STATISTICAL ANALYSIS OF VARIOUS SUB-SYSTEMS OF PANEL PRODUCTION SYSTEM IN UNDERGROUND COAL MINE

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Abstract

System Analysis Approach has been applied in the present field based research paper for a deep and gassy coal mine of Jharia coal fields. The working panel was considered as a System, splitted into various sub-Systems. The Sub-Systems were statistically analyzed in terms of frequency distribution (after prolonged field observations). The Mean, Median, Mode, Standard deviation, Variance and co-efficient of variation were calculated. Among the Mean, Median and Mode, Mean was considered for Capacity (in terms of production) calculation of various Sub-systems

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1. INTRODUCTION

The Supremacy of Coal as a Prime and secured source of energy is unlikely to be challenged in foreseeable future particularly in Indian context. The demands estimates of 620 million ton and 780 million ton during the terminal phases of XI and XII plan respectively also substantiate the larger dependence on coal (Chaoji, 2002 ; Rai et al, 2005). To cater the projected demand targets, the Indian coal industry needs be geared up for accelerated growth in terms of production as well as productivity. The open cast mining, with state of art mechanization is likely to become uneconomical beyond a certain depth, as the open cast technology and equipment have already reached a stage of plateau beyond which further growth is mostly unforeseen (Rai, 2001). Karmakar (1996) has also expressed that production of coal will depend more on underground mine as against present predominance of surface mines. Looking from these standpoints, the Industry may be compelled to increase its share of coal production from underground mines in forth coming years, particularly for deep seated reserves which are vastly untapped at this point of time.

At present, the underground coal mines of our country are generally stricken with problem of low production and productivity (sachdev, 1993 & Mathur, 1999). This is largely because of the fact that production planning for the underground coal mines is a cumbersome process which calls for sound understanding of various underlying operations to critically assess the sensitive interrelationships amongst them (Mukhopadhaya et al, 1993). Hence, immediate attention and investigation into the performance and appropriate planning process for the underground mines is imperative as also pointed by Bhattacherjee et al, 1996.

The system anlysis based approach appears to offer rationalized solution to solving the complex and intricate production planning from underground mines. In this approach the entire mine (or even a part of the mine) may be considered as system, the capacity of which is dependent on its related sub-systems (Ray et al, 1978). A proper understanding of any system and its related sub-systems could provide intriguing facts in order to practice of this approach in a large underground coal mine which falls in prime coking coal zone of Jharia Coal fields, Dhanbad, India.

2. AIMS OF THE STUDY:

As already stated, the present research paper aims at deploying the System Analysis approach for large underground Coal Mine of Jharia Coal Fields. The specific aims of the present work are enumerated as

1. To study the Panel as a system and to identify the important sub-systems for the panel
2. To Critically analysed the various sub-systems Statistically.

3. RELEVANT DETAILS OF THE MINE & MINE WORKINGS:

The present Research work was undertaken in a large, privately owned underground 'Mine-A', Jharia Coal Field. One seam, namely XI was being worked in the mine. The bore hole section of the Mine-A has been shown in fig.1.The salient geo-mining details of the Coal seam is as per table 1 & details of panels working as per table 2.

Table 1: Salient geo-mining details of the Coal seam

ITEM	XI SEAM
Av. thickness	7.31 m
Av. depth	400 m
Av. dip	1in 7
Dip direction	$S76^{0}$ 50' W
Shape of seam	Basin like
Degree of gassiness	Degree II
R.M.R. Value	34.46 (not good)
Geological features	Highly faulted with Intrusion
Mode of entry	3 shaft
Type of ventilation	CVS
Coal transportation	Through incline by Belt Conveyor upto Surface

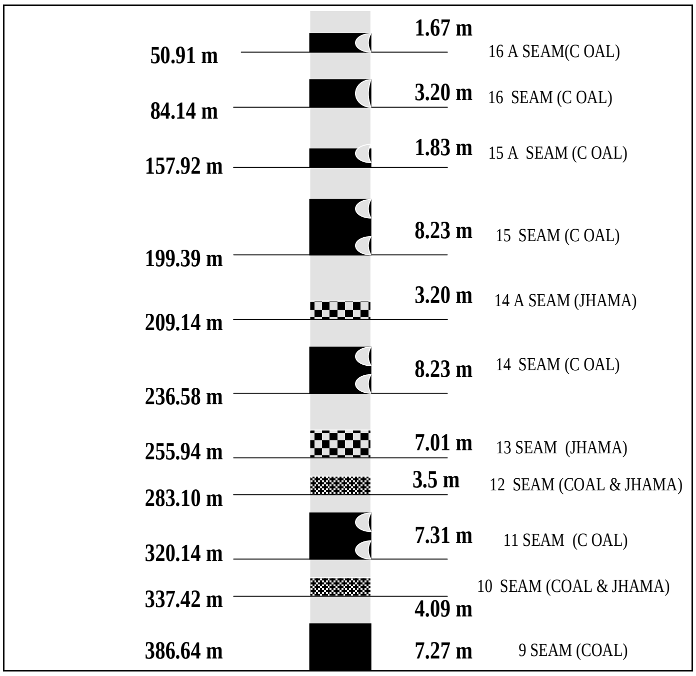

Fig 1: Bore hole section at 9 pit 'Mine-A'

Table 2: Details of panel working in the Mine-A

Panel Name	Minimum Avg.depth (m)	Avg. pillar size(m)	Gallery Size (m) (w×h)	Coal preparation method	Loading	Transport
Panel-11/10-S	370	45 × 45	4.2 × 3.0, 4.8 × 3.0 (slice)	Bord &Pillar (dep., bottom sec.)	SDL	Conveyor
Panel-11/7-S	400	45 × 45	4.2 × 2.8, 4.8× 2.8 (slice)	Bord & Pillar (dev. & dep., top sec.)	SDL	Conveyor
Panel-11/3-S	400	45 × 45	4.2× 2.7, 4.8× 2.7 (slice)	Bord & Pillar (dep., top sec.)	manual	Conveyor
Panel-11/9-S	325	45 × 45	4.2× 2.7, 4.8× 2.7 (slice)	Bord & Pillar (dev. & dep., bottom & top sec. both)	SDL	Conveyor

4. BRIEF DESCRIPTION OF COAL WINNING IN THE STUDY PANEL

There were three semi-mechanised panels namely, panel '11/7-S', '11/10-S' & '11/9-S' and one manual panel namely panel '11/3-S' in the given mine. The study was conducted in the semi-mechanised panel 11/7-S in the mine. The description of the coal winning in the study panel as follows:

Bottom section of panel 11/7-S had been developed and depillared upto 3.0 m height by bord and pillar (B/P) method of working in conjunction with hydraulic sand stowing. some portion of bottom section had been left for the purpose of sumping. Depillaring in bottom section had been done by splitting pillar into four parts. After leaving a parting of almost 1.5 m, top section 2.8m was being developed & depillared simultaneously by B/P method of working. Top section depillaring by means of modified depillaring method in which taking dip-rise slice simultaneously then judicial extraction of rib in conjunction with hydraulic sand stowing

Panel consisted of 3 SDLs, (one SDL for development and two SDLs for depillaring) loading coal on separate light duty chain conveyor (LDCC). Coal broken by drilling & blasting was loaded on LDCC by means of side discharge loader (SDL) with bucket capacity of 1.5cu.m. face conveyor discharged the coal on the belt conveyor to be carried out bye through a system of belts up to the coal washery located on surface. The galleries, splits and slices were supported systematically by the roof bolts having yield load of 5 tonne.

5. RESEARCH METHODOLOGY

The aforesaid concept of breaking a mine system into sub-systems for finer analysis, has been adopted in the present case study, considering Panel as a system. According the major sub-systems were formulated as given in fig.2.

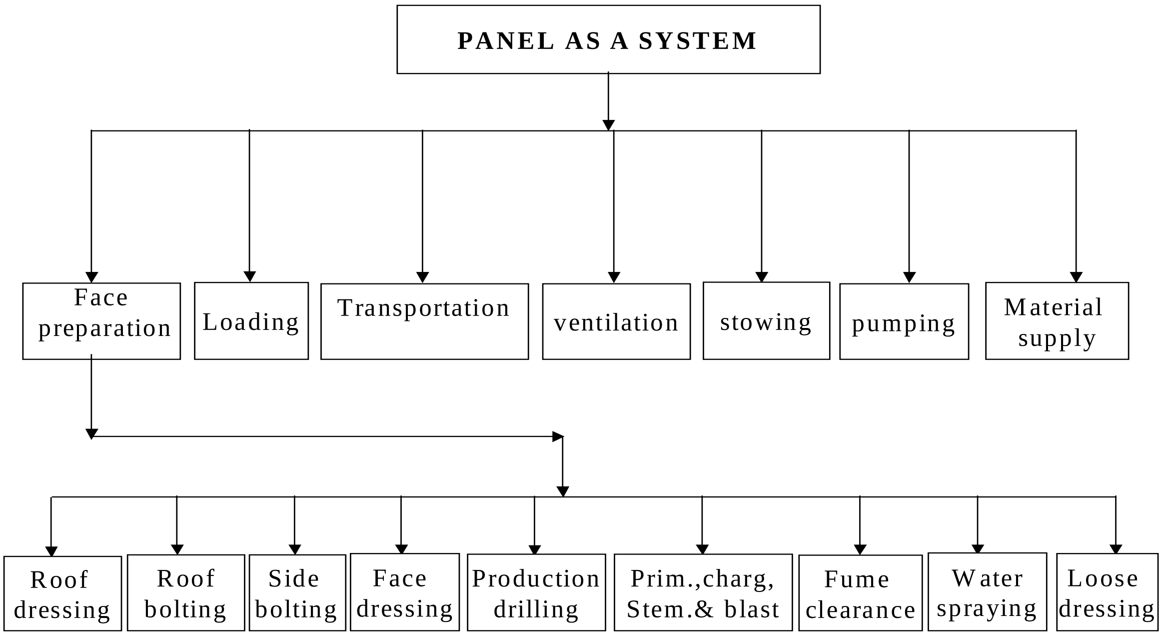

Fig. 2: Formulated systematic proposed model for Present working

6. FIELD OBSERVATIONS:

6.1 Time and Motion Study of Various Sub-Systems:

As per the formulated system model (fig.2) the time & motion studies were conducted at field scale for various sub-systems. The statistical data pertaining to the time & motion studies of various sub-systems such as, face preparation (roof dressing, roof bolting, side bolting etc.) loading etc. in statistical format is tabulated in tables 3 to 20. Based on the statistical tables the mean, median, mode, standard deviation & co-efficient of variation for face preparation & loading and mean (average) for stowing & ventilation sub-systems.

Table 3: Frequency distribution of roof dressing per face (minute)

Class mark (x)	Frequency (f)	fx	Cumulative frequency (c.f)	d = x-A = x-20.18	d²	fd²
14	11	154	11	-6.18	38.19	420.12
15	18	270	29	-5.18	26.83	482.98
16	7	112	36	-4.18	17.47	122.31
17	3	51	39	-3.18	10.11	30.34
18	3	54	42	-2.18	4.75	14.26
19	2	38	44	-1.18	1.39	2.78
20	2	40	46	-.18	.03	.06

50	1	50	47	29.82	889.23	889.23
55	1	55	48	34.82	1212.43	1212.43
60	1	60	49	39.82	1585.63	1585.63
70	1	70	50	49.82	2482	2482
75	1	75	51	54.82	3005.23	3005.23
	∑f = 51	∑fx = 1029				∑fd²=10247.37

Mean (A) = ∑fx ⁄ ∑f = 1029⁄51 = 20.18, Median (M) = 15, Mode (Mo) =15,

Standard deviation (σ) = √(∑fd²⁄∑f) = 14.17, Variance (σ²) = 200.92 and

Co-efficient of variation = (σ ⁄ A)×100 = 70.24%

Table 4: Frequency distribution of roof bolting per bolt (minute)

Class interval	Class mark (x)	Frequency (f)	fx	c.f	d = x-A = x-7.32	d²	fd²
4-6	5	40	200	40	-2.32	5.38	215.29
6-8	7	118	826	158	-.32	.10	12.08
8-10	9	20	180	178	1.68	2.82	56.45
10-12	11	2	22	180	3.68	13.54	27.08
12-14	13	2	26	182	5.68	32.26	64.52
14-16	15	5	75	187	7.68	58.98	294.91
16-18	17	3	51	190	9.68	93.7	281.10
18-20	19	1	19	191	11.68	136.42	136.42
		∑f = 191	∑fx = 1399				∑fd²=1087.85

Mean (A) = ∑fx ⁄ ∑f = 1399⁄191 = 7.32, Median (M) = 6.94, Mode (Mo) = 6.88,

Standard deviation (σ) = √(∑fd²⁄∑f) =2.38, Variance (σ²) = 5.69 and

Co-efficient of variation = (σ ⁄ A)×100 = 32.5%

Table 5: Frequency distribution of side bolting per face (minute)

Class interval	Class mark (x)	Frequency (f)	fx	c.f	d = x-A = x-3.97	d²	fd²
2.5-3.0	2.75	6	16.5	6	-1.22	1.490	8.93
3.0-3.5	3.25	5	16.25	11	-0.72	0.52	2.59
3.5-4.0	3.75	17	63.75	28	-0.22	0.0484	0.82
4.0-4.5	4.25	6	25.5	34	0.5	0.25	1.5
4.5-5.0	4.75	13	61.75	47	0.78	0.61	7.91
5.0-5.5	5.25	1	5.25	48	1.28	1.64	1.64
5.5-6.0	5.75	1	5.75	49	1.78	3.17	3.17
		∑f = 49	∑fx = 194.75				∑fd²=26.56

Mean (A) = ∑fx ⁄ ∑f =194.75⁄49 = 3.97, Median (M) = 3.89,Mode (Mo) = 3.76,

Standard deviation (σ) = √(∑fd²⁄∑f) =0.736, Variance (σ²) = 0.542 and

Co-efficient of variation = (σ ⁄ A)×100 =18.53 %

Table 6: Frequency distribution of face dressing per face (minute)

Class interval	Class mark (x)	Frequency (f)	fx	c.f	d = x-A = x-8.84	d²	fd²
6-7	6.5	10	65	10	-2.34	5.475	54.75
7-8	7.5	14	105	24	-1.34	1.795	25.14
8-9	8.5	8	68	32	-0.34	0.115	.92
9-10	9.5	8	76	40	0.66	0.435	3.48
10-11	10.5	0	0	40	1.66	2.755	0
11-12	11.5	0	0	40	2.66	7.075	0
12-13	12.5	0	0	40	3.66	13.395	0
13-14	13.5	2	27	42	4.66	21.72	43.43
14-15	14.5	3	43.5	45	5.66	32.03	96.11
15-16	16.5	2	31.0	47	6.66	44.75	88.71
		∑f = 47	∑fx = 415.5				∑fd²=312.54

Mean (A) = ∑fx ⁄ ∑f = 415.5 ⁄ 47 = 8.84, Median (M) = 7.96, Mode (Mo) = 7.4,

Standard deviation (σ) = √(∑fd²⁄∑f) = 2.578, Variance (σ²) = 6.65 and

Co-efficient of variation = (σ ⁄ A)×100 = 29.16%

Table 7: Frequency distribution of production drilling per hole (second)

Class interval	Class mark (x)	Frequency (f)	fx	c.f	d = x-A = x-80	d²	fd²
0-20	10	1	10	1	-70	4900	4900
20-40	30	9	570	10	-50	2500	22500
40-60	50	19	950	29	-30	900	17100
60-80	70	51	3570	80	-10	100	5100
80-100	90	26	2340	106	10	100	2600
100-120	110	17	1870	123	30	900	15300
120-140	130	68	1040	131	50	2500	20000
140-160	150	2	300	133	70	4900	9800
		∑f = 133	∑fx = 10650				∑fd²=97300

Mean (A) =∑fx ⁄ ∑f =10650⁄133 = 80, Median (M) = 74.7, Mode (Mo) = 71.23,

Standard deviation (σ) = √(∑fd²⁄∑f) =27.04, Variance (σ²) = 731.57 and

Co-efficient of variation = (σ ⁄ A)×100 = 33.7%

Table 8: Frequency distribution of preparing sand capsule, 36 capsule with 3 men (minute)

Class mark (x)	Frequency (f)	fx	c.f	d = x-A = x-17.44	d²	fd²
12	1	12	1	-5.44	29.59	29.59
13	3	39	4	-4.44	19.71	59.14
14	4	56	8	-3.44	11.83	47.33
15	6	90	14	-2.44	5.95	35.72
16	4	64	18	-1.44	2.07	8.29
17	3	51	21	-.44	0.19	.58
18	3	54	24	1.44	2.07	6.21
30	1	30	25	12.56	157.75	157.75

35	1	35	26	17.56	308.35	308.35
40	1	40	27	22.56	508.95	508.95
	∑f = 27	∑fx = 471				∑fd²=1161.91

Mean (A) = ∑fx ⁄ ∑f = 471⁄27 = 17.44, Median (M) = 15, Mode (Mo) =15, Standard deviation (σ) = √(∑fd²⁄∑f) = 6.56, Variance (σ²) = 43.03 and

Co-efficient of variation = (σ ⁄ A)×100 =37.61 %

Table 9: Frequency distribution of charging and blasting per face (minute)

Class interval	Class mark (x)	Frequency (f)	fx	c.f	d = x-A = x-36	d²	fd²
29-31	30	7	210	7	-6	36	252
31-33	32	4	128	11	-4	16	64
33-35	34	7	238	18	-2	4	8
35-37	36	1	36	19	0	0	0
37-39	38	6	228	25	2	4	24
39-41	40	4	160	29	4	16	64
41-43	42	3	126	32	6	36	108
43-45	44	2	88	34	8	64	128
45-47	46	1	46	35	10	100	100
		∑f = 35	∑fx =1260				∑fd²=768

Mean (A) = ∑fx ⁄ ∑f = 1260 ⁄ 35 = 36, Median (M) = 34.85, Mode (Mo) = 33.67, Standard deviation (σ) = √(∑fd²⁄∑f) = 4.68, Variance (σ²) = 21.94 and

Co-efficient of variation = (σ ⁄ A)×100 = 13%

Table 10: Frequency distribution of fume clearance per face (minute)

Class interval	Class mark (x)	Frequency (f)	fx	c.f	d = x-A = x-4.78	d²	fd²
3.5-4.0	3.75	2	7.5	2	-1.03	1.06	2.12
4.0-4.5	4.25	12	51	14	-0.53	0.28	3.37
4.5-5.0	4.75	13	61.75	27	-0.03	.0009	0.0117
5.0-5.5	5.25	6	31.5	33	0.47	.22	1.325
5.5-6.0	5.75	4	23	37	0.97	0.94	3.76
6.0-6.5	6.25	0	0	37	1.47	2.16	0
6.5-7.0	6.75	1	6.75	38	1.97	3.88	3.88
		∑f = 38	∑fx =181.5				∑fd²=14.46

Mean (A) = ∑fx ⁄ ∑f = 181.5 ⁄ 38 = 4.78, Median (M) = 4.69, Mode (Mo) = 4.56, Standard deviation (σ) = √(∑fd²⁄∑f) = 0.616, Variance (σ²) = 0.381 and

Co-efficient of variation = (σ ⁄ A)×100 = 12.88%

Table 11: Frequency distribution of time study of water spraying and loose dressing per face (minute)

Class interval	Class mark (x)	Frequency (f)	fx	c.f	d = x-A = x-17.98	d²	fd²
14-15	14.5	2	29	2	-3.48	12.11	24.22
15-16	15.5	3	46.5	5	-2.48	6.15	18.45
16-17	16.5	2	33	7	-1.48	2.19	4.38
17-18	17.5	6	105	13	-0.48	.23	1.38
18-19	18.5	6	111	19	0.58	.27	1.68
19-20	19.5	4	78	23	1.58	2.31	9.24
20-21	20.5	3	61.5	26	2.52	6.35	19.05
21-22	21.5	1	21.5	27	3.52	12.39	12.39
		∑f = 27	∑fx =485.5				∑fd²=295.32

Mean (A) = ∑fx ⁄ ∑f = 485.5 ⁄ 27 = 17.98, Median (M) = 18.08, Mode (Mo) =18

Standard deviation (σ) =√(∑fd²⁄∑f) = 3.31, Variance (σ²) = 10.93 and

Co-efficient of variation = (σ ⁄ A)×100 = 18.41%

Table 12: Frequency distribution of loading cycle time (second) at lead up to 5 metres

Class interval	Class mark (x)	Frequency (f)	fx	c.f	d = x-A = x-51.12	d²	fd²
35-40	37.5	8	300	8	-13.62	185.50	1484.03
40-45	42.5	23	977.5	31	-8.62	74.30	1709.00
45-50	47.5	19	902.5	50	-3.62	13.10	248.98
50-55	52.5	10	525	60	1.38	1.90	19.04
55-60	57.5	17	977.5	77	6.38	40.70	691.97
60-65	62.5	9	562.5	86	11.38	129.50	1165.53
65-70	67.5	5	337.5	91	16.38	268.30	1341.52
70-75	72.5	2	145	93	21.38	457.10	914.21
75-80	77.5	1	77.5	94	26.38	695.90	695.90
		∑f = 94	∑fx = 4805				∑fd²=8270.18

Mean (A) = ∑fx ⁄ ∑f = 4805 ⁄ 94= 51.12, Median (M) = 49.21, Mode (Mo) = 43.95

Standard deviation (σ) = √(∑fd²⁄∑f) =9.38, Variance (σ²) = 87.98 and

Co-efficient of variation = (σ ⁄ A)×100 = 18.34%

Table 13: Frequency distribution of loading cycle time (second) at lead 5-10 metres

Class interval	Class mark (x)	Frequency (f)	fx	c.f	d = x-A = x-75.58	d²	fd²
65-70	67.5	15	1012.5	15	-8.08	65.28	979.29
70-75	72.5	17	1232.5	32	-3.08	9.48	161.27
75-80	77.5	3	232.5	35	1.92	3.68	11.06
80-85	82.5	3	247.5	38	6.92	47.88	143.66

85-90	87.5	3	262.5	41	11.92	142.08	426.24
90-95	92.5	4	370	45	16.92	286.28	1145.14
95-100	97.5	2	195	47	21.92	480.48	960.97
		∑f = 47	∑fx =3552.5				∑fd²=3827.63

Mean (A) = ∑fx ⁄ ∑f = 3552.5⁄47 = 75.58, Median (M) = 72.5, Mode (Mo) = 70.63

Standard deviation (σ) = √(∑fd²⁄∑f) =9.02, Variance (σ²) =81.44 and

Co-efficient of variation = (σ ⁄ A)×100 =11.94 %

Table 14: Frequency distribution of loading cycle time (second) at lead 10-15 metres

Class interval	Class mark (x)	Frequency (f)	fx	c.f	d = x-A = x-83.29	d²	fd²
70-75	72.5	5	362.5	5	-10.79	116.42	582.12
75-80	77.5	7	542.5	12	-5.79	33.52	134.67
80-85	82.5	17	1402.5	29	-0.79	.624	10.61
85-90	87.5	9	787.5	38	4.21	17.72	159.52
90-95	92.5	4	370	42	9.21	84.82	339.29
95-100	97.5	1	97.5	43	14.21	201.92	201.92
100-105	102.5	1	102.5	44	19.21	369.02	369.02
		∑f = 44	∑fx =3665				∑fd²=1897.15

Mean (A) = ∑fx ⁄ ∑f = 3665 ⁄ 44 = 83.29, Median (M) = 82.94, Mode (Mo) = 82.77

Standard deviation (σ) = √(∑fd²⁄∑f) =6.57, Variance (σ²) =43.11

And Co-efficient of variation = (σ ⁄ A)×100 =7.88 %

Table 15: Frequency distribution of loading cycle time (second) at lead 15-20 metres

Class interval	Class mark (x)	Frequency (f)	fx	c.f	d = x-A = x-99.74	d²	fd²
90-95	92.5	17	1572.5	17	-7.24	52.42	891.14
95-100	97.5	14	1365	31	-2.24	5.02	70.25
100-105	102.5	7	717.5	38	2.76	7.62	53.32
105-110	107.5	5	537.5	43	7.76	60.22	301.08
110-115	112.5	3	337.5	46	12.76	162.82	488.45
115-120	117.5	2	235	48	17.76	315.42	630.83
120-125	122.5	1	122.5	49	22.76	518.02	518.02
		∑f =49	∑fx =4887.5				∑fd²=2453.09

Mean (A) =∑fx ⁄ ∑f = 4887.5 ⁄ 49 = 99.74, Median (M) = 97.67, Mode (Mo) = 94.25

Standard deviation (σ) = √(∑fd²⁄∑f) =7.07, Variance (σ²) =50.06 and

Co-efficient of variation = (σ ⁄ A)×100 =7.09 %

Table 16: Frequency distribution of loading cycle time (second) at lead 20-25 metres

Class interval	Class mark (x)	Frequency (f)	fx	c.f	d = x-A = x-122.09	d²	fd²
110-115	112.5	16	1800	16	-9.59	91.96	1471.48
115-120	117.5	11	1292.5	27	-4.59	21.06	231.75
120-125	122.5	6	735	33	0.41	.168	1.00
125-130	127.5	4	510	37	5.41	29.27	117.07
130-135	132.5	5	662.5	42	10.41	108.37	541.84
135-140	137.5	4	550	46	15.41	237.47	949.87
140-145	142.5	2	285	48	20.41	416.56	833.14
145-150	147.5	1	147.5	49	25.41	645.67	645.67
		∑f =49	∑fx =5982.5				∑fd²=4791.82

Mean (A) =∑fx ⁄ ∑f = 5982.5⁄49 =122.09, Median (M) = 118.86,Mode (Mo) =113.07

Standard deviation (σ) = √(∑fd²⁄∑f) =9.88, Variance (σ²) =97.79 and

Co-efficient of variation = (σ ⁄ A)×100 =8.09 %

Table 17: Frequency distribution of loading cycle time (second) at lead 25-30metres

Class interval	Class mark (x)	Frequency (f)	fx	c.f	d = x-A = x-153.09	d²	fd²
120-130	125	7	875	7	-28.09	789.05	5523.33
130-140	135	9	1215	16	-18.09	327.25	2945.23
140-150	145	6	870	22	-8.09	65.45	392.68
150-160	155	7	1085	29	1.91	3.65	25.54
160-170	165	2	330	31	11.91	141.85	283.69
170-180	175	3	525	34	21.91	480.05	1440.14
180-190	185	5	925	39	31.91	1018.25	5091.24
190-200	195	1	195	40	41.91	1756.45	1756.45
200-210	205	2	410	42	51.91	2694.65	5389.29
		∑f =42	∑fx =6430				∑fd²=22842.49

Mean (A) =∑fx ⁄ ∑f = 6430 ⁄ 42=153.09, Median (M) = 148.33, Mode (Mo) = 134,

Standard deviation (σ) = √(∑fd²⁄∑f) =23.32, Variance (σ²) =543.86 and

Co-efficient of variation = (σ ⁄ A)×100 = 15.23%

Table 18: Average loading cycle time w.r.t. different lead

Lead (metre)	Average cycle time (second)
Upto 5	51.12
5-10	75.58
10-15	83.29
15-20	99.74
20-25	122.09
25-30	153.09

Table 19: Monthly average stowing rate (te/hr) during the study period

Date	Daily Stowing rate (te/hr.)	Date	Daily Stowing rate (te/hr.)	Monthly average stowing rate (te/hr)
2/4/2006	105	2/5/2006	87.5	(90.95+96.05)/2 = 93.5
3/4/2006	92.85	3/5/2006	100	
5/4/2006	89.65	4/5/2006	100	
10/4/2006	94.16	8/5/2006	100	
11/4/2006	90	9/5/2006	90.9	
14/4/2006	57.14	10/5/2006	95	
17/4/2006	90.47	11/5/2006	85.71	
19/4/2006	100	18/5/2006	100	
24/4/2006	88.88	19/5/2006	97.43	
25/4/2006	92.31	20/5/2006	100	
26/4/2006	100	28/5/2006	100	
Monthly daily average stowing rate (te/hr.)	90.95		96.05	

Table 20: Average intake quantity, Quantity at LVC and VEQ (%)

Measurement Date	Intake quantity (cu.m /min.)	Quantity at LVC (cu.m /min.)	VEQ (%)
4/10/2005	1017	763	75
31/10/2005	1067	610	57.16
5/11/2005	1050	720	68.57
24/11/2005	1024	694	67.77
2/12/2005	1008	696	69
16/12/2005	1064	750	70.48
4/01/2006	1085	772	71.15
18/01/2006	1117	805	72.06
4/02/2006	1101	794	72.11
18/02/2006	902	742	82.26
7/3/2006	1113	834.75	75
16/3/2006	746	554	74.26
4/4/2006	763	534	69.98
2/4/2006	931	847	90.9
15/5/2006	706	669	94.75
Average	979.6	718.98	74.03

7. RESULTS & DISCUSSION

7.1 Results of Various Operations

Results of various operations of face preparation sub-system & loading sub-system are plotted as frequency distribution curves, and, shown in fig. 3to 17. Frequency distribution curves have been drawn from table 3 to 17. From these frequency distribution curves various time elements have been estimated and used for the computation of system capacities.

Further, in order to estimate the average loading cycle time (by SDLs at various lead distances) the SDL loading time was studied in the field & the results are graphically plotted as shown in fig. 18. Graph has been plotted from table 18.

Again, in order to estimate the average stowing rate the stowing operation was studied in the field & the results are graphically plotted in fig. 19. Graph has been plotted from table 19.

Again, in order to estimate the intake quantity, quantity at LVC & VEQ (%) ventilation operation was studied in the field & the results are graphically plotted in fig. 20. Graph has been plotted from table 20.

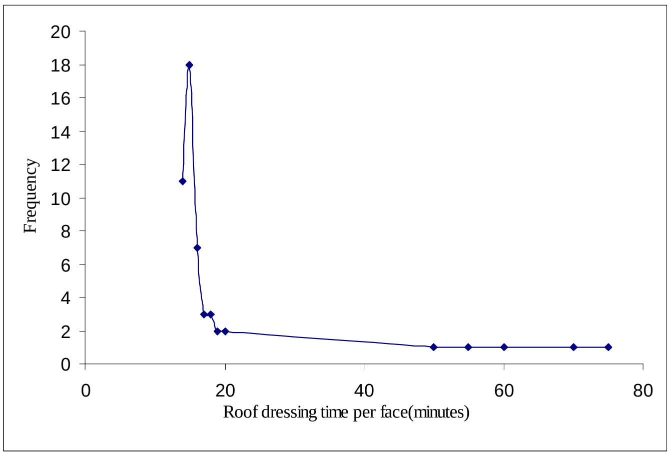

Fig. 3: Roof dressing time per face vs. Frequency

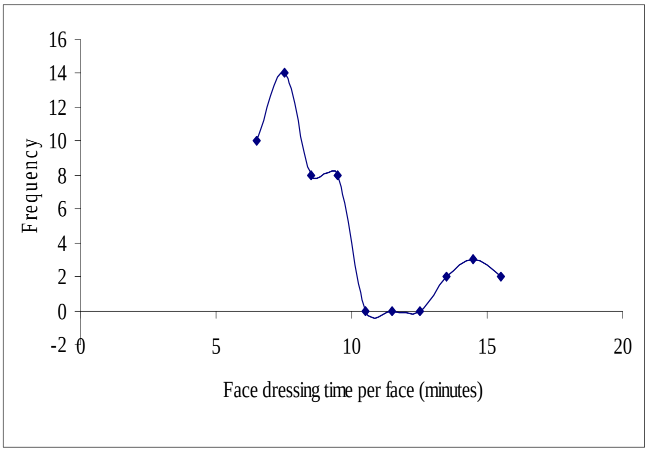

Fig. 6: Face dressing time per face vs. Frequency

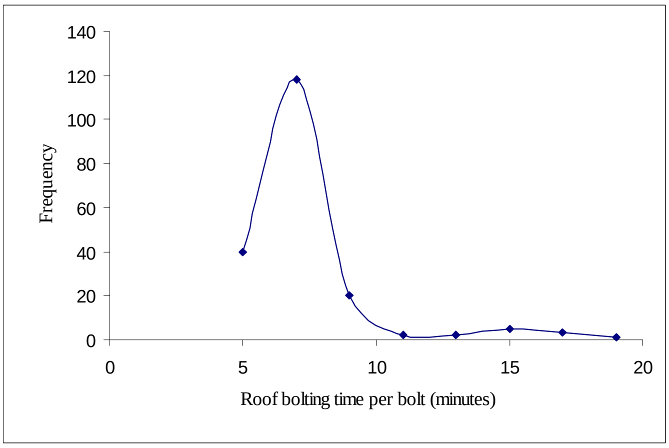

Fig. 4: Roof bolting time per bolt vs. Frequency

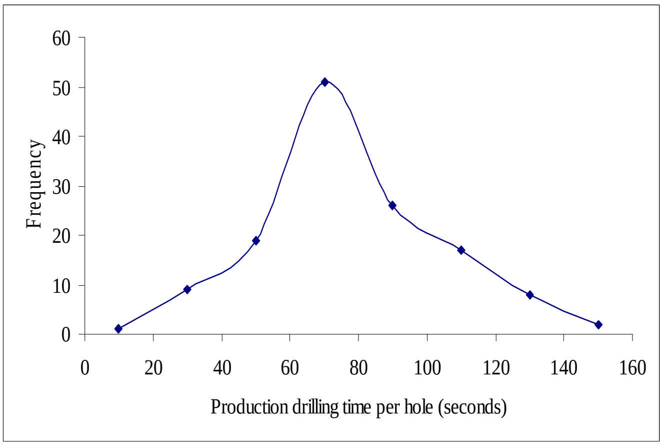

Fig. 7: Production drilling time per hole vs. Frequency

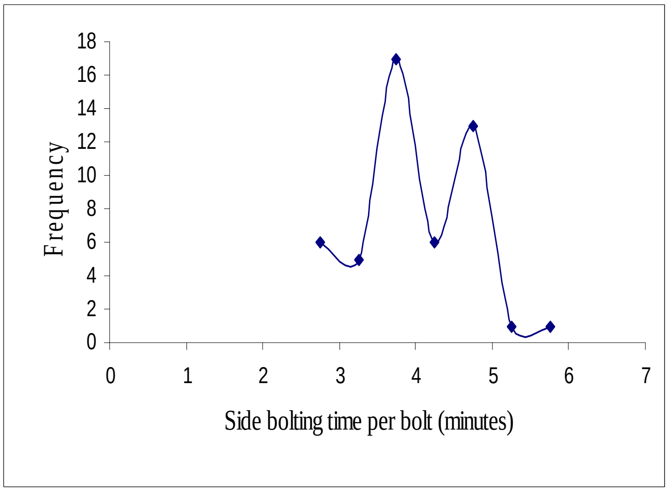

Fig. 5: Side bolting time per bolt vs. Frequency

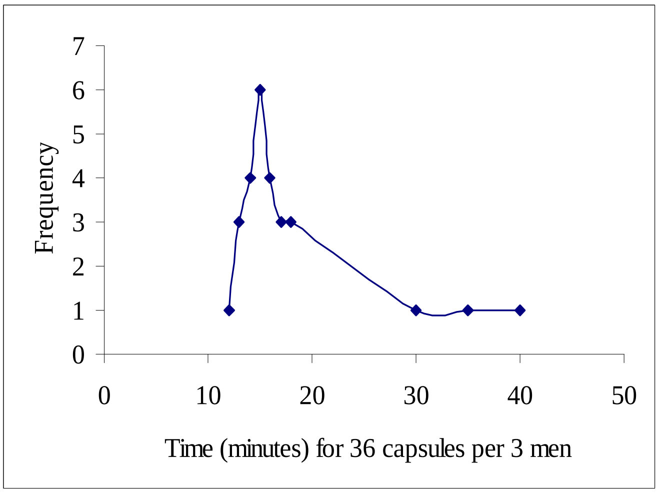

Fig. 8: Time for 36 sand capsules per 3 men vs. Frequency

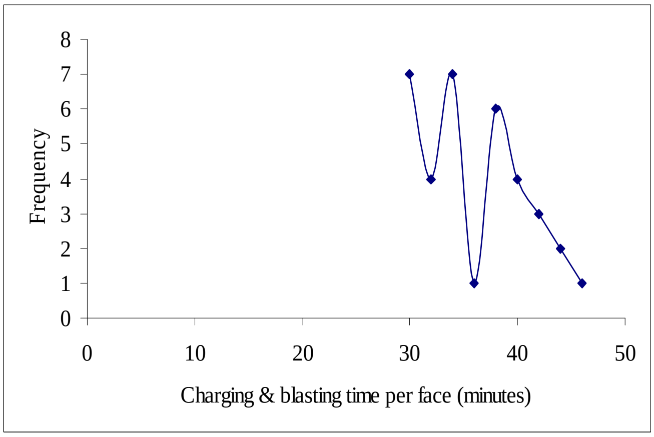

Fig. 9: Charging and blasting time per face vs. Frequency

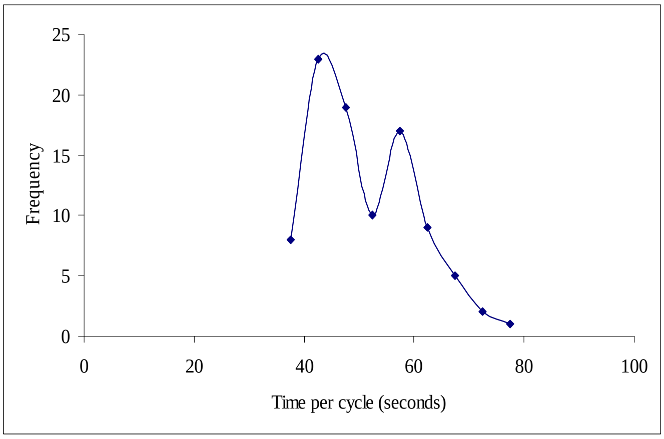

Fig. 12: Loading cycle time (lead up to 5m) vs. Frequency

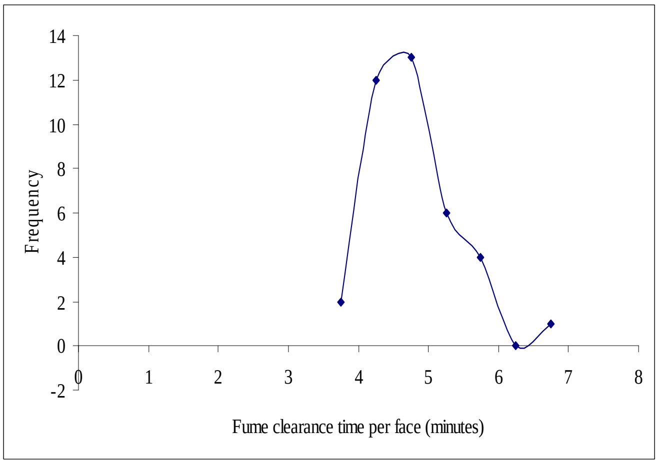

Fig. 10: Fume clearance time per face vs. Frequency

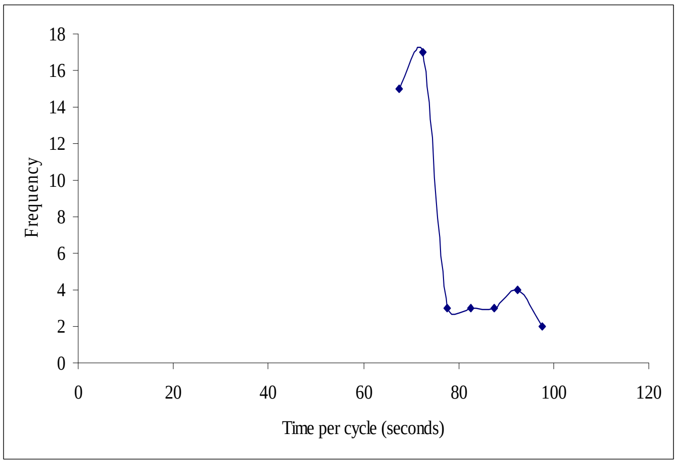

Fig. 13: Loading cycle time (lead 5-10m) vs. Frequency

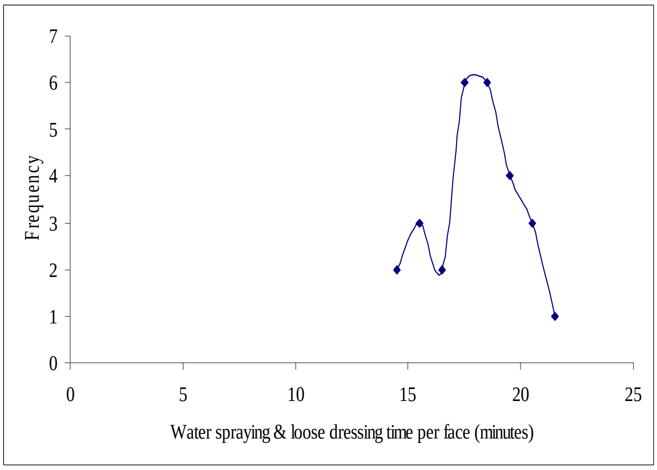

Fig. 11: Water spraying & loose dressing time per face vs. Frequency

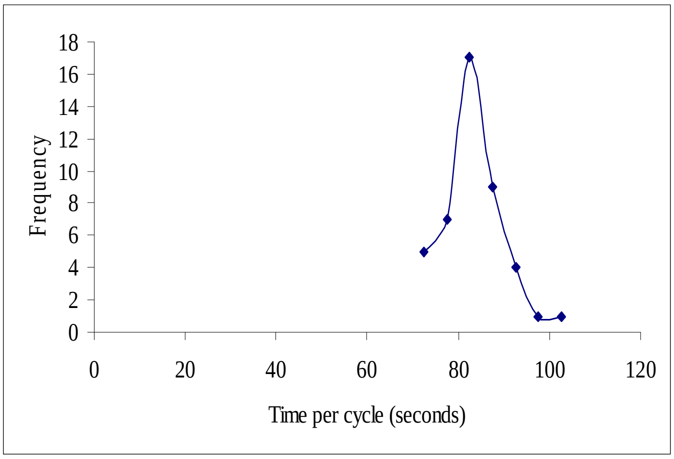

Fig. 14: Loading cycle time (lead 10-15m) vs. Frequency

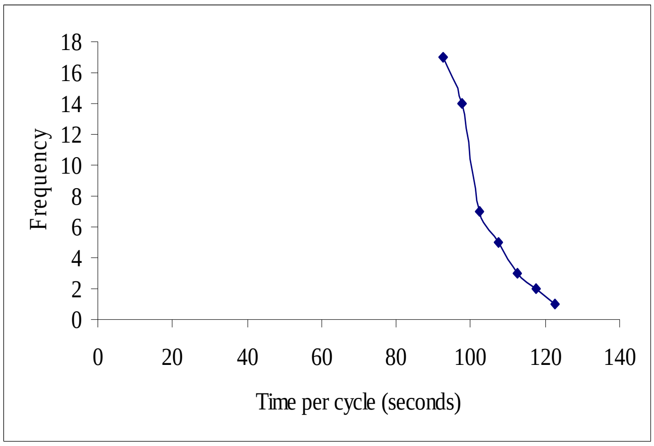

Fig.15: Loading cycle time (lead 15-20m) vs. Frequency

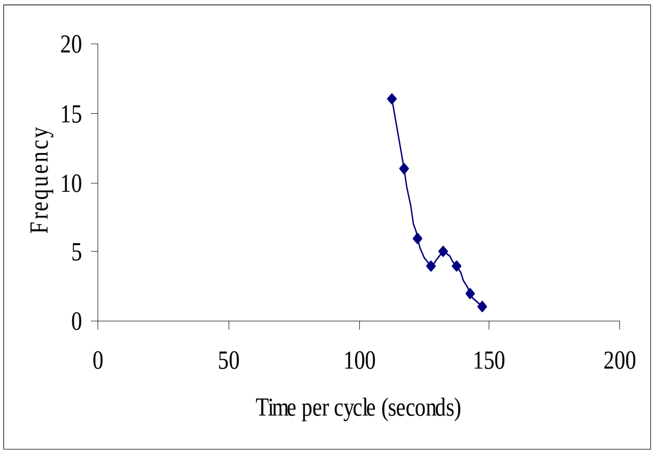

Fig. 16: Loading cycle time (lead 20-25m) vs. Frequency

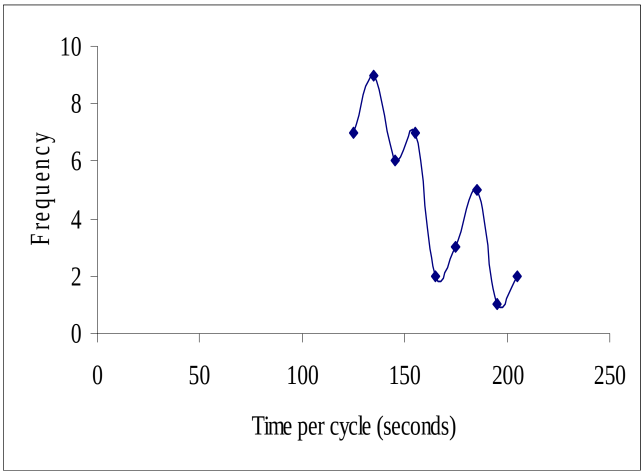

Fig. 17: Loading cycle time (lead 25-30m) vs. Frequency

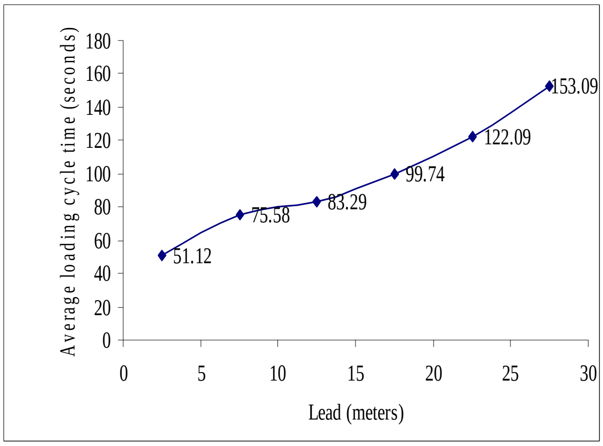

Fig. 18: Lead vs. Average loading cycle time

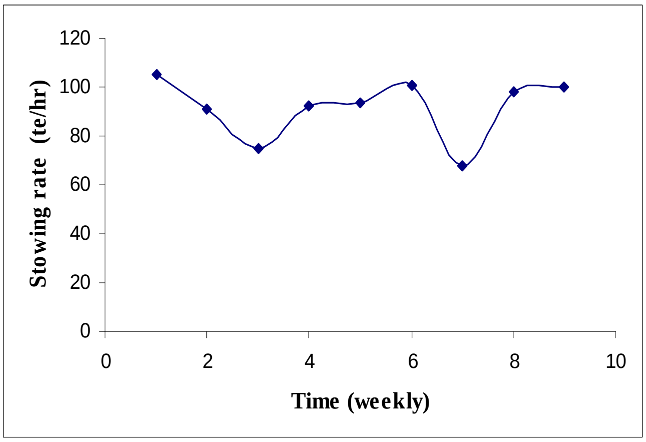

Fig. 19: Time vs. stowing rate

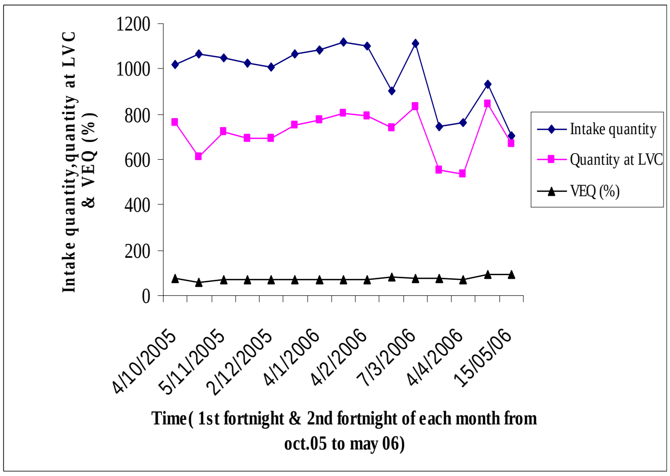

Fig. 20: Time vs. Intake quantity (cu.m/min.), Quantity at LVC and VEQ (%)

7.2 Statistical Results of Face Preparation & Loading Sub-System:

Statistical results of face preparation & loading sub-system are tabulated in table 21. Results in this table have been drawn from frequency distribution table 3 to 17 (Except table 8)

Table 21: Integrated table showing the statistical results of face preparation and loading sub-systems

Operations	Mean	Median	Mode	Standard Deviation	Variance	Co-efficient of variation (%)
face preparation time						
1. Roof dressing per face(minutes)	20.18	15	15	14.17	200.92	70.24
2. Roof bolting per bolt (minutes)	7.32	6.94	6.88	2.38	5.69	32.51
3.Side bolting per bolt(minutes)	3.97	3.89	3.76	0.736	0.542	18.53
4.Face dressing per face(minutes)	8.84	7.96	7.4	2.57	6.65	29.16
5.Production drilling per hole (seconds)	80	74.7	71.23	27.04	731.57	33.7
6.Charging & blasting per face (minutes)	36	34.85	33.67	4.68	21.94	13
7.Fume clearance per face(minutes)	4.78	4.69	4.56	.616	.381	12.88
8.WS+LD per face(minutes)	17.98	18.08	18	3.31	10.93	18.41
Loading cycle time (seconds)						
1 Lead (0-5m)	51.12	49.21	43.95	9.38	87.98	18.34
2. Lead (5-10m)	75.58	72.5	70.63	9.02	81.44	11.94
3.Lead (10-155m)	83.29	82.94	82.77	6.57	43.11	7.88
4.Lead (15-20m)	99.74	97.67	94.25	7.07	50.06	7.09
5.Lead (20-25m)	122.1	118.86	113.07	9.88	7.79	8.09
6.Lead (25-30m)	153.1	148.33	134	23.321	543.86	15.23

From the analysis of the results as given in table 21 the following important discussion may be drawn:

Statistical analysis of roof dressing operation shows significantly high value of co-efficient of variation (70.24%) in comparison to other operations which shows that data is not consistent. This, in turn, implies that the roof dressing operation is inconsistent in nature, being dependent and the prevailing geo-mining conditions. In this panel, particularly, the roof conditions were bad & variable due to presence of carbonaceous shale.

7.3 Results for Capacity Estimation:

From the fore going table 21 & related statistical computation (mean, median, mode, standard deviation & co-efficient of variation), it is quite justified to use the mean time element for the purpose of capacity estimation. Median & Mode appears to provide very optimistic data in uncertain geo-mining conditions. That is why the mean appears justifiable.

Table 22 & 23 provides the mean time element for various sub-systems under study.

Table 22: Mean time elements for various operations used for capacity estimation of sub-systems (Face Preparation & Loading)

Operations	Statistical Time (mean)
Face preparation time:	
1. Roof dressing per face(minutes)	20.18
2. Roof bolting per bolt(minutes)	7.32
3.Side bolting per bolt(minutes)	3.97
4.Face dressing per face(minutes)	8.84
5.Production drilling per hole (seconds)	80
6. Charging & blasting per face (minutes)	36
7.Fume clearance per face(minutes)	4.78
8.Water spraying & Loose dressing per face (minutes)	17.98
Loading cycle time (seconds):	
1. Lead (15-20m)	99.74

Table 23: Mean time elements for various operations used for capacity estimation of sub-systems (ventilation, transportation & stowing)

Ventilation sub-system	Transportation sub-system	Stowing sub-system
Average intake quantity =979.6 cu.m/min.	Tipper belt= 20hrs./day	Average stowing rate 93.5 te/hr(on monthly basis)
Average quantity at LVC =718.98 cu.m/min.	Trunk belt= 20 hrs./day	
Average leakages quantity =260.62 cu.m/min.	Sectional belt = 18hrs./day	
	Face chain conveyor =18 hrs./day	

CONCLUSIONS

1. Statistical analysis of roof dressing operation shows significantly high value of co- efficient of variation which means roof condition is not good.
2. Mean time elements will be considered as standard time for Capacity estimation purpose of various Sub-Systems

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