DATE: 2023-09-10

LAB 10: Randomized Block Design (RBD)

A chemist wishes to test the effect of four chemical agents on the strength of a particular type of cloth. There might be variability from one bolt to another, hence, the chemist decides to use a randomized block design, with the bolts of cloth considered as blocks. He selects five bolts and applies all four chemicals in random order to each bolt. The resulting tensile strength follow.

Chemical agents	Bolt				
	1	2	3	4	5
1	73	68	74	71	67
2	73	67	75	72	70
3	75	68	78	73	68
4	73	71	75	75	69

(a) Carryout two-way ANOVA
(b) Determine tensile strength is same for all four chemical agents? Use α = 0.05
(c) Determine tensile strength is same for all five bolts? Use α = 0.05

General Linear Model: Tensile Strength versus Chemical Agents, Bolt Type

Method

Factor coding	(-1, 0, +1)

Factor Information

Factor	Type	Levels	Values
Chemical Agents	Fixed	4	1, 2, 3, 4
Bolt Type	Fixed	5	1, 2, 3, 4, 5

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Chemical Agents	3	25.20	8.400	4.33	0.028
Bolt Type	4	179.50	44.875	23.11	0.000
Error	12	23.30	1.942		
Total	19	228.00			

Model Summary

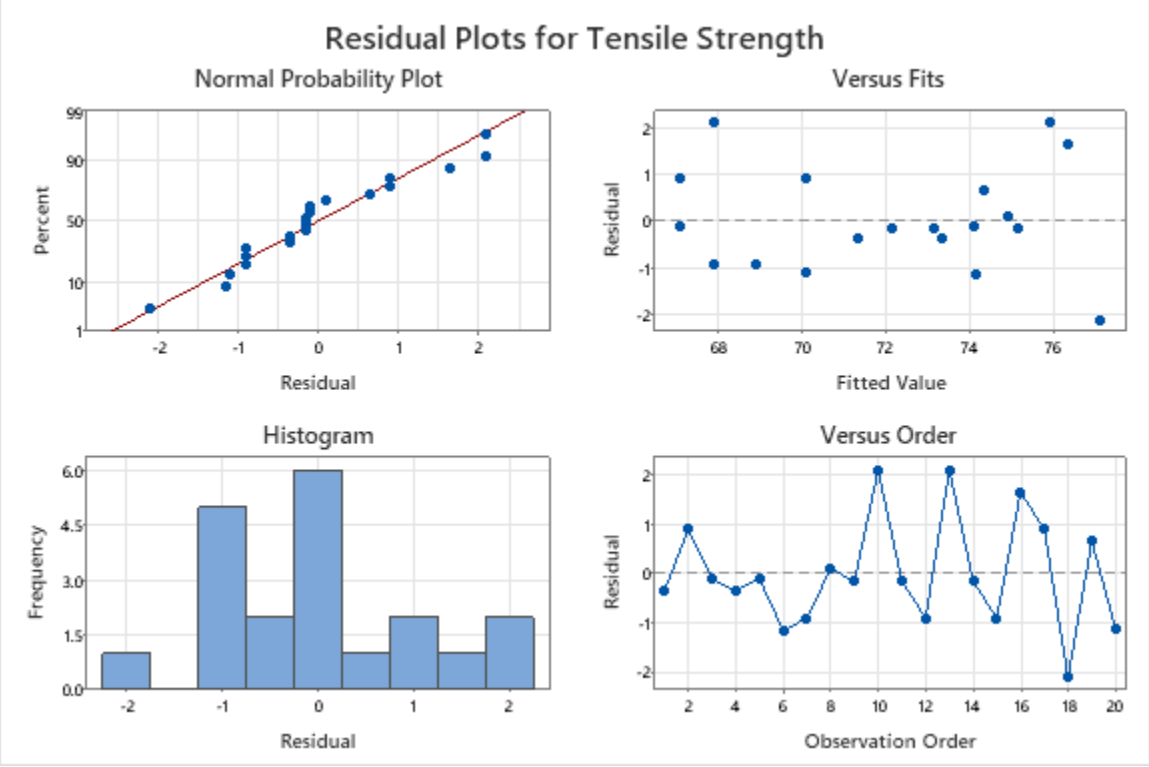
S	R-sq	R-sq(adj)	R-sq(pred)
1.39344	89.78%	83.82%	71.61%

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	72.000	0.312	231.08	0.000	
Chemical Agents					
1	-1.400	0.540	-2.59	0.023	1.50
2	-0.600	0.540	-1.11	0.288	1.50
3	0.400	0.540	0.74	0.473	1.50
Bolt Type					
1	2.750	0.623	4.41	0.001	1.60
2	-3.500	0.623	-5.62	0.000	1.60
3	3.500	0.623	5.62	0.000	1.60
4	0.750	0.623	1.20	0.252	1.60

Regression Equation

Tensile Strength = 72.000 - 1.400 Chemical Agents_1 - 0.600 Chemical Agents_2
+ 0.400 Chemical Agents_3 + 1.600 Chemical Agents_4
+ 2.750 Bolt Type_1
- 3.500 Bolt Type_2 + 3.500 Bolt Type_3 + 0.750 Bolt Type_4
- 3.500 Bolt Type_5



CONCLUSIONS

1. **Chemical Agents**: Since the p-value for Chemical Agents is 0.028, which is less than the significance level (α) of 0.05, we reject the null hypothesis at the 5% level of significance. This indicates that there is a significant difference in tensile strength among the four chemical agents.
2. **Model Fit**: The model summary indicates an R-squared value of 89.78%, suggesting that the linear model provides a good fit to the data. This means that the model explains a substantial portion (89.78%) of the variability in tensile strength.
3. **Tensile Strength by Chemical Agents**: The coefficients for Chemical Agents (-1.400, -0.600, 0.400) indicate the impact of different chemical agents on tensile strength. Circuit type 1 has the most negative effect on tensile strength (-1.400), while circuit type 3 has a positive effect (0.400).
4. **Tensile Strength by Bolt Type**: The coefficients for Bolt Type (2.750, -3.500, 3.500, 0.750) represent the effect of different bolt types on tensile strength. Bolt type 3 has the most positive effect (3.500), while bolt type 2 has the most negative effect (-3.500).
5. **Comparison of Mean Noise Levels**: The analysis reveals that circuit type 1 has the lowest mean noise level (19.20), while circuit type 4 has the highest mean noise level (79.80). This suggests that different circuit types have a significant impact on noise levels.
6. **Tukey's Comparison**: Tukey's comparison indicates the existence of two cluster groups. The first group consists of circuit types 3 and 1, which produce the lowest noise levels, and the second group comprises circuit types 4 and 2, which produce the highest noise levels. This implies that there is no significant difference between circuit types 3 and 1 in terms of the noise level they produce. Similarly, there is no significant difference between circuit types 4 and 2.
7. **Error Distribution**: The observation that the error distribution is not normal and is left-skewed indicates that the assumptions of normality may not be met. This suggests that the data may not follow a normal distribution.
8. **Homogeneity of Variance**: The analysis suggests that homogeneity of variance is not well met, which means that the variance of the errors is not consistent across different levels of the factors. This could impact the reliability of the analysis.
9. **Random Pattern of Errors**: The random pattern of errors in the graph of error vs. observation order indicates that errors are not related or structured in any particular way. This suggests that there are no systematic patterns in the residuals, which is a positive aspect of the model.