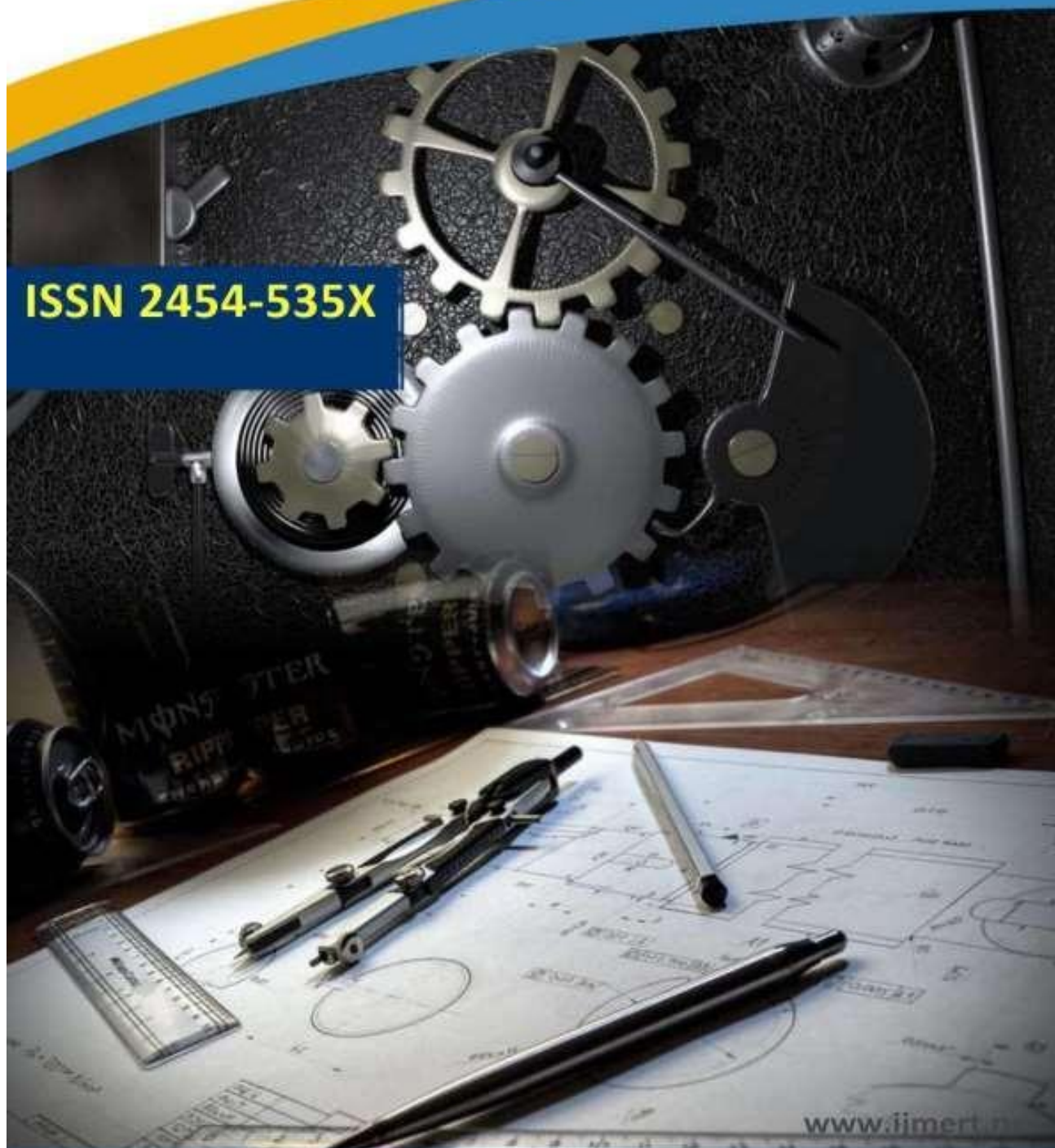




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Study on Use of Dredging Materials in Hai Phong Navigational Access Channel for Construction of Infrastructure and Protecting the Environment in Hai Phong Port

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ABSTRACT: The impact of marine works dredging activities is a topical issue in Vietnam that is gaining attention from public. One of the causes of environmental degradation is this; an average of 12 million tons of dredging material are used annually. Dredging has major detrimental consequences on the environment in addition to its practical repercussions on socioeconomic development. must possess practical ways to reduce adverse effects and encourage beneficial effects. Dredging as a technological process consists of three main steps: moving sediments, depositing sediments at disposal locations, and dredging sediments from river and sea bottoms. The working environment's natural state is being impacted by each of the aforementioned phases to some extent. Depending on the place, the hour,

KEYWORDS: Marine economy; port infrastructure; chemical additives; dredging material; navigational access channel

INTRODUCTION

Hai Phong Port is the most significant seaport in the Vietnamese seaport system's Northern Seaport group when it comes to fostering and advancing the growth of the country's economy overall and the marine industry in particular [1]. Over the past ten years, the amount of cargo passing through Hai Phong Port has increased steadily (by more than ten percent annually). As a result, the port's infrastructure has to be renovated and updated to fulfill the rising demand for logistics services in Hai Phong. According to statistical data from the Hai Phong Transportation Department, there are more than 60 significant warehouses spread across an area of approximately 701.14 hectares in Hai Phong that are used for logistics [2]. The Hai Phong method of warehouse and yard distribution

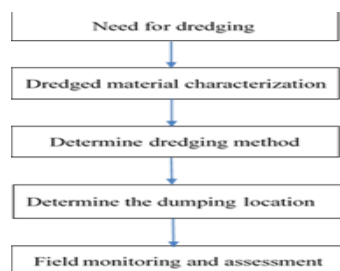


Figure 2. Dredged material assessment framework[11]

Marine soil deposits have a specific predisposed composition [4]. Dredging modifies this composition, changing the habitat that organisms

rely on and causing organisms that depend on the original soil composition to become extinct as a result of the unfavorable composition changes. The shift in the nature of the underwater soil has also

affected the turbidity of the soil beneath the sea [12]. This causes issues through the emergence of more dangerous and novel organisms, the spread of contaminants to other areas of the marine environment due to the movement of undesirable organisms, and organic processes that release

surplus and undesired nutrients, all of which have a negative impact on the marine environment [13].

For the reasons listed above, it is essential to take into

MATERIALS AND METHODOLOGY

To solve the above mentioned problems, the authors have chosen the current dredging project of Lach Huyen channel by Hai Phong Port with the geological parameters of ten locations in the dump area in the Dinh Vu Island (Figure 3). The geological parameters of the dredged material as shown in Table 1 and Table 2. The material analysis are based on TCVN 4198:14, TCVN 8719 : 12, ASTM D2434-68 (06), ASTM D2974, TCVN 4196 : 12, TCVN 4197 : 12 and 22 TCN 333-06. Summary technical properties of dredged materials is shown in Table 3. The comparison of metal content of the dredged material with metal permitted content from QCVN 43:2012 shows that the metal content of dredged material in the Lach Huyen channel meets the environmental requirements for construction materials.



Figure 3. Taking dredged material samples on site and material analysis in the laboratory

Table 1. Geological parameters of the Lach Huyen channel

Name of soil layer	Color	Value of N average
Sandy clay	Black, Gray	5.3
Clay mixed sand	Gray, brown, yellow	0.5
Silty clay mixed sand	Gray, yellow	12.9
Silty clay, soft	Gray, green, yellow	5.5
Silty clay, medium soft	Brown, red, yellow	12.2

Table 2. Analysis of the metal content at construction site

Name of sample	Metal content							
	Cr	Cu	Zn	Cd	Pb	Fe	As	Hg
S1	0.147	10.05	51.6	0.024	28.55	1770	3.48	0.104
S2	0.121	42.4	78.65	0.012	37.15	1786	2.978	0.111
S3	0.099	12.5	45.95	0.016	23.55	1741	2.753	0.121
S4	0.174	65.7	106.81	0.017	73.8	1823	3.866	0.173
S5	0.118	19.9	55.7	0.019	34.01	1759	3.015	0.124
S6	0.108	39.01	55.01	0.016	20.7	1761	2.595	0.097
S7	0.144	19.45	60.60	0.027	37.35	1766	2.775	0.194
S8	0.119	26.45	66.35	0.029	40.25	1775	2.681	0.107
S9	0.158	24.35	71.75	0.018	36.80	1802	2.812	0.186
S10	0.148	31.1	83.75	0.028	50.85	1818	2.922	0.171
QCVN 43:2017	160	108	271	4.2	112	20000	41.6	0.7

Table 3. Summary technical properties of soil

Sample	Specific	Grain size distribution (%)						Organic	Modulus	Consolid				
	gravity	D 1st						Clay	(%)	(MPa)			(%)	
		ρs	0,50-0,25	0,25-0,10	0,01-0,05	0,05-0,01	0,01-0,005							30,6
(g/cm³)						5				86,39				
N01.01	2,65	1,3	7	10,6	28,6	9,9	42,6	6,8	32,5	6,9	2,3	23,7		
N01.02	2,65	0,4	8,7	17,1	23,8	18,4	31,6		12,00	15,14	23,7	29,9		
N01.03	2,64	3,4	5,8	11,9	27,6	17,5	33,8	5	12,6	79,86	27,4	19,9		
N01.04	2,59	0	5,3	24,5	27	5	38,2	5	5,80	11,2	38,4	20,0		
N01.05	2,66	1,4	3,3	11,5	26,7	18,4	38,7	15	1,5	92,34				
N01.06	2,65			13,2	27,4	19,8	39,6	2,4	15,60	12,9	23,8	25,4		
N01.07	2,66		7,6	9,7	21,5	20	41,2	19	14,00	83,52	14,4	8,9		
N01.08	2,67		4	13,4	23,7	19,9	39,2	5,3	8,90	17,1	25,4	18,4		
N01.09	2,66		8,6	12,2	27,4	19,8	32,6	5	6,70	12,9	14,9	18,4		
N01.10	2,64		7,9	13,2	18,4	19,7	40,8		11,50	14,1	13,7	19,9		
N01.11	2,67		6,8	6,8	42,3	23	21,1		24,5	13,9	25,4	18,4		
N01.12	2,67		16,7	7,2	22,3	23,5	30,3	17	21,5	82,06	37,9	18,4		
N01.13	2,66		6,6	6,8	21,3	23,2	42,1	29,9	8,40	80,50	15,9	18,4		
N01.14	2,67	6,8	26	16,9	12,3	23,2	42,1	20	21,7	81,97	38,1	18,4		
N01.15	2,67	6,9		7,2		13,9	24,7	15,8	15,30	83,44	27,9	19,9		
N01.16	2,67			32,3	4				13,30	84,91				



N01.30	2,64		1,1	12,9	37,7	18,8	29,5		12,20	77,08
N01.31	2,65	3,3	7	12,6	28,6	15,9	32,6	38,5	13,50	78,55
N01.32	2,65	2,4	26	17,1	23,8	5,4	25,3	15	11,79	80,47
N01.33	2,64	4	2,8	11,9	27,6	17,5	36,2		11,42	78,35
N01.34	2,65	10,2	14	10,6	28,6	12,9	23,7	37	12,20	86,58
N01.35	2,66	1,4	3,3	21,5	26,7	18	29,1	8,2	10,50	76,97
N01.36	2,65	3,3	7	15	28,6	15,9	30,2		8,79	78,45
N01.37	2,65	2,4	11,7	17	23,8	15,4	29,7	28,9	17,42	79,12
N01.38	2,64	3,4	2,8	12	27,6	17,5	36,7	17	16,20	80,59
N01.39	2,67	0	5,3	18,2	21	15,9	39,6		21,50	82,06
N01.40	2,66	1,4	3,3	21,5	16,7	25,5	31,6		8,79	83,98

EXPERIMENTAL SETUP

Based on previous studies and standards related to road and yard design [14][2][1], the author proposed to use fly ash in combination with a small amount of cement to form geopolymer concrete as the foundation layer of roads or cargo yards replacing traditional sand layers. The proposed process of dredging material consists of three steps as follows:

Step 1. Dredged material is selected, then mixed with fly ash and PC30 cement according to the pilot ratio as: 6% of fly ash, 90% of dredged materials, 4% of cement for 1m³ mixture of materials. Sampling and testing have been carried out in the laboratory to determine the physical characteristics of the material mixture (Figure 6).

Step 2. Soaking of the casted sample in the water tank to achieve saturation state after 3 days, 7 days, 28 days and 35 days and compressing the samples to determine the compressive strength. From experimental data, the ratio of materials and additives are changed to meet the technical requirement of road foundation and cargo yard.

Step 3. Carry out construction of the road foundation in the field following road technical specifications. The verification and the acceptance of the foundation of the road and cargo yard should comply with the provisions in the document [1].

**Figure 4.** Casting samples in the laboratory (LAS 09)

RESULTS AND DISCUSSION

Experimental results

First, the ratio of materials and chemical additives for soil consolidation are required. Based on the literature review [12][4], five proportions of mix design have been carried out as shown in Table 5, casting 30 samples in the laboratory is shown in Figure 7, The detailed results of the compressive strength after 3 days, 7 days, 14 days, 28 days and 35 days of casted samples at saturated moisture are shown in Table 6.

Based on the experimental results of dredged material samples (Table 6), we see that after

treatment of dredged materials all samples from CP1 to CP5 completely meets the requirements of road foundation construction according to current Vietnamese standards TVCN 10379: 2014 and TCVN 8858: 2011 (According to Section 4.2 of TVCN 10379: 2014 Table 1- Physical and mechanical properties of consolidated soil), that requires compressive strength of samples in saturated condition at 7 days must be 2,0MPa or more. However, Samples CP4 and CP5 are not meeting the requirements for cargo yard foundation that requires compressive strength of samples in saturated condition at 7 days must be 3,0MPa or more.

Table 4. Five proportion of mix design for cargo yard foundation

No	Dredged material (%)	Clayish soil (%)	Cement (%)	Fly ash (%)	Chemical additive (lit)
CP1	70	20	4,0	6,0	4,0
CP2	75	15	4,0	6,0	4,0
CP3	80	10	4,0	6,0	4,0
CP4	85	5	4,0	6,0	4,0
CP5	90	0	4,0	6,0	4,0



Figure 5. Five group samples of dredged material mixture for foundation of cargo yard

Table 5. Results of determining compressive strength of samples according to TCVN 8858: 2011

Date (Days)	Compressive strength of samples (MPa)				
	CP1	CP2	CP3	CP4	CP5
3	1,0	0,9	0,8	0,7	0,6
7	3,2	3,1	3,0	2,8	2,6
14	4,2	4,0	3,9	3,1	2,9
28	5,0	4,7	4,4	3,6	3,2
35	6,0	5,8	5,1	3,7	3,3

The compressive strength of samples

The results of compressive strength of 30 samples are shown in Figure 8. It is clear that the compressive strength of sample CP1, CP2 and CP3 at 7 days meet the specification requirement for the foundation of cargo yard (must be 3MPa or more), whereas CP4 and CP5 do not. It means that the minimum 10% of clayish soil is required for mixture to meet the technical specification of foundation of cargo yard. Furthermore, the addition of more than 10% of clayish soil leads to continue significantly increasing of the compressive strength of the mixture after 28 days. Finally, the test results show that CP1 is more effective at increasing the compressive strength of mixture than the others, so this proportion have been selected for test work at Hai Phong City in Vietnam (Figure 7).

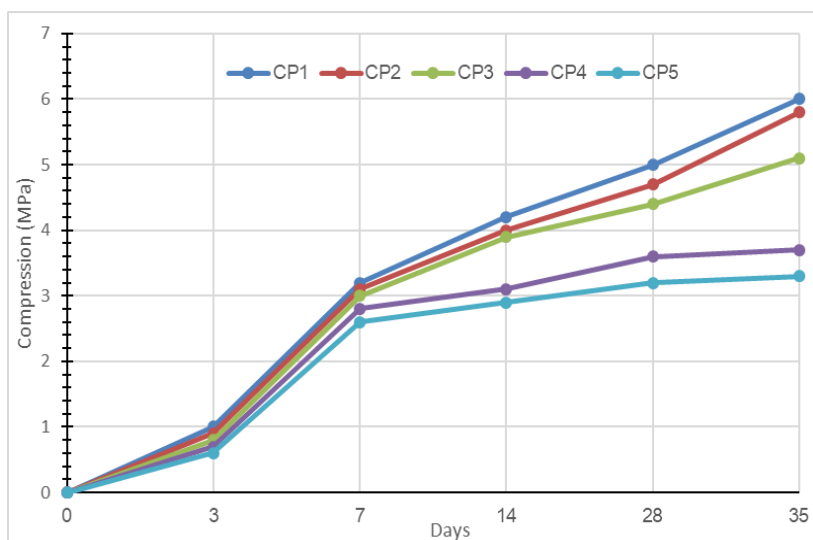


Figure 6. Representative curves showing compressive strength of samples with mixture of dredged material from 70% to 90%

The effect of time on compressive strength of samples

It can be seen from Table 5 and Figure 6 that the compressive strength of all sample CP1 to CP5 are increasing quickly during at the first 7 days and then gradually increasing from 8 days to 28 days, especially samples CP4 and CP5 slowly increase in compressive strength. After 28 days of curing in laboratory in standard condition, there are continuously increasing in compressive strength of samples CP1, CP2 and CP3, whereas small change in the value of compressive strength of sample CP4 and CP5 (the total change in compressive value of samples CP4 and CP5 is about 0,1MPa during 7 days). This means that the samples CP1, CP2 and CP3 will increase compressive strength after 35 days where samples CP4 and CP5 will not increase.

The effect of clayish soil on compressive strength of samples

It can be seen from Table 5 and Figure 6 that the compressive strength of the samples increases with the increasing of the clayish soil content. At 35 days of curing in laboratory in standard condition, the compressive strength

value of sample CP1 with 20% of clayish soil has the highest value (6,0MPa), it is about 1,5 times higher than the compressive strength value of the sample CP4 with 5% of clayish soil (3,7MPa). The minimum compressive strength value of the sample CP5 with 0% of clayish soil (3,3MPa). This means that the increasing in clayish soil content will result in the increasing of the compressive strength of the mixture of dredged material.



Figure 7. Application of dredged material for building foundation of cargo yard in Hai Phong, Vietnam

CONCLUSION

The study of using of the dredging materials from marine projects is not only improving the infrastructure and the capacity of seaports and transport services, but also helps marine environment protection, contributing to sustainable development Vietnam's marine economy. Therefore, this use of dredged materials needs to be further studied and replicated nationwide. For each type of different dredged material, it is necessary to analyze the various aggregate components of the dredged material to enable technical design to maximize the efficiency and economic outcomes. From the test results, it can be concluded that CP1 is more effective at increasing the compressive strength of mixture than the others. Furthermore, the samples CP1, CP2 and CP3 can increase compressive strength after 35 days where samples CP4 and CP5 will not increase. In addition, the increasing in clayish soil content will result in the increasing of the compressive strength of the mixture of dredged material. The results of this study are the basic information for the next research steps. In further research steps, the authors will present the results with the options of using different chemical additives such as: DZ33, RRP, SA44/LS40...including analysis when changing the component ratio of

materials.

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