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ANNEXURE: I

DUMP MATERIAL CHARACTERIZATION

S. No.	References	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Density (kg/m^3)	Cohesion (kPa)	Friction (degree)
1.	IIT-BHU (2021)	5	15	68	12	1760	21	28
2.	IIT-BHU (2019c)	6	16	44	34	1780	33	32
3.		14	18	52	16	1850	34	35
4.		3	8	43	46	1870	18	32
5.		4	13	51	32	1830	9	36
6.		8	14	54	24	1680	33	30
7.	IIT-BHU (2017)	11	29	47	13	1920	13	39
8.		0	12	49	39	1890	18	28
9.		3	25	70	2	1970	60	25
10.		0	14	73	13	1950	19	33
11.		2	21	67	10	1970	40	23
12.	Singh and Singh (2020)	4	14	67	15	1930	29.42	22
13.		6	15	74	5	1890	19.61	32.5
14.		4	4	92	0	1720	20.56	31.1
15.		6	17	77	0	1750	10	20.12
16.	IIT-BHU (2019b)	6	18	64	12	1920	19	36
17.		3	32	65	0	1420	39.23	20
18.		9	14	68	9	1850	39.23	22
19.		4	6	90	0	1983	25.22	28.11
20.	Behera et al. (2016a)	3	41	37	19	1800	36	22
21.		7	22	71	0	1760	64	32
22.	Koner (2015)	0	0	100	0	1765	4	48
23.	Poulsen et al. (2014)	5	22	73	0	1800		
24.						2070	0-48	25-34
25.	Rai and Mahapatro (2013)	0	2	95	3	1945	14	13
26.		0	3	96	1	1938	25	22.37
27.		0	3	97	0	1810	18	21
28.		0	4	94	2	2025	30	23.78
29.		0	4	90	6	1791	25	23
30.		0	5	47	48	1318.0	30.0	25.0
31.	Yellishetty and Darlington (2011)	9.38	33.33	37.5	23.96	1925	17	26.68
32.						1500	12	13.8
33.						1900	14	28.9
34.						2000	16	30
35.						2300	26	38
36.		13.1	41.2	45.7	0	1245		

37.	Rajak et al. (2020)	3.56	5.2	91.3	0	1720	20.46	31.1
38.	Kainthola et al. (2011)					2400	95	23.5
39.						2450	88	24
40.						2430	93	25.5
41.						2480	83	24.6
42.						2450	88	25
43.						2470	85	25.2
44.						2440	88.6	24.6
45.	Chelani et al. (2017)					1900	25	11
46.	Roy et al. (2013)					2000	65	30
47.	Dev (2019)					2141	46.09	25.71
48.	Roy et al. (2014)					1500	20	6
49.	Koner and Chakravarty (2010a)					2300	50	30
50.	Rai et al. (2012)					2000	9.4	33
51.	Chaulya (2012)	5	22	73	0	1800	64	32
52.		8	23	69	0	1700	125	34.3
53.	Koner and Chakravarty (2010b)					2000	2	20
54.	Verma et al. (2017)					1384	8.43	43.47
55.						1141	11.36	39.32
56.						1464	12.04	42.71
57.						1587	7.19	41.15
58.						1570	8.11	43.23
59.						1129	0	48.59
60.						1559	3.57	47.75
61.						1566	1.56	44.68
62.						1633	3.94	46.61
63.						1512	0	48.09
64.	Koner and Chakravarty (2016)					1790	0	38.56
65.						2440	0	48.65
66.						2260	13.97	27.93
67.						2290	26.87	32.58
68.						2380	26.89	22.25
69.	Chaulya et al. (2000), Chaulya (2011), Chaulya et al. (2013),Tripathi et al. (2012)	5	20	75	0	1900	58.83	32.5
70.		31	10	59	0	1750		
71.		7	22	71	0	1726	64	32
72.		15	17	68	0	1420		
73.		4	26	70	0	1790		
74.		8	23	69	0	1700	112	33.8
75.						1700	91	22.4

76.	Ranjan et al. (2017)					2310	81	15
77.	Singh et al. (2013)	0	1	94	5	1830	74	25
78.						2000	8	20
79.	Ahirwal et al. (2018)	4.2	23.1	72.7	0	2130		
80.		5	15	80	0	1840		
81.		4	18	78	0	1710		
82.		4	20	76	0	1670		
83.		4	22	74	0	1520		
84.	Upadhyay et al. (2007)	10	50	40	0		20	29
85.		0	5	25	70		0	37
86.		0	0	90	10		0	37
87.		0	0	10	90		0	37

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ANNEXURE: II

NUMERICAL MODELING RESULTS

T: total dump height, **H**: bench height, **A**: bench slope angle, **W**: bench width, **ρ**: density, **C**: cohesion, **φ**: friction angle, **FoS:** Factor of Safety, **XDIS:** Maximum horizontal displacement, **SSI:** Shear strain increment

Table AI.1 Estimation of safety factor, displacement, and strain of mine dump slopes

S. No.	T (m)	H (m)	A (°)	W (m)	C (MPa)	φ (°)	ρ (kg/m^3)	FoS	XDIS (m)	SSI
1	90	30	40	30	0.05	28	1800	1.56	0.001	0.0007
2	120	30	40	30	0.05	28	1800	1.49	0.0025	0.00125
3	150	30	40	30	0.05	28	1800	1.45	0.004	0.00175
4	180	30	40	30	0.05	28	1800	1.4	0.006	0.00225
5	210	30	40	30	0.05	28	1800	1.38	0.01	0.0035
6	240	30	40	30	0.05	28	1800	1.35	0.0125	0.0045
7	270	30	40	30	0.05	28	1800	1.33	0.015	0.005
8	180	20	40	30	0.05	28	1800	1.71	0.0025	0.0015
9	180	30	40	30	0.05	28	1800	1.4	0.006	0.00225
10	180	40	40	30	0.05	28	1800	1.26	0.0125	0.003
11	180	30	30	30	0.05	28	1800	1.72	0.002	0.0012
12	180	30	35	30	0.05	28	1800	1.54	0.004	0.00225
13	180	30	40	30	0.05	28	1800	1.4	0.006	0.00225
14	180	30	45	30	0.05	28	1800	1.29	0.01	0.0035
15	180	30	50	30	0.05	28	1800	1.2	0.015	0.005
16	180	30	40	20	0.05	28	1800	1.21	0.01	0.00225
17	180	30	40	25	0.05	28	1800	1.31	0.008	0.00225
18	180	30	40	30	0.05	28	1800	1.4	0.006	0.00225
19	180	30	40	35	0.05	28	1800	1.51	0.006	0.00225
20	180	30	40	40	0.05	28	1800	1.58	0.005	0.002
21	180	30	40	30	0.01	28	1800	0.92	125	17.5
22	180	30	40	30	0.012	28	1800	0.96	70	10
23	180	30	40	30	0.013	28	1800	0.98	30	4
24	180	30	40	30	0.014	28	1800	1.01	0.0175	0.004
25	180	30	40	30	0.015	28	1800	1.03	0.0175	0.004
26	180	30	40	30	0.02	28	1800	1.11	0.015	0.0035
27	180	30	40	30	0.025	28	1800	1.19	0.0125	0.003
28	180	30	40	30	0.03	28	1800	1.28	0.0025	0.003
29	180	30	40	30	0.05	28	1800	1.4	0.006	0.00225
30	180	30	40	30	0.07	28	1800	1.49	0.004	0.00175

31	180	30	40	30	0.09	28	1800	1.57	0.0025	0.0015
32	180	30	40	30	0.05	18	1800	0.94	80	30
33	180	30	40	30	0.05	19	1800	0.99	7	2.5
34	180	30	40	30	0.05	19.5	1800	1.01	0.1	0.03
35	180	30	40	30	0.05	20	1800	1.03	0.05	0.008
36	180	30	40	30	0.05	21	1800	1.07	0.02	0.0045
37	180	30	40	30	0.05	22	1800	1.13	0.015	0.004
38	180	30	40	30	0.05	26	1800	1.3	0.008	0.0025
39	180	30	40	30	0.05	30	1800	1.51	0.005	0.002
40	180	30	40	30	0.05	34	1800	1.72	0.003	0.0015
41	180	30	40	30	0.05	38	1800	1.94	0.0025	0.0015
42	180	30	40	30	0.05	28	1300	1.49	0.003	0.00125
43	180	30	40	30	0.05	28	1500	1.44	0.004	0.00175
44	180	30	40	30	0.05	28	1700	1.42	0.006	0.002
45	180	30	40	30	0.05	28	1900	1.4	0.006	0.0025
46	180	30	40	30	0.05	28	2100	1.37	0.0075	0.003
47	180	30	40	30	0.05	28	2300	1.36	0.01	0.0035
48	20	10	35	5	0.018	28	1890	1.62	1.2875E-06	0.0000009
49	30	10	35	5	0.018	28	1890	1.47	8.32917E-05	0.00006
50	40	10	35	5	0.018	28	1890	1.38	0.000233667	0.000225
51	50	10	35	5	0.018	28	1890	1.33	0.000409583	0.00035
52	60	10	35	5	0.018	28	1890	1.28	0.000606167	0.00045
53	70	10	35	5	0.018	28	1890	1.26	0.000944167	0.0005
54	80	10	35	5	0.018	28	1890	1.23	0.0012525	0.0006
55	90	10	35	5	0.018	28	1890	1.21	0.001665833	0.0005
56	100	10	35	5	0.018	28	1890	1.18	0.002249167	0.001
57	20	10	35	7.5	0.018	28	1890	1.73	6.025E-08	0.000000003
58	30	10	35	7.5	0.018	28	1890	1.61	5.40583E-05	0.00006
59	40	10	35	7.5	0.018	28	1890	1.53	0.000156667	0.000175
60	50	10	35	7.5	0.018	28	1890	1.47	0.000249167	0.00025
61	60	10	35	7.5	0.018	28	1890	1.42	0.000427	0.00035
62	70	10	35	7.5	0.018	28	1890	1.39	0.000714667	0.0005
63	80	10	35	7.5	0.018	28	1890	1.37	0.00096	0.0006
64	90	10	35	7.5	0.018	28	1890	1.35	0.001275	0.0007
65	100	10	35	7.5	0.018	28	1890	1.33	0.0016175	0.0009
66	20	10	35	10	0.018	28	1890	1.84	0.000000057	3.5E-09

67	30	10	35	10	0.018	28	1890	1.74	0.0000541	0.000035
68	40	10	35	10	0.018	28	1890	1.66	0.0001522	0.00015
69	50	10	35	10	0.018	28	1890	1.6	0.0002437	0.000225
70	60	10	35	10	0.018	28	1890	1.56	0.0003953	0.0003
71	70	10	35	10	0.018	28	1890	1.53	0.0005584	0.00045
72	80	10	35	10	0.018	28	1890	1.51	0.0006607	0.00045
73	90	10	35	10	0.018	28	1890	1.49	0.0008833	0.0005
74	100	10	35	10	0.018	28	1890	1.47	0.0012075	0.0007
75	20	10	35	12.5	0.018	28	1890	1.88	0.0000000	3.5E-09
76	30	10	35	12.5	0.018	28	1890	1.86	4.60833E-05	0.000045
77	40	10	35	12.5	0.018	28	1890	1.79	0.0001025	0.000125
78	50	10	35	12.5	0.018	28	1890	1.74	0.0001566	0.000175
79	60	10	35	12.5	0.018	28	1890	1.71	0.0002655	0.00025
80	70	10	35	12.5	0.018	28	1890	1.67	0.000437	0.0004
81	80	10	35	12.5	0.018	28	1890	1.65	0.0006253	0.00045
82	90	10	35	12.5	0.018	28	1890	1.63	0.0007833	0.0005
83	100	10	35	12.5	0.018	28	1890	1.62	0.000995	0.0007
84	100	10	34	20	0.25	30	1890	3.87	0.0002341	0.00002
85	100	20	34	20	0.25	30	1890	3	0.0003283	0.000025
86	100	25	34	20	0.25	30	1890	2.82	0.0003566	0.000025
87	120	30	34	20	0.25	30	1890	2.51	0.0006758	0.000035
88	105	35	34	20	0.25	30	1890	2.55	0.0004541	0.00006
89	120	40	34	20	0.25	30	1890	2.36	0.0007366	0.00004
90	180	30	45	30	0.025	25	1800	0.99	0.45	0.06
91	180	30	50	30	0.025	25	1800	0.90	125	20
92	60	30	35	20	0.018	28	1890	1.22	0.00125	0.0003
93	90	30	35	20	0.018	28	1890	1.22	0.0029125	0.001
94	120	30	35	20	0.018	28	1890	1.22	0.0059733	0.00175
95	150	30	35	20	0.018	28	1890	1.21	0.0083208	0.0025
96	180	30	35	20	0.018	28	1890	1.19	0.012425	0.004

97	210	30	35	20	0.018	28	1890	1.19	0.01665	0.005
98	250	30	35	20	0.018	28	1890	1.12	0.0215083 33	0.006
99	155	30	30	20	0.018	28	1890	1.34	0.0045975	0.00175
100	155	30	35	20	0.018	28	1890	1.16602	0.0090333 33	0.0025
101	155	30	40	20	0.018	28	1890	1.02539	0.0179666 67	0.004
102	155	30	45	20	0.018	28	1890	0.90039 1	156.58333 33	20
103	155	30	50	20	0.018	28	1890	0.80664 1	367.75	40
104	155	30	35	10	0.018	28	1890	1.04102	0.0213166 67	0.0035
105	155	30	35	15	0.018	28	1890	1.13086	0.0113166 67	0.003
106	155	30	35	20	0.018	28	1890	1.22	0.0089166 67	0.0025
107	155	30	35	25	0.018	28	1890	1.23	0.0078158 33	0.00225
108	155	30	35	30	0.018	28	1890	1.22	0.0068733 33	0.002
109	155	10	35	20	0.018	28	1890	1.85	0.0016283 33	0.0008
110	155	20	35	20	0.018	28	1890	1.41	0.0046916 67	0.00175
111	155	30	35	20	0.018	28	1890	1.21	0.0089416 67	0.0025
112	155	40	35	20	0.018	28	1890	1.1	0.0156416 67	0.004
113	155	50	35	20	0.018	28	1890	1.03	0.0256666 67	0.004
114	155	30	35	20	0.03	20	1890	0.92	115	35
115	155	30	35	20	0.03	25	1890	1.13	0.009725	0.0025
116	155	30	35	20	0.03	30	1890	1.37	0.0052891 67	0.00225
117	155	30	35	20	0.03	35	1890	1.62	0.0036833 33	0.00175
118	155	30	35	20	0.03	40	1890	1.87	0.0022141 67	0.00125
119	155	30	35	20	0.01	30	1890	1.1	0.0091666 67	0.0025
120	155	30	35	20	0.02	30	1890	1.27539	0.0070333 33	0.0025
121	155	30	35	20	0.03	30	1890	1.37	0.0052891 67	0.00225
122	155	30	35	20	0.04	30	1890	1.42	0.0041325	0.002
123	155	30	35	20	0.05	30	1890	1.47	0.003155	0.002
124	155	30	35	20	0.06	30	1890	1.51	0.0026458 33	0.002
125	155	30	35	35	0.018	28	1890	1.04	0.0081666 67	0.0015
126	60	30	35	20	0.035	24	1890	1.29	0.0003416 67	0.000175

127	90	30	35	20	0.035	24	1890	1.21	0.002116667	0.001
128	120	30	35	20	0.035	24	1890	1.16	0.005523333	0.002
129	150	30	35	20	0.035	24	1890	1.12	0.009241667	0.003
130	180	30	35	20	0.035	24	1890	1.1	0.014241667	0.004
131	210	30	35	20	0.035	24	1890	1.07	0.020158333	0.006
132	250	30	35	20	0.035	24	1890	1.05	0.039391667	0.008
133	155	30	30	20	0.035	24	1890	1.26	0.0045125	0.002
134	155	30	35	20	0.035	24	1890	1.11	0.009833333	0.003
135	155	30	40	20	0.035	24	1890	1	2.605	0.5
136	155	30	45	20	0.035	24	1890	0.900391	166.6666667	45
137	155	30	50	20	0.035	24	1890	0.83	313.9166667	70
138	155	30	35	10	0.035	24	1890	0.98	3.47	0.3
139	155	30	35	15	0.035	24	1890	1.04	0.015166667	0.0035
140	155	30	35	20	0.035	24	1890	1.12	0.009466667	0.003
141	155	30	35	25	0.035	24	1890	1.20	0.007456667	0.0025
142	155	30	35	30	0.035	24	1890	1.29	0.006375	0.0025
143	155	10	35	20	0.035	24	1890	1.77	0.0011575	0.0006
144	155	20	35	20	0.035	24	1890	1.29	0.0042775	0.00225
145	155	30	35	20	0.035	24	1890	1.13	0.00955	0.003
146	155	40	35	20	0.035	24	1890	1.03	0.021583333	0.0035
147	155	50	35	20	0.035	24	1890	0.97	4.75	0.6
148	155	30	35	20	0.03	18	1890	0.83	226	90
149	155	30	35	20	0.03	21	1890	0.96	53.68333333	12.5
150	155	30	35	20	0.03	24	1890	1.09	0.012366667	0.0035
151	155	30	35	20	0.03	27	1890	1.22	0.007195833	0.0025
152	155	30	35	20	0.03	30	1890	1.37	0.005289167	0.00225
153	155	30	35	20	0.01	24	1890	0.89	168.3333333	25
154	155	30	35	20	0.02	24	1890	1.03	0.027925	0.004
155	155	30	35	20	0.03	24	1890	1.09	0.012366667	0.0035
156	155	30	35	20	0.04	24	1890	1.14	0.008333333	0.003
157	155	30	35	20	0.05	24	1890	1.18	0.0058875	0.0025
158	155	30	35	20	0.06	24	1890	1.21	0.004523333	0.00225

159	60	10	35	10	0.023	26	1350	1.63	0.000125	0.0001
160	60	10	35	10	0.023	26	1616	1.56	0.0002	0.0002
161	60	10	35	10	0.023	26	1919	1.51	0.0003	0.0003
162	60	10	35	10	0.023	26	2222	1.47	0.0004	0.0004
163	180	30	40	30	0.05	18	1300	1.01	0.06	0.0125
164	180	30	40	30	0.05	18	1600	0.96	35	12.5
165	180	30	40	30	0.05	18	1900	0.94	100	40
166	180	30	40	20	0.005	18	1850	0.54	800	250
167	180	30	40	25	0.005	18	1300	0.58	500	200
168	180	30	40	25	0.005	18	1600	0.55	700	250
169	180	30	40	25	0.005	18	1900	0.54	800	300
170	180	30	40	25	0.005	18	2200	0.52	1000	450
171	180	30	40	30	0.005	18	1350	0.58	500	200
172	180	30	40	30	0.005	18	1650	0.55	600	225
173	180	30	40	30	0.005	18	1940	0.53	800	300
174	180	30	40	30	0.005	18	2190	0.52	1000	350
175	180	30	40	35	0.015	18	1400	0.79	225	70
176	180	30	40	35	0.015	18	1700	0.74	350	120
177	180	30	40	35	0.015	18	2000	0.70	450	150
178	180	30	40	40	0.02	20	1350	0.97	35	8
179	180	30	40	40	0.02	20	1650	0.89	125	35
180	180	30	40	40	0.02	20	1950	0.84	225	60
181	180	30	40	40	0.02	20	2200	0.80	300	90
182	180	30	40	30	0.01	18	1300	0.71	350	125
183	180	30	40	30	0.01	18	1600	0.66	500	175
184	180	30	40	30	0.01	18	1900	0.63	600	225
185	180	30	40	30	0.01	18	2200	0.61	800	300
186	180	30	40	30	0.03	20	1400	0.97	9	3
187	180	30	40	30	0.03	20	1650	0.96	50	20
188	180	30	40	30	0.03	20	1900	0.94	100	35
189	180	30	40	30	0.03	20	2150	0.92	125	45
190	180	30	40	30	0.05	18	2200	0.91	150	60
191	180	30	40	30	0.07	18	1400	1.08	0.02	0.0035
192	180	30	40	30	0.07	18	1650	1.04	0.04	0.006
193	180	30	40	30	0.07	18	1900	1.00	0.8	0.35
194	180	30	40	30	0.07	18	2200	0.97	35	12.5
195	180	30	40	30	0.09	18	1350	1.18	0.004	0.00175
196	180	30	40	30	0.09	18	1600	1.12	0.015	0.003
197	180	30	40	30	0.09	18	1850	1.07	0.03	0.005
198	180	30	40	30	0.09	18	2100	1.04	0.05	0.007
199	180	30	40	30	0.015	18	1300	0.82	250	80
200	180	30	40	30	0.015	18	1600	0.76	350	125
201	180	30	40	30	0.015	18	1900	0.71	500	175
202	180	30	40	30	0.015	18	2200	0.68	600	225
203	180	30	40	30	0.015	22	1300	0.94	70	12.5
204	180	30	40	30	0.015	22	1600	0.87	150	30

205	180	30	40	30	0.015	22	1900	0.83	225	60
206	180	30	40	30	0.015	22	2200	0.79	300	80
207	180	30	40	30	0.015	26	1400	1.04	0.015	0.0035
208	180	30	40	30	0.015	26	1700	0.97	40	5
209	180	30	40	30	0.015	26	1950	0.94	100	15
210	180	30	40	30	0.015	26	2200	0.90	150	25
211	90	30	40	30	0.05	28	1300	1.69	0.0005	0.00025
212	90	30	40	30	0.05	28	1400	1.66	0.0006	0.00035
213	90	30	40	30	0.05	28	1500	1.63	0.0006	0.0005
214	90	30	40	30	0.05	28	1600	1.60	0.00075	0.0006
215	90	30	40	30	0.05	28	1700	1.58	0.00075	0.0007
216	90	30	40	30	0.05	28	1900	1.53	0.001	0.0008
217	90	30	40	30	0.05	28	2000	1.50	0.00125	0.0009
218	90	30	40	30	0.05	28	2200	1.44	0.0015	0.001
219	90	30	40	30	0.05	28	2300	1.42	0.002	0.001
220	120	30	40	30	0.05	28	1300	1.60	0.00075	0.0007
221	120	30	40	30	0.05	28	1550	1.54	0.0015	0.001
222	120	30	40	30	0.05	28	2050	1.45	0.003	0.0015
223	120	30	40	30	0.05	28	2300	1.42	0.005	0.00175
224	150	30	40	30	0.05	28	1400	1.51	0.002	0.001
225	150	30	40	30	0.05	28	1650	1.46	0.003	0.0015
226	150	30	40	30	0.05	28	2150	1.41	0.006	0.002
227	180	30	40	30	0.005	18	1300	0.58	500	175
228	180	30	40	30	0.005	18	1590	0.56	600	225
229	180	30	40	30	0.005	18	2150	0.53	1000	350
230	180	30	40	30	0.05	18	2300	1.36	0.01	0.0035
231	180	30	40	30	0.015	16	2300	0.62	900	350
232	210	30	40	30	0.005	16	1400	0.51	600	225
233	210	30	40	30	0.005	16	1600	0.50	700	300
234	210	30	40	30	0.005	16	2000	0.47	1000	350
235	210	30	40	30	0.005	16	2200	0.47	1250	500
236	240	30	40	30	0.05	28	1300	1.41	0.007	0.0025
237	240	30	40	30	0.05	28	1550	1.37	0.01	0.003
238	240	30	40	30	0.05	28	2050	1.33	0.015	0.005
239	240	30	40	30	0.05	28	2300	1.31	0.02	0.006
240	270	30	40	30	0.05	28	1350	1.36	0.01	0.004
241	270	30	40	30	0.05	28	1580	1.34	0.0125	0.0045
242	270	30	40	30	0.05	28	2200	1.28	0.02	0.007
243	180	20	40	30	0.05	28	1300	1.80	0.00125	0.0008
244	180	20	40	30	0.05	28	1400	1.78	0.0015	0.001
245	180	20	40	30	0.05	28	1500	1.76	0.0015	0.001
246	180	20	40	30	0.05	28	1600	1.74	0.002	0.00125
247	180	20	40	30	0.05	28	1700	1.72	0.002	0.00125
248	180	20	40	30	0.05	28	1900	1.69	0.003	0.0015
249	180	20	40	30	0.05	28	2000	1.68	0.003	0.00175
250	180	20	40	30	0.05	28	2300	1.65	0.004	0.00225

251	180	30	40	30	0.05	28	1400	1.46	0.003	0.0015
252	180	30	40	30	0.05	28	1550	1.44	0.004	0.00175
253	180	30	40	30	0.05	28	2150	1.37	0.01	0.003
254	180	40	40	30	0.05	28	1300	1.34	0.005	0.002
255	180	40	40	30	0.05	28	1550	1.29	0.008	0.002
256	180	40	40	30	0.05	28	2050	1.23	0.015	0.003
257	180	40	40	30	0.005	18	2300	0.49	1250	500
258	180	30	30	30	0.005	18	1300	0.78	200	50
259	180	30	30	30	0.05	28	1590	1.76	0.0015	0.0006
260	180	30	30	30	0.05	28	2200	1.67	0.003	0.00225
261	180	30	35	30	0.05	28	1400	1.60	0.002	0.00175
262	180	30	35	30	0.05	28	1650	1.56	0.003	0.002
263	180	30	35	30	0.05	28	2250	1.49	0.006	0.003
264	180	30	40	30	0.05	28	1400	1.46	0.003	0.0015
265	180	30	40	30	0.05	28	1590	1.43	0.005	0.00175
266	180	30	40	30	0.05	28	2150	1.37	0.01	0.003
267	180	30	45	30	0.005	18	1300	0.51	600	300
268	180	30	45	30	0.005	18	1550	0.49	700	300
269	180	30	45	30	0.005	18	2200	0.45	1250	500
270	180	30	50	30	0.015	18	1300	0.67	450	125
271	180	30	50	30	0.015	18	1600	0.62	600	175
272	180	30	50	30	0.015	18	1900	0.58	800	200
273	180	30	40	20	0.005	18	1350	0.57	600	225
274	180	30	40	20	0.005	18	1600	0.55	700	300
275	180	30	40	20	0.005	18	2200	0.52	1000	450
276	20	10	35	5	0.015	18	1300	1.27	0.000003	0.0000017 5
277	20	10	35	5	0.015	18	1600	1.17	0.00006	0.00003
278	20	10	35	5	0.015	18	1900	1.10	0.00035	0.000175
279	20	10	35	5	0.015	18	2200	1.04	0.001	0.0005
280	30	10	35	5	0.018	18	1400	1.15	0.0001	0.000045
281	30	10	35	5	0.018	18	1690	1.08	0.0006	0.000225
282	30	10	35	5	0.018	18	2185	0.99	8	2.5
283	40	10	35	5	0.018	20	1350	1.14	0.00025	0.000175
284	40	10	35	5	0.018	20	1750	1.06	0.001	0.0004
285	40	10	35	5	0.018	20	2050	1.02	0.004	0.00175
286	40	10	35	5	0.018	20	2200	1.00	0.3	0.09
287	50	10	35	5	0.018	18	1350	0.99	12.5	4.5
288	50	10	35	5	0.018	18	1650	0.93	90	30
289	50	10	35	5	0.018	18	1950	0.89	150	60
290	50	10	35	5	0.018	18	2200	0.87	225	90
291	60	10	35	5	0.014	18	1340	0.88	125	45
292	60	10	35	5	0.014	18	1640	0.84	200	80
293	60	10	35	5	0.014	18	1900	0.81	250	100
294	60	10	35	5	0.014	18	2180	0.79	350	150
295	70	10	35	5	0.02	20	1400	1.00	0.125	0.025

296	70	10	35	5	0.02	20	1600	0.97	40	8
297	70	10	35	5	0.02	20	1850	0.94	90	20
298	70	10	35	5	0.02	20	2200	0.90	150	40
299	80	10	35	5	0.016	16	1314	0.78	250	100
300	80	10	35	5	0.016	16	1520	0.75	300	125
301	80	10	35	5	0.016	16	1818	0.72	400	175
302	80	10	35	5	0.016	16	2121	0.70	500	225
303	90	10	35	5	0.022	17	1414	0.84	175	60
304	90	10	35	5	0.022	17	1616	0.81	250	90
305	90	10	35	5	0.022	17	1819	0.79	300	120
306	90	10	35	5	0.022	17	2087	0.77	400	150
307	100	10	35	5	0.017	22	1355	0.99	5	0.6
308	100	10	35	5	0.017	22	1699	0.94	70	10
309	100	10	35	5	0.017	22	1995	0.92	125	17.5
310	100	10	35	5	0.017	22	2280	0.91	175	25
311	20	10	35	7.5	0.0135	20	2183	1.17	0.00025	0.000125
312	20	10	35	7.5	0.0135	20	1340	1.37	0.000002	0.000002
313	20	10	35	7.5	0.0135	20	1689	1.27	0.00003	0.000015
314	20	10	35	7.5	0.0135	20	1845	1.23	0.00008	0.000045
315	30	10	35	7.5	0.028	28	1310	2.04	0.0000075	0.00000125
316	30	10	35	7.5	0.028	28	1598	1.91	0.0000075	0.0000015
317	30	10	35	7.5	0.028	28	1909	1.81	0.00001	0.000008
318	30	10	35	7.5	0.028	28	2273	1.72	0.00004	0.00003
319	40	10	35	7.5	0.023	23	1405	1.47	0.00006	0.00006
320	40	10	35	7.5	0.023	23	1723	1.39	0.0001	0.000125
321	40	10	35	7.5	0.023	23	1999	1.34	0.0002	0.0002
322	40	10	35	7.5	0.023	23	2146	1.31	0.00025	0.000225
323	50	10	35	7.5	0.0193	19.3	1411	1.15	0.0004	0.000225
324	50	10	35	7.5	0.0193	19.3	1668	1.10	0.001	0.0004
325	50	10	35	7.5	0.0193	19.3	2111	1.04	0.0035	0.0009
326	50	10	35	7.5	0.0193	19.3	2300	1.02	0.006	0.002
327	60	10	35	7.5	0.022	22.5	1322	1.31	0.0002	0.000175
328	60	10	35	7.5	0.022	22.5	1551	1.26	0.0003	0.00025
329	60	10	35	7.5	0.022	22.5	1788	1.22	0.0005	0.00035
330	60	10	35	7.5	0.022	22.5	2247	1.17	0.001	0.0005
331	70	10	35	7.5	0.0195	21.7	1325	1.19	0.0006	0.0004

332	70	10	35	7.5	0.0195	21.7	1659	1.13	0.001	0.0006
333	80	10	35	7.5	0.021	24	1378	1.28	0.0006	0.00045
334	80	10	35	7.5	0.021	24	1542	1.25	0.0008	0.0005
335	80	10	35	7.5	0.021	24	1941	1.20	0.00125	0.0008
336	80	10	35	7.5	0.021	24	2156	1.18	0.00175	0.0009
337	90	10	35	7.5	0.02	23	1347	1.19	0.001	0.0005
338	90	10	35	7.5	0.02	23	1718	1.14	0.00175	0.0008
339	90	10	35	7.5	0.02	23	2036	1.11	0.0025	0.0009
340	90	10	35	7.5	0.02	23	2300	1.10	0.0035	0.001
341	100	10	35	7.5	0.011	26	1323	1.22	0.0015	0.0007
342	100	10	35	7.5	0.011	26	1684	1.19	0.002	0.0009
343	100	10	35	7.5	0.011	26	1959	1.17	0.003	0.001
344	100	10	35	7.5	0.011	26	2188	1.16	0.0035	0.00125
345	20	10	35	10	0.016	16	1419	1.32	0.000003	0.0000015
346	70	10	35	10	0.015	21	2300	1.10	0.004	0.0012
347	100	10	35	10	0.026	22	2222	1.19	0.0025	0.001
348	60	10	35	12.5	0.018	20	2298	1.20	0.002	0.0006
349	100	10	35	12.5	0.03	26	2245	1.55	0.001	0.0007
350	100	10	34	20	0.02	20.5	1325	1.60	0.0003	0.00025
351	100	10	34	20	0.02	20.5	1723	1.54	0.0015	0.0005
352	100	10	34	20	0.02	20.5	2011	1.51	0.0025	0.0007
353	100	10	34	20	0.02	20.5	2300	1.49	0.003	0.0009
354	100	20	34	20	0.01	16	1409	0.82	175	80
355	100	20	34	20	0.01	16	1713	0.80	250	120
356	100	20	34	20	0.01	16	1956	0.77	350	150
357	100	20	34	20	0.01	16	2259	0.74	400	175
358	120	40	34	20	0.02	25	2275	1.02	0.03	0.0045
359	120	40	34	20	0.02	25	1375	1.09	0.007	0.0015
360	100	25	34	20	0.04	28	2257	1.48	0.0015	0.001
361	105	35	34	20	0.025	24	1325	1.15	0.0025	0.0007
362	105	35	34	20	0.025	24	1625	1.12	0.005	0.001
363	105	35	34	20	0.025	24	1925	1.08	0.009	0.0015
364	105	35	34	20	0.025	24	2225	1.06	0.0125	0.002
365	90	45	34	20	0.03	18	1375	0.91	100	30
366	90	45	34	20	0.03	18	1675	0.87	200	70
367	90	45	34	20	0.03	18	1975	0.83	300	100
368	90	45	34	20	0.03	18	2275	0.80	400	150
369	100	50	34	20	0.023	18	1360	0.81	225	80
370	100	50	34	20	0.023	18	1645	0.78	300	120
371	100	50	34	20	0.023	18	1987	0.75	450	150
372	100	50	34	20	0.023	18	2287	0.73	500	200

373	180	30	40	5	0.05	28	1800	0.90	12.5	0.6
374	180	30	40	10	0.05	28	1800	1.01	0.04	0.006
375	180	30	40	15	0.05	28	1800	1.12	0.015	0.003
376	180	20	40	30	0.025	25	1800	1.30	0.007	0.0025
377	180	40	40	30	0.025	25	1800	0.99	20	2.5
378	180	30	30	30	0.025	25	1800	1.41	0.005	0.002
379	180	30	35	30	0.025	25	1800	1.23	0.01	0.0035
380	180	30	40	30	0.01	25	1800	0.83	200	40
381	270	30	40	30	0.025	25	1800	1.10	0.035	0.007
382	300	30	40	30	0.05	28	1800	1.31	0.02	0.006
383	330	30	40	30	0.05	28	1800	1.29	0.02	0.007
384	360	30	40	30	0.05	28	1800	1.15	0.025	0.009
385	390	30	40	30	0.05	28	1800	1.08	0.030	0.0095
386	420	30	40	30	0.05	28	1800	1.02	0.035	0.010

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ANNEXURE: III

WATER TABLE PARAMETRIC STUDY RESULTS

T: total dump height, **FoS:** Factor of Safety, **XDIS:** Maximum horizontal displacement, **SSI:** Shear strain increment

Table AII.1 Displacement, strain and safety factor based on the static analysis (no phreatic surface)

T (m)	XDIS (mm)	SSI	FoS
30	0.000015	0.0000025	1.6
60	0.0001	0.00005	1.6
90	0.001	0.0007	1.56
120	0.0025	0.00125	1.49
150	0.004	0.00175	1.45
180	0.006	0.00225	1.4
210	0.01	0.0035	1.38
240	0.0125	0.0045	1.35
270	0.015	0.005	1.33

Table AII.2 Displacement, strain and safety factor based on the water table (WT) analysis

Dump Height (m)	Water Table Position (%)	XDIS (mm)	SSI	FoS	WT FoS/Static FoS	WT XDIS/Static XDIS	WT SSI/Static SSI
30	10	0.00006	0.000025	1.6	1	4	10
	25	0.00015	0.000035	1.6	1	10	14
	40	0.00035	0.00005	1.6	1	23	20
	50	0.0005	0.00007	1.6	1	33	28
	60	0.0007	0.00009	1.6	1	47	36
	70	0.0009	0.0001	1.6	1	60	40
	80	0.0012	0.00012	1.6	1	80	48
	90	0.0015	0.000125	1.6	1	100	50
	100	0.002	0.00025	1.6	1	133	100
60	10	0.00015	0.00003	1.6	1	1.5	0.6
	25	0.0005	0.00007	1.6	1	5	1.4
	40	0.0012	0.00012	1.6	1	12	2.4
	50	0.00175	0.00015	1.6	1	17.5	3

	60	0.0025	0.000175	1.6	1	25	3.5
	70	0.0035	0.0002	1.6	1	35	4
	80	0.005	0.000225	1.6	1	50	4.5
	90	0.006	0.00025	1.59	0.994	60	5
	100	0.008	0.0025	1.59	0.994	80	50
90	10	0.0003	0.00005	1.56	1	0	0
	25	0.001	0.0001	1.56	1	1	0
	40	0.0025	0.000175	1.55	1	3	0
	50	0.004	0.000225	1.55	1	4	0
	60	0.006	0.00025	1.55	1	6	0
	70	0.008	0.0003	1.54	1	8	0
	80	0.01	0.00035	1.52	1	10	1
	90	0.015	0.0005	1.49	1	15	1
	100	0.02	0.007	1.45	1	20	10
120	10	0.0004	0.00006	1.49	1	0	0
	25	0.00175	0.00015	1.49	1	1	0
	40	0.0045	0.000225	1.49	1	2	0
	50	0.007	0.0003	1.48	1	3	0
	60	0.01	0.00035	1.46	1	4	0
	70	0.015	0.0004	1.43	1	6	0
	80	0.02	0.0007	1.4	1	8	1
	90	0.03	0.0025	1.35	1	12	2
	100	0.045	0.008	1.3	1	18	6
150	10	0.0005	0.00007	1.45	1	0	0
	25	0.0025	0.000175	1.44	1	1	0
	40	0.007	0.0003	1.45	1	2	0
	50	0.01	0.00035	1.42	1	3	0
	60	0.0175	0.00045	1.39	1	4	0
	70	0.025	0.0005	1.37	1	6	0
	80	0.035	0.0035	1.32	1	9	2
	90	0.05	0.005	1.26	1	13	3
	100	0.08	0.009	1.19	1	20	5
180	10	0.0007	0.00009	1.4	1.0	0.1	0.0
	25	0.0035	0.000225	1.4	1.0	0.6	0.1
	40	0.009	0.00035	1.4	1.0	1.5	0.2
	50	0.015	0.00045	1.37	1.0	2.5	0.2
	60	0.0225	0.0005	1.34	1.0	3.8	0.2
	70	0.035	0.00225	1.31	0.9	5.8	1.0
	80	0.06	0.008	1.25	0.9	10.0	3.6
	90	0.09	0.01	1.19	0.9	15.0	4.4
	100	0.125	0.02	1.11	0.8	20.8	8.9

210	10	0.0015	0.000175	1.38	1.0	0.2	0.1
	25	0.006	0.00025	1.38	1.0	0.6	0.1
	40	0.0125	0.0004	1.38	1.0	1.3	0.1
	50	0.0225	0.0005	1.35	1.0	2.3	0.1
	60	0.03	0.0006	1.35	1.0	3.0	0.2
	70	0.045	0.0007	1.33	1.0	4.5	0.2
	80	0.07	0.006	1.3	0.9	7.0	1.7
	90	0.1	0.0125	1.27	0.9	10.0	3.6
	100	0.125	0.01	1.23	0.9	12.5	2.9
240	10	0.00175	0.0002	1.35	1.0	0.1	0.0
	25	0.007	0.0003	1.35	1.0	0.6	0.1
	40	0.0175	0.0005	1.35	1.0	1.4	0.1
	50	0.03	0.0006	1.35	1.0	2.4	0.1
	60	0.045	0.0007	1.32	1.0	3.6	0.2
	70	0.06	0.00175	1.29	1.0	4.8	0.4
	80	0.09	0.01	1.25	0.9	7.2	2.2
	90	0.125	0.0175	1.22	0.9	10.0	3.9
	100	0.2	0.0225	1.19	0.9	16.0	5.0
270	10	0.00225	0.00025	1.33	1.0	0.2	0.1
	25	0.009	0.00035	1.33	1.0	0.6	0.1
	40	0.0225	0.0005	1.33	1.0	1.5	0.1
	50	0.035	0.0007	1.31	1.0	2.3	0.1
	60	0.06	0.00125	1.28	1.0	4.0	0.3
	70	0.08	0.006	1.25	0.9	5.3	1.2
	80	0.125	0.0175	1.23	0.9	8.3	3.5
	90	0.175	0.0175	1.2	0.9	11.7	3.5
	100	0.25	0.06	1.12	0.8	16.7	12.0

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Annexure: IV

LIST OF PUBLICATIONS AND AWARDS

Journal

- Gupta, G., Sharma, S. K., & Singh, G.S.P., Numerical Modelling Based Sensitivity Analysis of Overburden Dump Slope Stability. Journal of the Geological Society of India (Accepted).
- Gupta, G., Sharma, S.K., Singh, G.S.P. Dump Slope Stability Analysis Using Artificial Intelligence. Journal Of Mines, Metals & Fuels, Vol.70, No.3, (2022)
- Gupta, G., Sharma, S.K., Singh, G.S.P., Kishore, N. Numerical Modelling-Based Stability Analysis of Waste Dump Slope Structures in Open-Pit Mines-A Review. Journal of The Institution of Engineers (India): Series D, 102, 589–601 (2021). https://doi.org/10.1007/s40033-021-00277-y

International Conference

- Gupta, G., Sharma, S.K., Singh, G.S.P. Multiclass Classification of Overburden Dump Slope Stability Conditions deploying Machine Learning, YSRM 2019: The 5th ISRM Young Scholars' Symposium on Rock Mechanics & REIF 2019: International Symposium on Rock Engineering for Innovative Future (2019), Okinawa, Japan.
- Gupta, G., Sharma, S.K., Singh, G.S.P. An Improved Numerical Modelling Approach for Assessment of Instability in Large Overburden Dump Structures, 2nd International Conference on Opencast Mining Technology and Sustainability (ICOMS-2019), (2019), Singrauli, M.P., India.

Awards

- *Grade "A" scholarship (1 Lakh Yen) for innovative paper presentation at Okinawa, Japan by International Society for Rock Mechanics* in the 5th ISRM Young Scholars' Symposium on Rock Mechanics & REIF 2019: International Symposium on Rock Engineering for Innovative Future (2019).
- *Young Scientist Award for the best paper presentation at NCL, Singrauli, M.P., India* in the 2nd International Conference on Opencast Mining Technology and Sustainability (2019).