced nine cylinders each. The cylinders were then separated and portioned out so that four could be used for a three-day compressive strength test and four could be used for a seven-day compressive strength test. One was left out so that testing of the fourteen-day compressive strength could take place. The reasoning for only one to be used for fourteen testing is that on average, a concrete mix will achieve ninety percent of its overall strength within the first week of curing. Because of this, it was deemed more important to accurately calculate the average three and seven-day compressive strength with the testing of a large sample of cylinders.

After the first day of curing, the concrete cylinders were removed from the plastic casings and left to continue curing at a normal room temperature and normal humidity conditions. This was done using the idea that the bricks, tiles, and other concrete objects would be cured in large quantities inside of a large open area. The products would be protected from natural weather but would not receive any special curing conditions such as high temperatures or humidity.

Four cylinders from each batch, baseline and ten percent soil replacement, were broken using a hydraulic compression machine after curing for three full days. Initially a sulfuric capping compound was

used in attempt to level any voids of the top and bottom surfaces of the cylinders. However, after the first two test of the baseline and another subsequent test of the ten percent replacement, a sharp reduction in compressive strength was noticed (See Table Eight). Testing then switched to being performed using two steel capping cylinders with rubber inlays. This method of testing continued through the duration of the research to keep results consistent.

After seven full days of the concrete curing, the cylinders set aside for the seven-day compressive strengths were tested. The process from the first testing round was repeated for the seven-day samples. The results from the seven-day compressive testing were recorded and the next phase of the research began.

Development of a twenty-five and forty percent soil replacement mix began after the testing of the seven-day compression tests. The only changes to the new mixes were the amounts of contaminated soil being added as substitution for the construction sand.

Table Five: Concrete Mix Component Volumes and Weights for 25% and 40% Replacement Mix

25% Soil Replacement			**40% Soil Replacement**		
Components	Total Volume (in^3)	Total Weight (g)	Components	Total Volume (in^3)	Total Weight (g)
Portland Cement	50.76	2662.4	Portland Cement	50.76	2662.4
Limestone #8	152.28	6739.2	Limestone #8	152.28	6739.2
Construction Sand	114.21	4960.8	Construction Sand	91.37	3968.6
Contaminated Soil	-	1653.6	Contaminated Soil	-	2645.8
Water	73.14	1198.1	Water	73.14	1198.1

With the increased volume due to the differences in specific gravity of materials, as well as the nature and dryness of the soil itself, extra water was added in order for the concrete mix to properly blend together. Plastol 6400, a polycarboxylate based high range water-reducing admixture (See Plastol-6400 Data Sheet, Appendix A) was used to limit the amount of extra water added to the mix, in attempt to preserve a lower water-cement ratio for high compressive strengths. The amounts of both extra water and Plastol-6400 were recorded.

Table Six: Extra Water and High Range Water Reducer Added to 25% and 40% Mixes

25% Soil Replacement		**40% Soil Replacement**	
Normal Batch Water	1198.1 g	Normal Batch Water	1198.1 g
Normal W/C Ratio	0.45	Normal W/C Ratio	0.45
Added Water	420 g	Added Water	900 g
Added Plastol-6400	60 g	Added Plastol-6400	60 g
New W/C Ratio	0.63	New W/C Ratio	0.81

The same procedure of creating and proportioning cylinders was performed for the twenty-five and forty percent soil replacement batches. Extra cylinders were produced from the forty percent soil batch due to a significant increase in material volume. This allowed for multiple fourteen-day testing cylinders. Cylinders were striped after one full day of curing in the plastic containers. Four cylinders from each batch were used in the three-day compressive strength testing, as well as the seven-day compression testing. During the testing of the seven-day cylinders, one sample from the baseline and ten percent soil replacement batches were tested for the fourteen-day strength data (See Table Twelve).

A third-round testing process began after the seven-day strengths were recorded. This time concrete mixes were created using a fifty, seventy-five, and one hundred percent soil replacement of construction sand. The nature of this test was to determine if concrete would cure properly with the large amount of soil and to test the possibility of creating tiles or bricks using the concrete mixes. For this reason, the coarse aggregate of number eight limestone was substituted for the much smaller aggregate, Haydite (#16) (See Haydite data sheet, Appendix A). This aggregate was used for its size and available surplus and was substituted using the same direct weight substitution method for the soil-sand replacement.

Only four cylinders were created for each mix. These were used to determine approximate three and seven-day compressive strengths. Left over material for each batch was used to test the possibility of producing a concrete tile from a small mold. In order to test the effective ness of the plastic mold, several hexagon tiles were made without first applying a form-releasing agent to the plastic.

Figure One: Hexagon Tiles made from 100% Soil Replacement, No Mold Release

Similar to the twenty-five and forty percent replacement trials, extra water and Plastol-6400 were added in order for the concrete to blend.

50% Soil Replacement		75% Soil Replacement		100% Soil Replacement	
Normal Batch Water	1198.1 g	Normal Batch Water	1198.1 g	Normal Batch Water	1198.1 g
Normal W/C Ratio	0.45	Normal W/C Ratio	0.45	Normal W/C Ratio	0.45
Added Water	460 g	Added Water	600 g	Added Water	720 g
Added P-6400	90 g	Added P-6400	90 g	Added P-6400	120 g
New W/C Ratio	0.66	New W/C Ratio	0.71	New W/C Ratio	0.77

Table Seven: Extra Water Plastol-6400 Added to 50%, 75% and 100% Soil Replacement Mixes

During the fifty, seventy-five and one-hundred percent soil replacement trials, the amount of Plastol-6400 was increased to attempt to further mitigate the excess water being added. The final water-cement ratios of these three test show a significant decrease in pure water being added. More testing will be performed later to find the optimal ratio of Plastol-6400 to water being added to the base amounts in order to create a workable material while sacrificing as little strength as possible.

A vibration table was used for cylinders produced from the seventy-five and one-hundred percent soil replacement mixes to ensure that all possible voids were filled. This was needed due to the stiffness of the concrete after mixing.

The cylinders made from the fifty, seventy-five and one-hundred percent soil replacement followed the same process as cylinders made from the first and second trials. Cylinders from each batch were broken at three and seven days after curing to recorded compressive strength of the mix. The hexagon tiles were stripped at the same time of the cylinders for each corresponding batch and the conditions of these were recorded. Tiles made from the fifty and seventy-five percent soil replacement concrete mixes had their molds lubricated with traditional form release. These tiles came out cleanly with sharp edges from the mold design. (See Figure Two)

The final round of testing gave great insight into how the amount of contaminated soil affected the concrete mixes and illustrated how the mixes could be formed with specific molds. (See Table Twelve for complete listing of all Compressive Strength Data)

Results

Results from the first round of testing, the baseline mix and the ten-percent replacement mixes, showed that the baseline mix achieve higher compressive strengths at three days, but the ten-percent replacement mix achieve high compressive strengths at seven days. This result was unexpected and will be tested again in the future, to ensure that no extra variables came into effect (See Table Eight).

The compressive strengths from the fourteen-day testing reinforced the difference in compressive strength of each mix. No noticeable differences were observed in the mixing of either concrete batch and no modifications were performed, such as those done in later trials.

During the initial testing of the baseline and the ten percent soil replacement mixes, a significant difference in mix strength was noticed when concrete cylinders were leveled with a sulfur-capping compound. The capped cylinders reached an effective strength that was, on average, four-hundred PSI lower than the uncapped cylinders. This error most likely resulted from poor handling and inexperienced capping procedure. Testing of the three-day compressive strengths continued using rubber-inlayed steel cylinder caps. Testing through this method proved to result in more consistent testing and would continue to be used through the remainder of the research.

Table Eight: Baseline and 10% Replacement Compressive Strengths

Soil Replacement	0%	10%
3-Day PSI Compressive Strength	3710	2519*
3-Day PSI Compressive Strength	3721	3705
3-Day PSI Compressive Strength	3309*	3389
3-Day PSI Compressive Strength	3306*	2977
Average 3-Day Compressive Strength	3512	3148
7-Day PSI Compressive Strength	3625	4757
7-Day PSI Compressive Strength	3904	4498
7-Day PSI Compressive Strength	4283	4728
7-Day PSI Compressive Strength	4424	4768
Average 7-Day Compressive Strength	4059	4688

***** = Cylinder with Sulfur Caps During Testing

A noticeable increase in the compressive strength of the concrete was observed in the testing of a twenty-five percent soil replacement. This concrete produced a nine percent increase compared to the baseline mix and a twenty-two percent increase compared to the ten-percent soil replacement mix at the three-day testing benchmark. At seven days an increase of compressive strength of thirty-three percent compared to the baseline mix and an increase of fifteen percent compared to the ten-percent soil replacement was observed. This suggests that the soil itself caused an increase in the overall compressive strength of the concrete mix.

Table Nine: Average 3, 7, and 14 Day Compressive Strengths of Baseline, 10% and 25% Soil Replacement Mixes.

Soil Replacement	0%	10%	25%
Average 3-Day Compressive Strength (PSI)	3512	3148	3832
Average 7-Day Compressive Strength (PSI)	4059	4688	5399
Average 14-Day Compressive Strength (PSI)	4306	5028	5732

The forty-percent soil replacement result showed significant decrease in average compressive strength.

Table Ten: Percentage Strength Comparison of 10%, 25% and 40% Mixes with Baseline as Reference.

Soil Replacement	0%	10%	25%	40%
Average 3-Day Compressive Strength	3512	89.64%	109.11%	41.83%
Average 7-Day Compressive Strength	4059	115.50%	133.01%	70.81%
Average 14-Day Compressive Strength	4306	116.77%	133.12%	66.05%

Table ten illustrates the percentage change in compressive strength compared to the strengths recorded from the baseline mix cylinder tests. For instance, at three days of curing the ten percent soil replacement produced strengths approximately 10% weaker than the baseline at three days, while the twenty-five percent soil replacement produced strengths approximately 10% greater than the baseline at three days.

The results shown in table ten suggest that there is a peak amount of soil that can be added to the concrete before it begins to negatively affect the strength of the material. Based on the extreme change in strength, the data would suggest that is change occurs around the thirty-one to thirty-three percent replacement area. Future testing may be done to better analyses this peak amount and to determine the highest possible strength the material can reach. With the current research, the maximum strengths were achieve using a twenty-five percent contaminated soil replacement of construction sand.

Testing of extremely high percentages of construction sand replacement showed that the concrete compressive strength continued to diminish significantly. Average strengths of mixes with fifty percent or greater replacement of sand at three days curing showed a strength loss of over seventy percent when compared to the baseline mix. A one-hundred percent replacement retained less than ten-percent baseline strength. The rate of diminishing dropped significantly when the same mixes were tested after seven days of curing. This correlation may continue with even longer curing durations and could possible lead to strengths comparable to the baseline mix.

Table Eleven: Percentage Strength Comparison of 40%, 50%, 75% and 100% Mixes with Baseline as Reference.

Soil Replacement	0%	40%	50%	75%	100%
Average 3-Day Compressive Strength	3512	41.83%	28.96%	25.37%	7.46%
Average 7-Day Compressive Strength	4059	70.81%	50.58%	43.16%	14.34%

Even at the decreased strengths, the cylinders of fifty and seventy-five percent soil replacements were strong enough to be classified as low-strength structural concrete. Even the extremely low strengths of the one-hundred percent replacement mix would be enough to fulfill the requirements for certain landscaping or architectural usage. The hexagons tiles made from the high range substitution mixes showed that the concrete would be able to be poured into lubricated molds and produce simple objects that could then be used for a variety of designs.

Figure Two: (Right to Left) Cylinders of 50%, 75% and 100% Soil Replacement with Hexagon Tiles.

Table Twelve: Complete Table of all Mix and Cylinder Tests, with Average Strengths

Soil Replacement	0%	10%	25%	40%	50%	75%	100%
3-Day PSI Compressive Strength	3710	2519	3899	1323	1024	885	264
3-Day PSI Compressive Strength	3721	3705	3869	1704	1010	897	259
3-Day PSI Compressive Strength	3309	3389	3853	1473	-	-	-
3-Day PSI Compressive Strength	3306	2977	3706	1374	-	-	-
Average 3-Day Compressive Strength	3512	3148	3832	1469	1017	891	262
7-Day PSI Compressive Strength	3625	4757	5396	2734	2163	1811	617
7-Day PSI Compressive Strength	3904	4498	5434	2738	1943	1692	546
7-Day PSI Compressive Strength	4283	4728	5302	3523	-	-	-
7-Day PSI Compressive Strength	4424	4768	5465	2501	-	-	-
Average 7-Day Compressive Strength	4059	4688	5399	2874	2053	1752	582
14-Day PSI Compressive Strength	4306	5038	5732	2710	-	-	-
14-Day PSI Compressive Strength	-	-	-	2978	-	-	-
Average 14-Day Compressive Strength	4306	5028	5732	2844	-	-	-

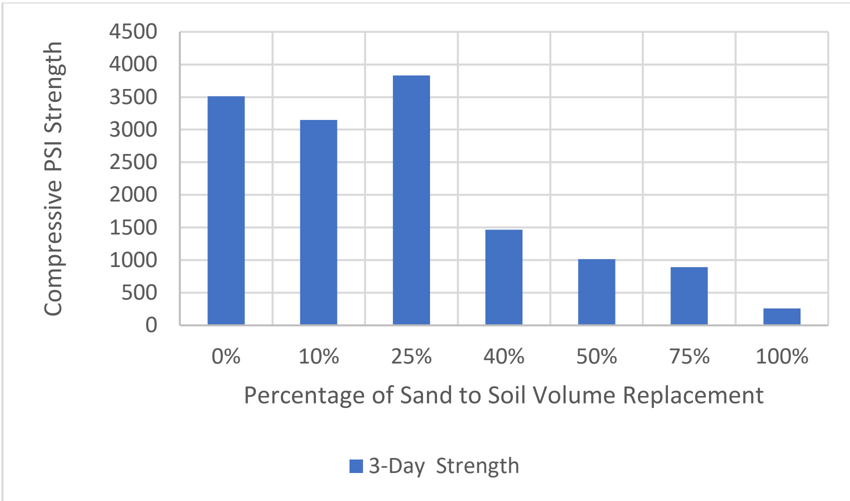


Figure Three: Average Compressive Strengths of Three-Day Soil Replacement Cylinders

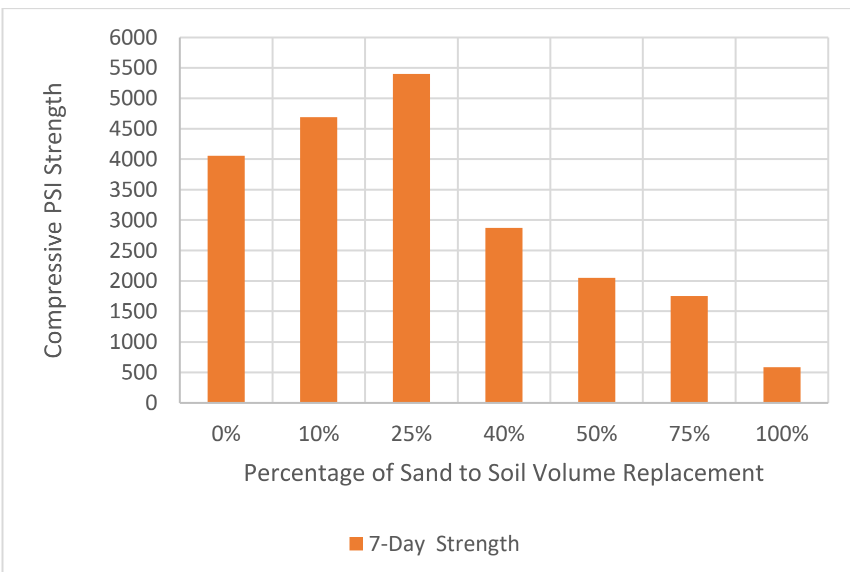


Figure Four: Average Compressive Strengths of Seven-Day Soil Replacement Cylinders

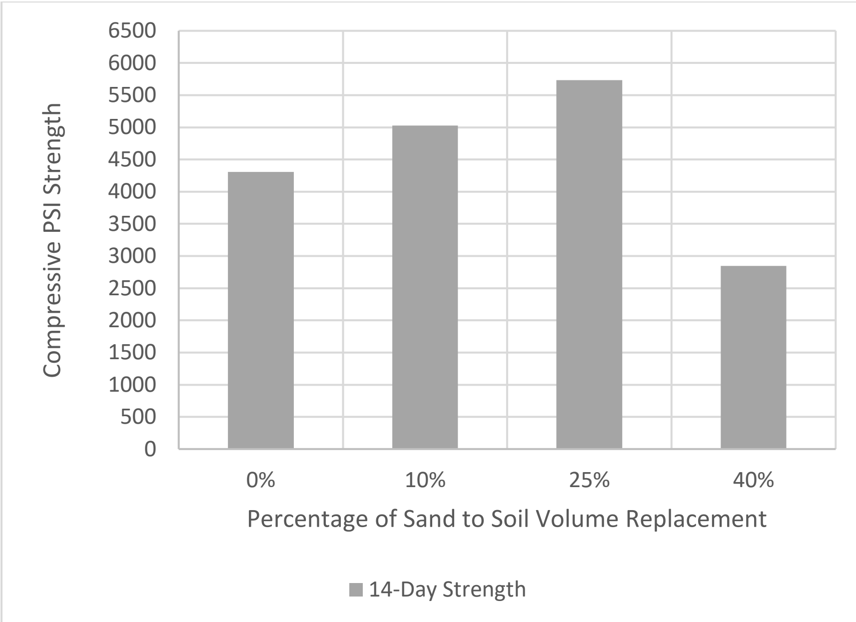


Figure Five: Average Compressive Strengths of Fourteen-Day Soil Replacement Cylinders

The overall results from this research indicate several things:

1. The use of contaminated soil as an aggregate replacement in traditional concrete is feasible
2. The use of contaminated soil as an aggregate replacement can lead to higher compressive strengths compared to traditional concrete in certain concentrations.
3. The concrete produced by using the contaminate soil can be formed in to different objects using lubricated molding.

Recommendations

Future research using this material could serve to create a concrete that is even more environmentally friendly and potentially strong enough to serve as a structural building material.

One recommendation for future testing would be to decrease the overall level of Portland cement to reduce the overall carbon foot print and energy cost of the concrete, as well as supplementing cementitious materials such as slag cement and fly ash. The introduction of these cementitious by-products would create a greener concrete product and could serve to increase the material strength properties as well.

Another recommendation would be to increase the amounts of Plastol-6400 to lower the need for excess water. This change could result in higher strength concrete given the lower water to cement ratio of the mixes. More testing should be performed on the soil itself to determine the levels of saturation and the amount of water initially needed to bring it to a saturated surface dry condition. This information would allow for a more accurate calculation of the water needed for the soil to reach SSD conditions.

Below is one possible mix design that encompasses the previously stated ideas. This mix is based on a thirty-three percent sand-soil replacement and takes into account approximate aggregate absorption values. A low water-cement ratio is used to calculate the free water needed, to offset any overestimation of the material absorption rates. A higher dosage of Plastol-6400 is used to maintain the low w/c value, using the high-percentage replacement tests as a reference.

Table Thirteen: Proposed Modified Mix, 33% Soil Replacement

Cementitious Material	**Material Specific Gravity**	**Weight (g)**	**Volume (in^3)**	
Portland Cement	3.15	1700	32.9	
Fly-Ash	2.38	345	8.9	
Slag Cement	2.94	435	9.0	
Aggregate				**Absorption**
Limestone #8	2.70	6740	152.4	10%
Construction Sand	2.65	4435	102.2	5%
Contaminated Soil	-	2180	-	25%
Water (SSD)	1.00	1440.75	88.0	**W/C Ratio**
Water Free	1.00	868	53.0	0.35
Plastol 6400	1.09	120	6.7	

Appendix A: Supplemental Figures

Figure Six – Seven-Day Cylinder Breaks of 25% Soil Replacement Mixes

Figure Seven – Seven-Day Cylinder Breaks of 40% Soil Replacement Mixes

40 Percent Soil | 50 Percent Soil | 75 Percent Soil | 100 Percent Soil

Figure Eight – Visual Comparison of Different Sand-Soil Replacement Cylinders

Figure Nine - Fifty Percent Sand-Soil Replacement, Seven Day Breaks

Figure Ten – Seventy-Five Percent Sand-Soil Replacement, Seven Day Breaks

Figure Eleven – One-Hundred Percent Sand-Soil Replacement, Seven Day Breaks

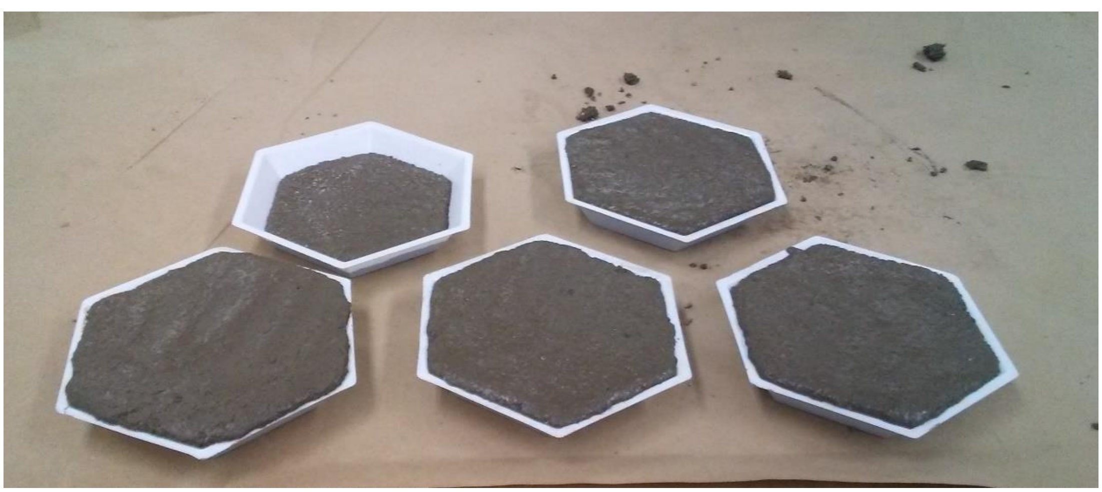


Figure Twelve – One-Hundred Percent Sand-Soil Replacement Hexagon Tiles (In mold)

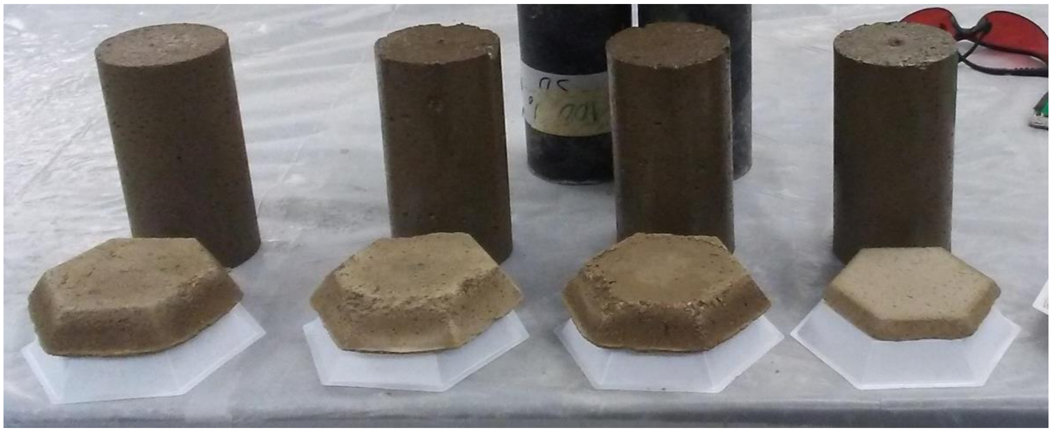


Figure Thirteen – One-Hundred Percent Sand-Soil Replacement Cylinders and Hexagon Tiles

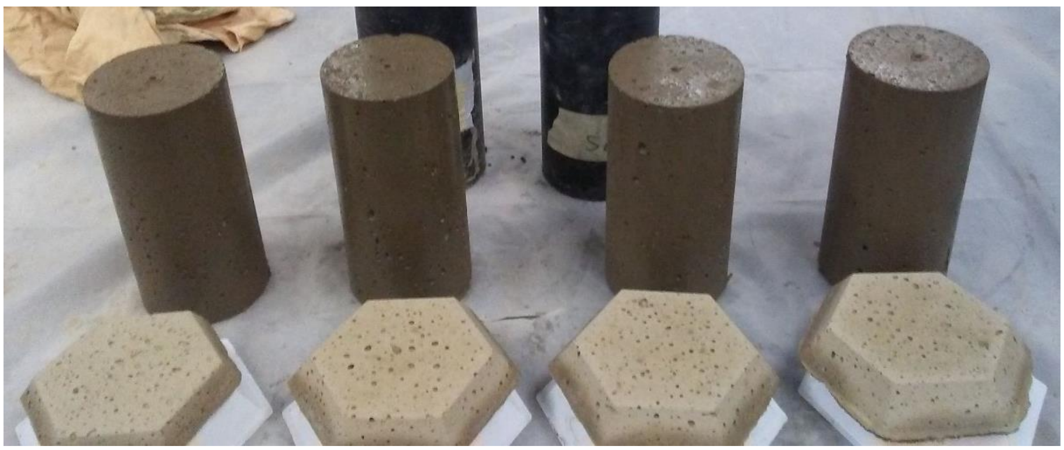


Figure Fourteen – Seventy-Five Percent Sand-Soil Replacement Cylinders and Hexagon Tiles

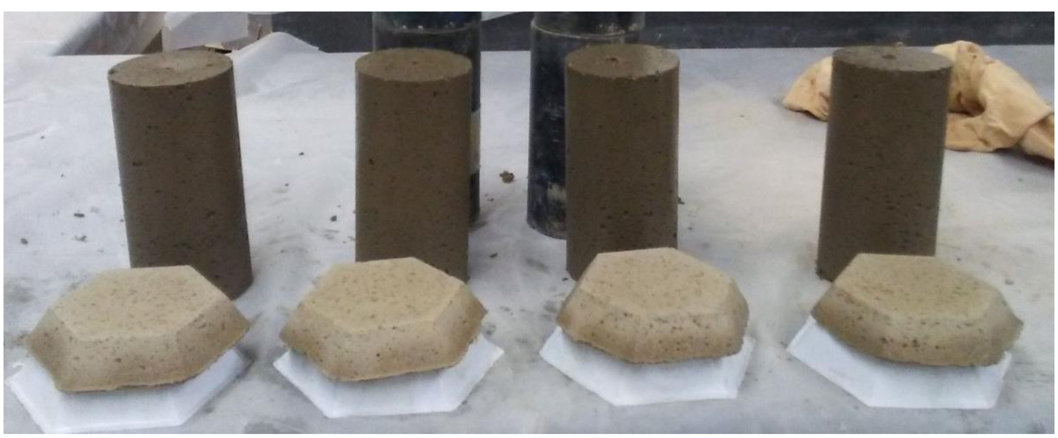


Figure Fifteen – Fifty Percent Sand-Soil Replacement Cylinders and Hexagon Tiles

Appendix B:

Plastol 6400 – High Range Water Reducer (The Euclid Chemical Company)

See Attachment for Material Specifications: Pages 21 -22

Haydite – Expanded Shale Lightweight Aggregate (Buildex, New Market Missouri Plan)

See Attachment for Material Specifications: Pages 23 - 26

PLASTOL 6400

HIGH RANGE WATER REDUCER - SUPERPLASTICIZER

EUCLID CHEMICAL

DESCRIPTION

PLASTOL 6400 is a polycarboxylate based high range water-reducing admixture which enables concrete to be produced with very low water to cement ratios. Plastol 6400 produces flowable and self-consolidating concrete at low doses and can obtain up to 45% water reduction. Plastol 6400 does not contain added chlorides and will not promote corrosion in steel. Plastol 6400 is compatible with air-entraining agents, microsilica, accelerators and many other admixtures; however, each material should be added to the concrete separately.

PRIMARY APPLICATIONS

- High performance concrete
- Negative slump concrete
- Heavily reinforced concrete
- Flatwork and mass concrete
- High early strength concrete
- Precast/prestressed concrete
- High slump, flowable concrete

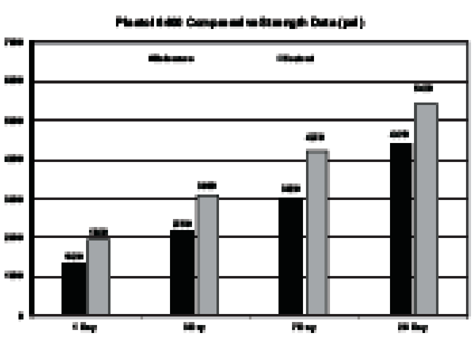
FEATURES/BENEFITS

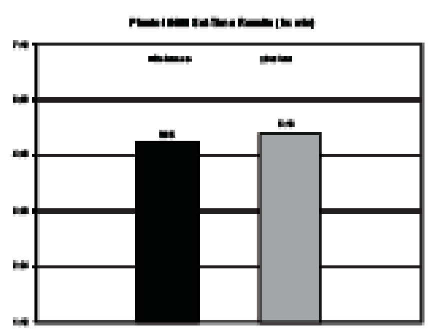
- Produces low water content and low water/cement ratio concrete allowing higher strengths
- Produces flowing concrete with quicker stripping strengths
- Aids in concrete placement and reduces labor cost
- When used in precast work with Type I and Type III cements, Plastol 6400 will produce very high early strengths
- Improved air stability characteristics

TECHNICAL INFORMATION

Performance Data:

The following test results were achieved using typical ASTM C 494 mix design requirements, 517 lb/yd³ (307 kg/m³) cement content and similar (± 0.5)% air content. These results were obtained under laboratory conditions with materials and mix designs meeting the specifications of ASTM C 494. Changes in materials and mix designs can affect the dosage response of PLASTOL 6400.





PLASTOL 6400

MASTER FORMAT#:
03 30 00 03 40 00
03 70 00

PACKAGING

Plastol 6400 is packaged in bulk, 275 gal (1041 L) totes, 55 gal (208 L) drums and 5 gal (18.9 L) pails.

SHELF LIFE

1 year in original, unopened container.

SPECIFICATIONS/COMPLIANCES

- Fully complies with the requirements of ASTM C 494, Types A & F admixtures.
- Complies with the requirements of AASHTO M 194.
- ANSI/NSF STD 61 registered

DIRECTIONS FOR USE

PLASTOL 6400 can be added to the initial batch water or directly on the freshly batched concrete and mixed for approximately 5 minutes or 70 revolutions. However, better results have been observed batching directly on the freshly batched concrete. It should not come into contact with dry cement or other admixtures until mixed thoroughly with the concrete batch.

PLASTOL 6400 is typically used at dosages of 3 to 12 oz per 100 lbs (200 to 780 mL per 100 kg) of cementitious material. Other dosages are acceptable with prior testing and confirmation of the desired performance with specific materials being used.

For any concrete application including Self-Consolidating Concrete (SCC), the dosage of PLASTOL 6400 will vary depending on the mix design, local materials, and individual needs of the concrete producer. Trial mixes should be run to verify plastic and hardened performance with local materials. If the material gradations are not optimum for SCC, a viscosity modifier may be used to improve the quality of the mix. Please consult a local Euclid Chemical Sales Professional for trial mixtures and dosage recommendations.

PLASTOL 6400 is compatible with most admixtures including air-entraining agents, accelerators, most water-reducers, retarders, shrinkage reducers, corrosion inhibitors, viscosity modifiers, and microsilica; however, each material should be added to the concrete separately.

PRECAUTIONS / LIMITATIONS

- Care should be taken to maintain Plastol 6400 above freezing; however, freezing and subsequent thawing will not harm the material if thoroughly agitated. Never agitate with air or an air lance.
- Keep concrete from freezing until a minimum strength of 1000 psi (7 MPa) is reached.
- If re-dosing Plastol 6400 at the jobsite, it is recommended that the air content is checked to conform to job specifications.
- In all cases, consult the Safety Data Sheet before use.

Rev. 11.14

Haydite Expanded Shale
Lightweight Aggregate

Aggregate Physical Properties

Buildex Expanded Shale Lightweight Aggregate
New Market Missouri Plant

Our New Market plant is located one mile south of the town of New Market, Missouri on State Highway 371. This plant is located near a large deposit of Weston shale that is used in production.

Table 1
Typical Physical Properties of Production Sizes
Buildex New Market MO Plant

Production Size	Specific Gravity (a)	Density, lb/cu ft (b)	Percent Absorption (c)
5/8" x 3/8"	1.10	38	18
3/8" x 1/4"	1.15	42	15
1/4" x 1/8"	1.20	44	12
1/8" x 0	1.80	58	8

(a) ASTM C 127 / C 128, bulk specific gravity.
(b) ASTM C 29, loose unit weight (density).
(c) ASTM C 127 / C 128, 24 hour absorption.

Table 2
Typical Gradation of Production Sizes
Buildex New Market MO Plant

Cumulative Percent Retained

Sieve	5/8" x 3/8"	3/8" x 1/4"	1/4" x 1/8"	1/8" x 0
3/4"	0			
1/2"	22	0		
3/8"	82	3	0	
No. 4	98	95	22	0
No. 8	99	99	96	12
No. 16			99	43
No. 30				67
No. 50				80
No. 100				86

Buildex, Inc. P. O. Box 77 Ottawa, Kansas 66067-0077 Toll Free (888)-HAYDITE (429-3483)
Tel (785) 242-2177 Fax (785) 242-1281 www.buildex.com

These production sizes can be sold "as is," but more often are blended before loading to meet appropriate industry specifications.

For producing pumpable structural lightweight concrete, the coarse blends like 1/2" x No. 4 and 3/8" x No. 8 are vacuum saturated at our plant prior to shipment. The fines (3/8" x 0 and 1/4" x 0) are pre-wetted while stockpiled at the concrete producers' plant.

Table 3
Typical Physical Properties of ASTM Blends
Buildex New Market MO Plant

ASTM Blend	Specific Gravity (a)	Density, lb/cu ft (b)	Percent Absorption (c)	Saturated Density, lb/cu ft
3/4" x No. 4	1.15	43	30	54 (d) (e)
1/2" x No. 4	1.15	43	25	54 (d)
3/8" x No. 8	1.3	44	20	54 (d) (e)
3/8" x 0	1.45	54	10	65 (f)
1/4" x 0	1.45	54	10	65 (f)

(a) ASTM C 127 / C 128, bulk specific gravity.
(b) ASTM C 29, loose unit weight (density) @ normal 6% shipping moisture content.
(c) ASTM C127 / C 128, 24 hour water absorption at ambient pressure. Please note that the 24 hour absorption figure is not appropriate for use in determining moisture content of Buildex used in pumped concrete.
(d) Unit Weight (density) when vacuum saturated at Buildex plant for concrete pump placement.
(e) 3/4" x No. 4 and 3/8" x No. 8 are available vacuum saturated by advance special order only.
(f) The 3/8" x 0 and 1/4" x 0 fines are not available vacuum saturated; values for stockpile ambient saturated density are shown for these materials.

Buildex aggregate is produced to meet or exceed applicable industry standards, including ASTM C330 "Standard Specification for Lightweight Aggregates for Structural Concrete" and ASTM C 331 "Standard Specification for Lightweight Aggregates for Concrete Masonry Units."

Table 4 - Typical Blended Aggregate Gradation
Lightweight Aggregates for Structural Concrete
ASTM C 330 - 3/4" x No. 4
Builder New Market MO Plant

Sieve	Percent Retained		Percent Passing	
	Typical Gradation	3/4" x No. 4 Specification*	Typical Gradation	3/4" x No. 4 Specification*
1"	0	0	100	100
3/4"	0	0-10	100	90-100
1/2"	17	---	83	---
3/8"	60	50-90	40	10-50
No. 4	97	85-100	3	0-15
No. 8	99	---	1	---

*ASTM C330 "Standard Specification for Lightweight Aggregates for Structural Concrete".

Table 5 - Typical Blended Aggregate Gradation
Lightweight Aggregates for Structural Concrete
ASTM C 330 - 1/2" x No. 4
Builder New Market MO Plant

Sieve	Percent Retained		Percent Passing	
	Typical Gradation	1/2" x No. 4 Specification*	Typical Gradation	1/2" x No. 4 Specification*
3/4"	0	0	100	100
1/2"	9	0-10	91	90-100
3/8"	35	20-60	65	40-80
No. 4	96	80-100	4	0-20
No. 8	99	90-100	1	0-10

*ASTM C330 "Standard Specification for Lightweight Aggregates for Structural Concrete"

Table 6 - Typical Blended Aggregate Gradation
Lightweight Aggregates for Structural Concrete
ASTM C 330 - 3/8" x No. 8
Buildex New Market MO Plant

Sieve	Percent Retained		Percent Passing	
	Typical Gradation	3/8" x No. 8 Specification*	Typical Gradation	3/8" x No. 8 Specification*
1/2"	0	0	100	100
3/8"	3	0-20	97	80-100
No. 4	85	60-95	15	5-40
No. 8	99	80-100	1	0-20
No. 16	99	90-100	1	0-10

*ASTM C330 "Standard Specification for Lightweight Aggregates for Structural Concrete"

Table 7 - Typical Blended Aggregate Gradation
Lightweight Aggregates for Structural Concrete
ASTM C 330 - 3/8" x 0
Buildex New Market MO Plant

Sieve	Percent Retained		Percent Passing	
	Typical Gradation	3/8" x 0 Specification*	Typical Gradation	3/8" x 0 Specification*
1/2"	0	0	100	100
3/8"	0	0-10	100	90-100
No. 4	12	10-35	88	65-90
No. 8	45	35-65	55	35-65
No. 16	65	---	35	---
No. 30	80	---	20	---
No. 50	88	75-90	12	10-25
No. 100	92	85-95	8	5-15

*ASTM C330 "Standard Specification for Lightweight Aggregates for Structural Concrete".

Table 8 - Typical Blended Aggregate Gradation
Lightweight Aggregates for Structural Concrete
ASTM C 330 - 1/4" x 0
Buildex New Market MO Plant

Sieve	Percent Retained		Percent Passing	
	Typical Gradation	1/4" x 0 Specification*	Typical Gradation	1/4" x 0 Specification*
3/8"	0	0	100	100
No. 4	5	0-15	95	85-100
No. 8	30	---	70	---
No. 16	55	20-60	45	40-80
No. 30	74	---	26	---
No. 50	84	65-90	16	10-35
No. 100	89	75-95	11	5-25

*ASTM C330 "Standard Specification for Lightweight Aggregates for Structural Concrete"

Table 9 - Typical Blended Aggregate Gradation
Lightweight Aggregates for Concrete Masonry
ASTM C 331 - 1/4" x 0
Buildex New Market MO Plant

Sieve	Typical Cumulative Grading	Typical Individual Grading	Suggested Individual Grading*
3/8"	0	0	0-2
No. 4	5	5	0-10
No. 8	30	25	15-35
No. 16	55	25	15-35
No. 30	74	19	5-20
No. 50	84	10	5-15
No. 100	89	5	5-15
Pan	100	11	8-20

*ASTM C331 "Standard Specification for Lightweight Aggregates for Concrete Masonry Units".