PROBABILITY & STATISTICS
(M.E CEM)
SEM-I

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Part -3

Measures of Dispersion

for a large data set

Measures of dispersion

1. Arithmetic mean, $\bar{x} = \frac{\Sigma x}{N}$,

   where N = total no. of observations
   x = value of each observation

2. Range, R = Largest value − Smallest value

3. Coeff of range, C.R. $= \frac{L-S}{L+S}$

4. Standard deviation from the mean, $\sigma = \sqrt{\frac{1}{N}\Sigma(x-\bar{x})^2}$

5. Variance, $V = \sigma^2$

6. Coeff. of variation, $C.V = \frac{\sigma}{\bar{x}} \times 100$

"Tolerances" : Acceptable Limits

- For the construction of a diaphragm wall, the contractor used concrete which consisted of different batches. The following compressive crushing strengths in N/mm² were recorded for each batch of concrete for M30 Grade

Batch no.	Comp. strgth (N/mm^2)	Batch no.	Comp. strngth (N/mm^2)
1	28.5	31	28.2
2	31.2	32	31.8
3	27.3	33	33.9
4	34.5	34	30.0
5	37.2	35	32.1
6	29.3	36	24.9
7	31.2	37	27.6
8	31.4	38	35.8
9	30.3	39	34.7
10	25.6	40	36.2
11	28.7	41	21.8
12	29.3	42	30.1
13	31.6	43	37.1
14	32.6	44	24.7
15	26.5	45	26.3
16	30.0	46	28.2
17	30.8	47	23.9
18	27.3	48	34.5
19	29.6	49	31.5
20	28.9	50	37.6
21	33.4	51	31.0
22	28.7	52	32.1
23	33.1	53	29.8
24	32.8	54	27.4
25	31.6	55	28.6
26	28.6	56	31.9
27	26.8	57	34.2
28	30.1	58	26.4
29	30.4	59	27.3
30	36.3	60	33.6

The quality control department from the client's side has Bench Marked the following norms for accepting or rejecting the concrete work. These are

1. Min^m target strength for each batch of concrete should be $30 \pm 1.5\sigma$
2. Std. deviation itself should be within 6%
3. The coeff. of variation should be within

You are the quality control incharge from the client's side. Perform statistical analysis using the measures of dispersion and decide whether you would accept or reject the concrete for the construction of the diaphragm wall. Justify your decision

Analyse the reasons for the inconsistencies in the concrete batch & make recommendations to contractor inorder to improve concrete quality in future.

Batch no.	Comp st (N/mm²)	$\bar{x}$	$(x - \bar{x})$	$(x - \bar{x}$

(1) $30 \pm 1.5\sigma = 30 \pm 1.5\sigma = 33.975$

(2) $\sigma = \sqrt{\frac{1}{N} \Sigma (x - \bar{x})^2} = \sqrt{\frac{1}{60} \Sigma (x - \bar{x})^2}$

$= 2.65$ N/m²

(3) $C.V = \frac{\sigma}{\bar{x}} \times 100 = 8.69\% < 10\%$

→ Readings are not within range.
As two of the 3 norms are outside the range ~~of~~ as bench marked, the construction is liable to be rejected.

The reason for obtaining high comp. strength would be
- rapid setting of cement
- low w/c ratio
- high dose of accelerating admixtures
- silica fumes
- evaporation due to heat etc.

The reason for obtaining low comp. strength would be
- voids left due to improper compaction
- high w/c ratio due to moistness while testing
- excessive use of retarding admixtures
- use of cement with low heat of hydration.

→ Recommendation:
1. Efficient compaction using suitable techniques
2. Proper use of admixtures if required.
3. Care while handling and placing
4. Maintaining optimum w/c ratio.
5. Care while transporting by transit mixer
6. Proper testing, placement of moulds of all batches under normal conditions
7. Neglect the use of batch which shows results out of range even after proper supervision.

– Measures of dispersion – cost control.

eg: By using microsoft project software tool, a construction company executing multi-storeyed building project, has got the following figure as regards the cost growth on 25 of their building projects.

Project no	% cost growth(x)	$\bar{x}$	$(x-\bar{x})$	$(x-\bar{x})^2$
1	4.3		-17.85	318.62
2	6.9		-15.25	232.56
3	11.3		-10.85	117.72
4	28.6		6.45	41.60
5	55		32.85	1079.12
6	38.3		16.15	260.82
7	13.3		-8.85	78.32
8	16.4		-5.75	33.06
9	36.4		14.25	203.06
10	30.8		8.65	74.82
11	26.8		4.65	21.62
12	0		-22.15	490.62
13	42.9	22.15	20.75	430.56
14	14		-8.15	66.42
15	29.8		7.65	58.52
16	22.2		0.05	0.0025
17	5		-17.15	294.12
18	60.4		38.25	1463.06
19	26		3.85	14.82
20	21.2		-0.95	0.9
21	28.6		6.45	41.60
22	11.1		-11.05	122.10
23	11.1		-11.05	122.10
24	1.4		-20.75	430.56
25	11.6		-10.55	111.30
				$\Sigma = 6107.1$

$\bar{x} = 22.15$

Through the MIS created within the company, the data was carefully observed by the managing director and he was terribly shocked. He decided to make statistical analysis and hence set a bench mark to be adopted as policy for implementation atleast in future work.

You have been involved in the above process. Perform statistical analysis and set the B.M. as regards the standard deviation and coeff. of variation.

Justify the B.M. suggested. Identify the various reasons that are causing cost growth. Suggest remedial controls in future.

Soln : $\bar{x} = \frac{\Sigma x}{N} = 22.15\ \%$

$$\sigma = \sqrt{\frac{1}{N}\Sigma(x-\bar{x})^2} = \sqrt{\frac{6107.1}{25}}$$

$= 15.63\%$

Variance $= 244.28$

$$C.V = \frac{15.63}{22.15} \times 100$$

$= 70.56\%$

→ B.M. are set as follows

(a) The cost growth should not exceed 6%

(b) Std deviation should not increase more than 4%.

(c) C.V. should not increase 15%

→ The cost growth of project no. 1, 12, 17 and 24 can be accepted

→ σ = 15.63 > 4. This cant be accepted.

→ C.V = 70.56 > 15%. This cannot be accepted.

→ The reasons of cost growth are as follows:

1. Improper financial analysis made by client.
2. Lack of technical knowledge of the contractor
3. Labour strikes
4. For long duration projects, increase in cost of materials in due course
5. Claims, disputes and arbitration
6. Accidents on site and subsequent trauma
7. Unforeseen environmental hazards like floods, droughts, earthquakes etc.
8. Rework due to below average work or improper finishing

→ Remedies

1. Production theories, like 6 sigma, Lean construction techniques, supply chain management, etc should be incorporated in the project.
2. SQM & TQM should be thoroughly practiced.
3. Regular (fortnightly / weekly / monthly) m... of PM should be taken to add...