

STUDY OF ARMOUR STONE SHAPE CHARECTERESTICS AND PACKING EFFICIECY OF SEAWALL STRUCTURE

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1. INTRODUCTION

A seawall is a structure made of stones, concrete, masonry or sheet piles, built parallel to the shore at the transition between the beach and the mainland or dune. Seawalls are generally made of armourstone. The stones are readily available and are not considered as a manufactured product just because they come directly from quarry. Since they are naturally formed, they are not a threat to marine life in any way. The stones generally have a longer life compared to the rest of the safety measures. The only threat is that they may be washed away due to the high tide strength.

Armour stone packaging is important for preparing goods for containment, protection, transport, handling, distribution, delivery and presentation. During the construction of seawalls, it is necessary to have proper packing of armour stone. It's impossible to arrange the stones one by one manually for the construction of the seawall because of the following reasons-

- Working on the shores is both difficult and dangerous at the same time
- A very large number of labours are required
- Its impossible to handle very stones using manual labours
- It'll literally take years for the construction if it's done manually.
- As a lot of labours are required the cost is increase drastically.

Therefore one way of achieving packing efficiency is to arrange armour stone using heavy machineries like a crane or a JCB.

While packing stones it is essential to have voids of a certain percentage. This is because a structure packed in 0% void can be easily broken by wave action. When a void is given, a certain amount of seawater passes through it and the impact of the wave on the sea wall decreases.

Packing affects the shape of the structure so it is important to have proper packing. Usually while construction of a seawall the only gradation of armour stones are considered, but if only gradation is considered the quality and overall bill are affected. For example if the design condition is to have stones of grade 350-700 and we used any stones within this grade irrespective of their shape and quality there is a chance of huge void formation within the structure which can adversely affect the bill and overall stability of the structure. Thus shape is an important factor that has to be considered.

The Armourstone for the construction of the seawalls are obtained from the quarry's. The stones obtained from the quarry are blasted to become the product we want. Stones blasted in this way are available in various shapes and sizes. In the old days, we used split stones for the construction of sea wall. It was made of exactly the same cubical shape. The void ratio between them was less than 5% as it is not available for construction now, blasted stones are used instead.

The blasted stones come in various shapes and size like flaky, cubical, elongated etc. Therefore it is very important to select the appropriately shaped stones during construction. In this project we have used two parameters to determine which shaped stones are suitable and which is not one is aspect ratio and the other is blockiness.

1.1 PARAMETERS

ASPECT RATIO

Aspect Ratio (Length-to-thickness ratio) is defined as the maximum length(m) divided by the minimum distance, d (m), between parallel lines through which the particle would just pass. This form description is the industry standard now embodied in EN 13383 for both armourstone and aggregates.

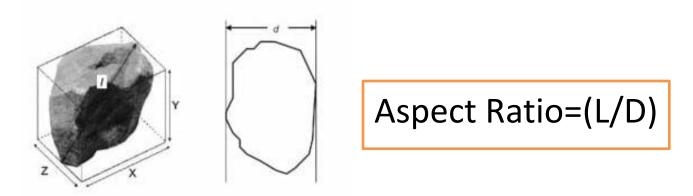


FIG 4.2 ASPECT RATIO OF STONE

BLOCKINESS

- Blockiness (BL) is defined as the volume of a stone divided by the volume of the enclosing XYZ orthogonal box with a minimum volume.
- Higher blockiness can lead to higher density, more numbers of contact points and finally it will result into greater interlock.

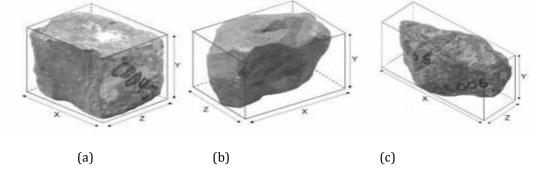


FIG 4.3 BLOCKINESS OF STONE

(a) CUBICAL (b) FLAKEY STONE (c) ELONGATED STONE

BL=[Vstone/Vcubical] x100

Armour stone with an aspect ratio greater than 3 is considered as an elongated or Flaky stone so such stones should not be used and it should be rejected .Stones with an aspect ratio between 1 to 2 are most preferred as they provide better packing.

Blockness of a perfectly cubic stone is 100% so as the number goes down the shape of the stone becomes lesser cubic and more of an elongated or flakey shaped stone, but 100% blocky stones is nearly impossible to obtain because these are obtained from blasting there for the cubic stones that we get usually have a blockness of 60 to 70% sometimes up to 80 percentage.

2. EXPERIMENT 1- CONSTRUCTION OF SEAWALL EMBANKMENT USING MIXED STONES

We collected 70 samples of armour stone for this experiment. 70 stones were randomly taken and had different shapes and sizes. Using these stones we constructed a frustum embankment by dropping each stones.

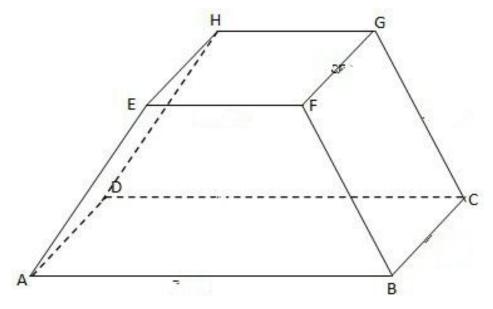


FIG 1 EMBANKMENT USING MIXED STONE

The dimensions of the so formed embankment were measured and noted down,

The resultant embankment has the following dimensions.

Base length=170cm

Base width=90cm

Top length=110cm

Top width=50cm

Height=75cm

Using the obtained data's we were able to calculate the volume of the frustum section. Each stone from the embankment were taken out to measure it's weight and dimensions(length,breadth,depth). These readings were noted down. Using these readings, we calculated the aspect ratio(Aspect Ratio=(L/D) and blockiness (BL=[Vstone/Vcubical] x100) of each stone.

Now to find Volume of voids we need to subtract the total volume of stones from the volume of the embankment. Next step is to find the value Void Ratio & Porosity.

Void Ratio=(Volume of Voids/Total volume of stones)

Porosity = (Volume of Void / Total volume of embankment)

3. EXPERIMENT 2- CONSTRUCTION OF SEAWALL EMBANKMENT USING CUBIC STONES

We collected 84 samples of cubical armourstone for this experiment. Although these are cubical stones they are not exactly cubical but resembles cubical stones .Using these stones we constructed another frustum embankment by dropping each stones .

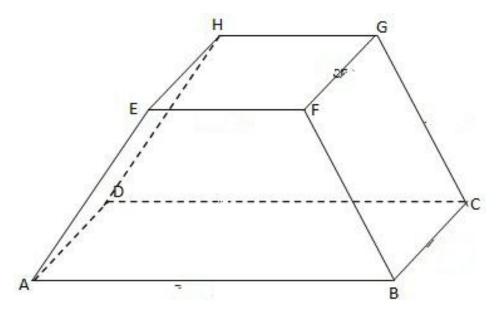


FIG2 EMBAKMENT USING CUBICAL STONE

The dimensions of the so formed embankment were measured and noted down,

The resultant embankment has the following dimensions

Base length=160cm

Base width=90cm

Top length=100cm

Top width=30cm

Height=70cm





FIG3 MINIATURE EMBAKMENT USING CUBICAL STONES

Using the obtained data's we were able to calculate the volume of the frustum section. One by one each stone from the embankment were taken out to measure it's weight and dimensions(length,bredth,depth). These readings were noted down. Using these readings we calculated the aspect ratio(Aspect Ratio=(L/D) and blockiness (BL=[Vstone/Vcubical] x100) of each stone



Fig 4 CUBICAL STONES

Now to find Volume of voids we need to subtract the total volume of stones from the volume of the embankment. Next step is to find the value Void Ratio & Porosity.

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	60	1.2	12.5	9.6	7.2	1.736111111	0.000444444	91578	4.85318E-07



3.44398E-07	150558.096	0.000518519	1.268518519	10.8	9.6	13.7	1.4	61
4.23002E-07	227649.564	0.000962963	2.493670886	7.9	13.8	19.7	2.6	62
5.49741E-07	592871.292	0.003259259	2.062015504	12.9	16.3	26.6	8.8	63
4.98702E-07	505014.57	0.002518519	2.410526316	9.5	21.9	22.9	6.8	64
4.02933E-07	404442.3	0.00162963	1.316546763	13.9	15	18.3	4.4	65
5.44058E-07	1484045.94	0.008074074	2.817460317	12.6	31.3	35.5	21.8	66
4.364E-07	1442781.2	0.006296296	2.2625	16	23.5	36.2	17	67
4.67837E-07	1013332.8	0.004740741	1.88	15	22.6	28.2	12.8	68
7.87435E-07	968921.344	0.00762963	1.819548872	13.3	28.4	24.2	20.6	69
1.43836E-06	793086	0.011407407	2.416666667	12	21.5	29	30.8	70
4.47086E-07	546750.48	0.002444444	2.222222222	10.8	19.9	24	6.6	71
3.51888E-07	1789288.416	0.006296296	1.945054945	18.2	26.2	35.4	17	72
2.8358E-07	600785.04	0.001703704	1.423611111	14.4	19.2	20.5	4.6	73
4.1157E-07	1907779.88	0.007851852	1.527093596	20.3	28.6	31	21.2	74
4.29187E-07	2174654.808	0.009333333	1.606965174	20.1	31.6	32.3	25.2	75
4.64319E-07	989102.472	0.004592593	2.401515152	13.2	22.3	31.7	12.4	76
4.35707E-07	1343071.77	0.005851852	2.223021583	13.9	29.5	30.9	15.8	77
4.26482E-07	937905.744	0.004	1.30994152	17.1	23.1	22.4	10.8	78
3.44015E-07	2777654.57	0.009555556	1.78111588	23.3	27.1	41.5	25.8	79
4.23453E-07	2641420.72	0.011185185	2.012931034	23.2	23	46.7	30.2	80
3.70725E-07	919120	0.003407407	1.793103448	14.5	23	26	9.2	81
1.55899E-07	1330400	0.002074074	1.717791411	16.3	27.5	28	5.6	82
1.3239E-07	2182110	0.002888889	1.02739726	29.2	23.5	30	7.8	83
5.21217E-07	1222211.1	0.00637037	1.780821918	21.9	13.5	39	17.2	84

Total 0.39337

TABLE 1MEASUREMENT AND CALCULATION USING CUBICAL STONE

CALCULATION

Total volume of stones = 0.39337m³

Volume of embankment = 0.0.55936m³

Volume of voids =Volume of embankment - Total volume of stones

=0.16599m^3

Void Ratio (e) = (Volume of Voids / Total volume of stones)

0.16599 / 0.39337= 0.42196

Porosity (n) = (Volume of Void / Total volume of embankment)

0.16599 / 0.55936 =<u>0.2967</u>

<u>=29%</u>

4. EXPERIMENT 3- CONSTRUCTION OF SEAWALL EMBANKMENT USING FLAKEY & ELONGATED STONES

We collected 46 samples of flaky and elongated armourstone for this experiment. Now it's clearly visible that the no of stones decreased drastically this shows the presence of voids & decrease in stone volume. Using these stones we again constructed a frustum embankment by dropping each stones.

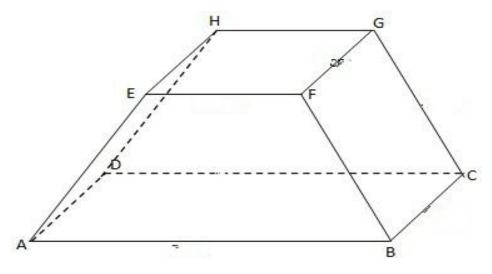


FIG5 EMBAKMENT USING FLAKEY STONES

The dimensions of the so formed embankment were measured and noted down,

The resultant embankment has the following dimensions

Base length=160cm Base width=90cm Top length=95cm Top width=50cm Height=70cm



FIG 6 MINIATURE EMBAKMENT USING FLAKEY STONE



Using the obtained data's we were able to calculate the volume of the frustum section. One by one each stone from the embankment were taken out to measure it's weight and dimensions (length,bredth,depth). These readings were noted down. Using these readings we calculated the aspect ratio(Aspect Ratio=(L/D) and blockiness (BL=[Vstone/Vcubical] x100) of each stone

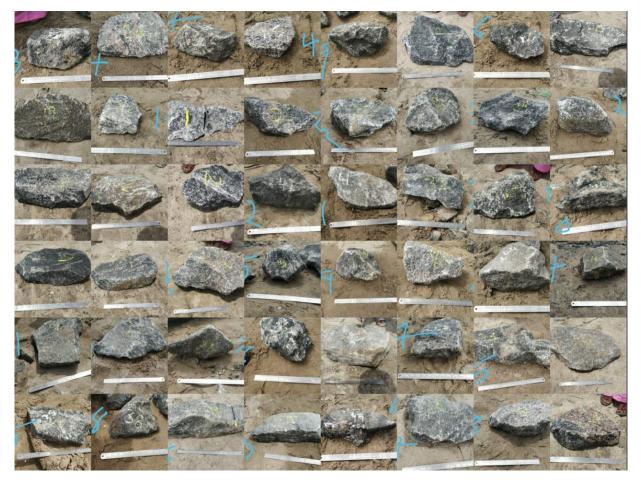


FIG 7 FLAKEY STONES

Now to find Volume of voids we need to subtract the total volume of stones from the volume of the embankment. Next step is to find the value Void Ratio & Porosity.



SI no.		Weight	Length	Width	Depth	Aspec ratio	Vol of stone	Vol of stone in cubical	Blockiness
1.	1	5.6	41.6	22	10.6	3.924528302	0.002113208	0.00970112	21.78312965
	2	21.2	43.6	26.6	13.6	3.205882353	0.008	0.015772736	50.72043303
	3	29.8	50	33.5	19.5	2.564102564	0.011245283	0.0326625	34.42872719
	4	21	40	31	13	3.076923077	0.007924528	0.01612	49.15960485
	5	15.4	47	19.8	11.4	4.122807018	0.005811321	0.01060884	54.77809784
	6	16.8	43.2	31.5	9.3	4.64516129	0.006339623	0.01265544	50.09405158
	7	37.8	66.5	32.3	15.4	4.318181818	0.014264151	0.03307843	43.1222127
	8	23.2	42.3	23.2	12.2	3.467213115	0.008754717	0.011972592	73.12298775
	9	36	46.6	37.3	11.3	4.123893805	0.013584906	0.019641434	69.16453076
	10	43.8	62.3	41.2	17.1	3.643274854	0.016528302	0.043891596	37.65709929
	11	28.6	48.5	44.5	20.7	2.342995169	0.010792453	0.044675775	24.15728173
	12	12.4	32.3	26.5	12.2	2.647540984	0.004679245	0.01044259	44.80924065
	13	7.8	26	21	14.2	1.830985915	0.002943396	0.0077532	37.96363084
	14	12	41.2	32	9.2	4.47826087	0.004528302	0.01212928	37.33364129
	15	7	23.6	17.5	9.5	2.484210526	0.002641509	0.0039235	67.32533284
	16	16.8	42	32	15	2.8	0.006339623	0.02016	31.44654088
	17	16.8	49.7	23.2	16.5	3.012121212	0.006339623	0.01902516	33.3223092
	18	15.6	41.3	23.2			0.005886792	0.01101884	
	19	20	36.2	29.5			0.00754717	0.01014505	74.39263297
	20	12.8	36.2	18.9			0.004830189	0.010125864	
	21	15	41.2	21.3			0.005660377	0.009828672	57.59045941
	22	22.8	39.9	26.2			0.008603774		
	23	26.4		23			0.009962264		
	24	32.4		26			0.012226415		65.8654996
	25	23.2		31.2			0.008754717		
	26	30.4		18.3			0.011471698		
	27	7.6		19.2			0.002867925		
	28	6.6		22			0.002490566		
	29	13.2		28.6			0.004981132		
	30	8.6		26.7			0.003245283		
	31	7.6		21			0.002867925		
	32	11	41	24			0.004150943		
	33	7		17.2			0.002641509		
	34	5.6		23.4			0.002113208		
	35	7.8		19.2			0.002943396		
	36	4.2	24.3	19.2			0.001584906		
	37	8		21.3			0.003018868		31.39528807
	38	7.6	39.2	15.5			0.002867925	0.00625828	
	39	7.4		17.5			0.002792453		
	40	8.4		22			0.003169811	0.006138	
	41	7.2		12.3			0.002716981	0.004374864	
	42	6.8		18.2			0.002566038		47.87473154
	43	4		16.5			0.001509434		
	44	5.3		25			0.002		30.41825095
-	45	6.2		16.2			0.002339623		67.17262824
	46	4.4	19.2	14.3	7.8	2.461538462	0.001660377	0.002141568	77.53091933
						Total=	0.262301887		

TABLE2 MEASUREMENT AND CALCULATION USING FLAKEY STONE

CALCULATION

Total volume of stones =0.2623m^3 Volume of embankment = 0.6398m^3 Volume of voids =Volume of embankment – Total volume of stones =0.3775m^3 Void Ratio (e) = (Volume of Voids / Total volume of stones) 0.3775 / 0.2623=1.43



Porosity (n) = (Volume of Void / Total volume of embankment)

=0.3775 /0.6398 =<u>0.590</u>

=<u>59%</u>

SI no.	v	/eight	Length	Width	Depth	Aspec ratio	Vol of stone	Vol of stone in cubical	Blockiness
	1	16.9	30.75	22	20.1	1.529850746	0.006259259	0.01359765	46.03191919
	2	3.4	21.3	19.8	12.6	1.69047619	0.001259259	0.005313924	23.6973517
	3	6.8	22	16.8	13.3	1.654135338	0.002518519	0.00491568	51.23438707
	4	9.6	32.5	22	17.8	1.825842697	0.003555556	0.012727	27.93710659
	5	5.6	24.2	16.1	12.2	1.983606557	0.002074074	0.004753364	43.63381542
	6	13.4	30.1	20.9	19.4	1.551546392	0.004962963	0.012204346	40.66553802
	7	8	25.6	19.4	13.8	1.855072464	0.002962963	0.006853632	43.23201133
·	8	6.6	27.6	13.7	11.6	2.379310345	0.002444444	0.004386192	55.73044783
	9	6.6	13.7	19	10.2	1.343137255	0.002444444	0.00265506	92.06738998
	10	7.2	30.7	14.9	14.3	2.146853147	0.002666667	0.006541249	40.76693406
·	11	7	21.9	19.5	15.3	1.431372549	0.002592593	0.006533865	39.67931068
	12	4.6	16.6	15.1	13.4	1.23880597	0.001703704	0.003358844	50.72291847
	13	25.2	30.6	30.1	21.9	1.397260274	0.009333333	0.020171214	46.2705583
	14	26.2	36.4	20.9	23.5	1.54893617	0.009703704	0.01787786	54.27776984
-	15	4.8	15.6	12	11.1	1.405405405	0.001777778	0.00207792	85.55564111
	16	9.2	23.9	17.9	14.5	1.648275862	0.003407407	0.006203245	54.92943463
	17	26.6	34.5	26.5	19.4	1.778350515	0.009851852	0.01773645	55.54579328
	18	3.8	20.4	13.4	12.8	1.59375	0.001407407	0.003499008	40.22304057
	19	3.2	20.9	11.1	10.9	1.917431193	0.001185185	0.002528691	46.86951412
	20	3.2 32.6	23.5	12.1 29.6	10.2 21.6	2.303921569 1.583333333	0.001185185 0.012074074	0.00290037	40.86324108 55.21820282
	22	36.08	45.2	34.9	23.1	1.956709957	0.013362963	0.036439788	36.6713521
	23	18.3	37	20.1	19	1.947368421	0.006777778	0.0141303	47.96626949
-	24	32.2	39	33.5	20.2	1.930693069	0.011925926	0.0263913	45.18885362
-	25	30.8	40.5	29.4	22.9	1.768558952	0.011407407	0.02726703	41.83590001
	26	21.6	40.2	23	26	1.546153846	0.008	0.0240396	33.27842393
	27	23	31.1	29.5	25.2	1.234126984	0.008518519	0.02311974	36.84521763
	28	18	29.3	20.1	21	1.395238095	0.006666667	0.01236753	53.90459264
	29	35.6	34.9	26.1	30	1.163333333	0.013185185	0.0273267	48.25019188
	30	16.8	29.2	21.4	18.6	1.569892473	0.006222222	0.011622768	53.53477091
	31	21.4	31.1	22.1	17.6	1.767045455	0.007925926	0.012096656	65.52162784
	32	19	37.7	30.1	18.6	2.02688172	0.007037037	0.021106722	33.34026495
	33	23	37.7	26.6	20.7	1.821256039	0.008518519	0.020758374	41.03654033
	34	13.2	29	22.2	30.8	0.941558442	0.004888889	0.01982904	24.65519707
	35	22.8	14.4	24.5	14.4	1	0.008444444	0.00508032	166.2187509
	36	4.4	17 32	14.8	14.2	1.197183099	0.00162963	0.00357272	45.61313592
	37	17.6 25		26.6	16.8	1.904761905	0.006518519	0.01430016	45.58353556
	38 39	15.8	37.6	25.5	24	1.566666667 1.260273973	0.009259259 0.005851852	0.0243648	38.00260728 37.96644602
-	40	14.6	34.6	26.2	17	2.035294118	0.005407407	0.01541084	35.08833657
-	41	25.8	35	29.5	21.4	1.635514019	0.009555556	0.0220955	43.24661382
-	42	13	27.7	26.4	16.6	1.668674699	0.004814815	0.012139248	39.66320496
	43	10	29.6	21.4	18.9	1.566137566	0.003703704	0.011972016	30.93634108
	44	6.4	24	21.5	11.6	2.068965517	0.00237037	0.0059856	39.60121576
	45	9.2	24.1	21.3	20.9	1.153110048	0.003407407	0.010728597	31.76004661
	46	10.6	36.5	18.1	15	2.4333333333	0.003925926	0.00990975	39.61680089
	47	19.4	38.6	33.5	17.6	2.193181818	0.007185185	0.02275856	31.57135243
	48	17.5	28.9	16.2	20	1.445	0.006481481	0.0093636	69.21997396
	49	18.6	37	27.5	16.6	2.228915663	0.006888889	0.0168905	40.78558295
	50	14.2	31.6	30.3	18.1	1.745856354	0.005259259	0.017330388	30.347037
	51	11.6	26.5	24	8.6	3.081395349	0.004296296	0.0054696	78.54863786
	52	7.4	38	29	17.5	2.171428571	0.002740741	0.019285	14.21177465
	53	15.2	30.6	26.5	17.8	1.719101124	0.00562963	0.01443402	39.00250678
	54 55	15 2	34.4	20.1	15.7	2.191082803	0.005555556	0.010855608 0.0146349	51.17682543
	55	15.2 6.6	32.2	30.3	15	2.1466666667 1.795774648	0.00562963	0.00803862	38.46715474 30.40875728
1	57	19	33.9	22.2	14.2	2.337931034	0.007037037	0.010568325	66.58611499
	58	15.6	33.9	25.8	18.5	1.832432432	0.005777778	0.01618047	35.70834332
	59	10	32.4	25.7	13.5	2.492307692	0.003703704	0.01082484	34.21485864
	60	13.2	30.2	25.4	16.6	1.819277108	0.004888889	0.012733528	38.39382839

ISO 9001:2008 Certified Journal | Page 1919



International Research Journal of Engineering and Technology (IRJET)e-ISSN: 2395-0056Volume: 09 Issue: 07 | July 2022www.irjet.netp-ISSN: 2395-0072

49.1099582	0.00874832	0.004296296	3.258928571	11.2	21.4	36.5	11.6	61
59.3468753	0.007364112	0.00437037	2.370967742	12.4	20.2	29.4	11.8	62
60.46932878	0.006247428	0.003777778	1.482269504	14.1	21.2	20.9	10.2	63
43.95267678	0.00707832	0.003111111	1.55862069	14.5	21.6	22.6	8.4	64
45.7092698	0.007130412	0.003259259	2.508196721	12.2	19.1	30.6	8.8	65
43.098144	0.007562412	0.003259259	2.991150442	11.3	19.8	33.8	8.8	66
45.7079962	0.005834136	0.002666667	1.597402597	15.4	15.4	24.6	7.2	67
50.6968989	0.004967796	0.002518519	1.34591195	15.9	14.6	21.4	6.8	68
45.4541974	0.00619264	0.002814815	1.475	16	16.4	23.6	7.6	69
56.4527436	0.004330072	0.002444444	2.532608696	9.2	20.2	23.3	6.6	70
		0.37533	Fotal	1				

TABLE 3 MEASURMENT AND CALCULATION OF MIXED STONES

CALCULATION

Total volume of stones = $0.375m^3$

Volume of embankment = 0.749m³

Volume of voids =Volume of embankment - Total volume of stones

 $= 0.37367 \text{m}^{3}$

Void Ratio (e) = (Volume of Voids / Total volume of stones)

0.37367 / 0.37533=<u>0.995</u>

Porosity (n) = (Volume of Void / Total volume of embankment)

0.37367 / 0.749 =<u>0.5</u>

<u>=50%</u>



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FIG 8 MIXED STONES

5.PAYMENT ISSUES

There are two bulk volumes to consider. Before construction the design bulk volume, Vd, is required. This volume equals the area A times the orthogonal thickness Td,which is a theoretically predicted average thickness that the engineer has introduced for the design drawings, using recommended layer thickness coefficients. Clearly, for a given range of armourstone weights or sizes, the best design guidance on the expected single or double layer thickness is required. These volume calculations are necessary for ordering the quantities prior to construction. After construction, in addition to profile tolerance conformance checks, it may be necessary to determine volumes for payment purposes. Having surveyed the under layer surface and the armour layer surface, the average cross-sectional area, D, times the chainage length L gives the surveyed bulk volume, Vs. From D and the down-slope length, an actual average orthogonal thickness can be deduced and this often makes an interesting comparison with the orthogonal thickness shown on the design drawings. Large differences generally lead to contractual problems.

6. HOW VOIDS AFFECT THE OVERALL COST OF THE PROJECT

Consider building a seawall with dimensions 2m, 3m & 5m.

Let this seawall extend to a length up to 5 km.

Volume of the entire embankment = ([3+5] / 2)*2*5000 =40000m^3

• For 30% voids

40000*0.7= 28000m^3 volume of stones are needed

ie 40000*0.3=12000m^3 volume is just voids

Weight of the stones in ton =volume of stones in embankment * specific gravity of stone

Weight=28000*2.65=74200 ton stones are needed (Ideal)

• For 10% voids

40000*0.9= 36000m^3 volume of stones are needed

Example 40000*0.1=4000m^3 volume is just voids

Weight of the stones in ton =Volume of stones in embankment * specific gravity of stone

Weight=36000*2.65=95400 ton stones are needed

• For 40% of voids

40000*0.6= 24000m^3 volume of stones are needed

ie 40000*0.4=16000m^3 volume is just voids

Weight of the stones in ton =volume of stones in embankment * specific gravity of stone

- Weight=24000*2.65=63600 ton stones are needed
 - For 20% decrease in voids with respect to 30% voids -Increase in stones volume =95400-74200=21200 ton(for the contractor)

Considering the cost 1 ton of stone costs 710rs

Example if 10% volume of voids are considered total cost would be

```
95400*710= 6.77 CR
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Cost of stones for 30% voids= 74200*710=5.26 CR

Example 6.77-5.26=1.51CR extra cost for 20% decrease in voids with respect to 30% voids

• For 10% increase in voids with respect to 30% volume -decrease in stones volume =74200-63600=10600 ton(for the company)

Considering the cost,1 ton of stone costs 710rs

Example if 40% volume of voids are considered total cost would be

63600*710= 4.51 CR

Cost of stones for 30% voids= 74200*710=5.26 CR

Example 5.26-4.51=0.75 CR decrease in cost for 10% increase in voids with respect to 30% voids

7. CONCLUSION

Among the three experiments conducted cubical stones gave better packing with a porosity 30%. The 30% void gives favourable cost for buyers and sellers in Sea wall construction.

Good interlocking property was provided for the sea wall when using cubicle stone. Secondly, we used flaky stones for the experiment in which the structure was not stable with this stone. With flaky stones R valuable to lateral forces. These kinds of stones tend to break when dropped from a certain height since it's porosity value is more.

Finally, mixed stones like flaky, elongated and cubical were used for the structure the porosity value that we got for the structure is 50% so it's better to use cubicle stones which is better for the construction of seawall than mixed stone structure.

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