Development of Correlation between Cost of Canal Base Small Hydro Power Scheme and Rated Power

Shilpesh C. Rana, Jayantilal N. Patel

Abstract*: *Paper With the correlation, relationship between different variables can be found out. The objective of research is to develop correlation between cost of canal based small hydro power scheme and rated power. For correlation development, four canal fall locations of Sakarda and four canal fall locations of Ranoli branch canal have been considered. Correlation has been developed using regression analysis, and the developed model is validated with T-test method. After designing of hydro power components, cost of small hydro power (variable) has been estimated using current market rates. Small hydro power components are designed as per Indian Standard guidelines. As a result coefficient of determination found is 0.856, which shows that there is a positive significant relation between both the variables (cost of canal based small hydro power scheme and rated power). Developed correlation is validated using T-test. T-test was carried out for confidence level of 95 % and 99 %. From the results of T-test, finally it is concluded that regression is significant and developed correlation can be use to find out cost of canal base hydro power scheme.

***Keywords* : *Regression, T-test, Correlation, Variable, Branch canal, Small hydro power*.**

I. INTRODUCTION

Sardar Sarovar project is a life line for the water supply and irrigation to Gujarat state. As shown in Figure 1. Both the canals Sakarda and Ranoli are the part of Sardar Sarovar project. Sakarda is a branch canal off takes from Narmada main canal (Rana and Patel (2018)). For the development of correlation between cost of canal based small hydro power scheme and rated power four canal fall on Sakarda and four canal fall on Ranoli canal has been finalized.

II. LITERATURE REVIEW

Blyashko (2010) Small hydro power is the most efficient kind of renewable energy source.
Single et al. (2010) mentioned that not a single country can survive without energy.

Singal & Saini (2008) explained that physical sizes of civil works and electro-mechanical equipments affect the cost of the project. They have also developed correlation between both the parameters.
Vyas et al. (2015) conveyed the message that nation can be made self sufficiency if it promote the use of renewable energy sources.
Tiago et al. (2017) Mentioned that the production of power using falling water is old and has experienced a growth in demand since modern time.
Redpath & Ward (2017) worked on investigation of electricity production potential of low head hydro power in Northern Ireland.
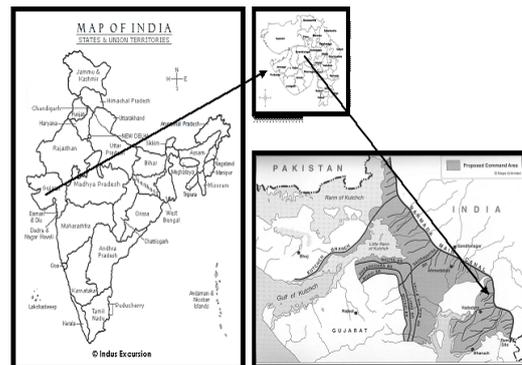

Fig. 1. Ranoli and Sakarda Canals Map
(Ref: Rana and Patel (2018))

III. FUTURE SCOPE

Developed correlation will help finding cost of canal based small hydro power schemes for any value of rated power, without doing design and estimation costing of hydro power components.

IV. LIMITATIONS

The major limitation of developed correlations is that it is applicable to canal based small hydro power projects. The estimation and costing has been carried out using market rates of year 2017, hence year wise inflation rates will be applicable to find project cost after 2017 years.

V. RESEARCH METHODS

Four canal fall locations (at chainages 7525 m, 9825 m, 17367 m, 19214 m & 19844 m) of Ranoli canal and four canal fall locations of Sakarda (at chainages 11214 m, 13242 m, 14022 m, 16550 m & 18234 m) considered for research work.

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For the analysis following steps are followed.

Step 1: Estimation of rated power using formula 1.

P = 9.81 X Q X H X η   …..(1)

Where, P = Rated power (kW)

Q = Discharge (cumec)

H = Head available (m)

η = Efficiency (%)

Step2: Designing of hydro power components using Indian Standard codes IS 9761(Hydro Power Intake Design), IS11639-3 (Standard Design of Penstock Criteria), IS 11625 (Criteria for hydro design of penstock), IS 11388 Recommendations for Design of Trash Racks for Intakes, Center Board of Irrigation and Power guidelines for small hydro etc.

Step 3: Estimation and costing of hydro power components applying current market rates.

Step 4: Regression analysis.

Step 5: Development of correlation between costs of canal based small hydro power scheme.

Step 6: Validation of correlation using T-test.

VI. ANALYSIS AND DISCUSSION

As indicated in methodology step 1. Estimated values of rated power are given in Table 1.

Table -I. Probable Power at Different Chainages of Ranoli and Sakarda Canals

Canal	Chainage	Discharge	Fall	Power
		Q	H	P
	m	cumec	m	kW
Ranoli Canal	7525	6.5	4.0	230.0
	9825	6.0	3.5	185.4
	17367	3.0	4.5	119.0
	19844	2.2	4.5	87.4
Sakarda Canal	11214	5.0	4.0	183.60
	14022	5.0	4.5	198.65
	16550	3.5	3.5	133.525
	18234	4.5	4.5	178.80
	11214	5.0	4.0	183.60

As indicated in methodology step 2 and step 3   design and estimation costing of the hydro power components like head race, fore bay, penstock intake, penstock, trash rack, turbine casing, air vent, power house etc.

A. *Overall Cost*

Cost of civil work are calculated by summing up cost of hydro power structures like Fore bay, head race , transitions channel, penstock, air vent ,trash rack, machine hall, erection bay and control bay . Total cost has been determined by summing up cost of civil work, electro mechanical equipment cost and other cost. According to Singal and Saini (2008) cost of Electro Mechanical equipment is 57.3% and other cost is 11.5% of Total cost. Chainage wise cost is given in Table -II.

Table-II. Chainagewise cost analysis

| Chainage	Cost of Civil Work	Electro Mechanical Equipment Cost	Other Cost	Total Cost
m	Rs.	Rs.	Rs.	Rs.
Ranoli Canal				
7525	2434839	4771958	936477	8143274
9825	2569145	5035180	988133	8592458
17367	1438161	2641238	530091	4609490
19844	1171619	2151723	431847	3755189
Sakarda Canal				
11214	2249894	4409491	865343	7524729
14022	2233194	4376761	858920	7468876
16550	1900677	3490666	700570	6091913
18234	1766689	3244592	651183	5662465
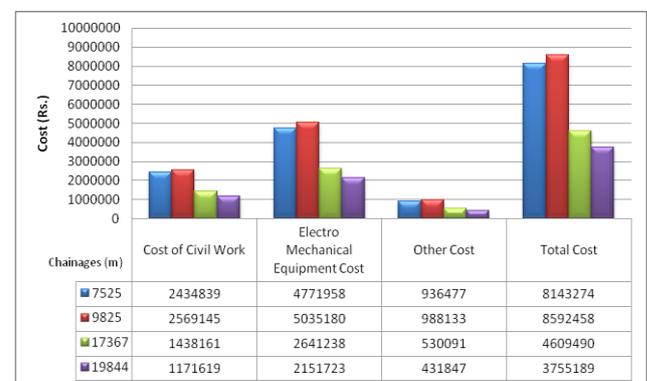
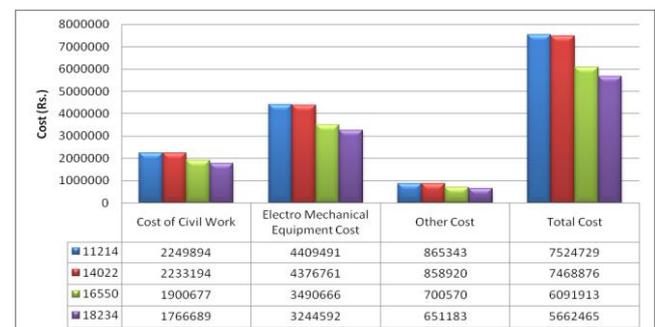**Figure 2 Chainage Wise Cost Comparison Ranoli Branch Canal**

Figure 3 Chainage Wise Cost Comparison Sakarda Branch Canal

B. *Correlation Development*

As given in Table-III rated power and project cost are considered as parameters for the correlation development. From the regression analysis the R^2 value achieved is 85.58%. And the equation developed is given below. 8 rows are used to develop correlation. To validate the correlation T-test has been carried out. As result of t-test value of T achieved is 5.97 and T critical for 99.9%   is 5.96. As the T is greater than T critical, the regression is significant.

Table-III   Row Data to Develop Correlation

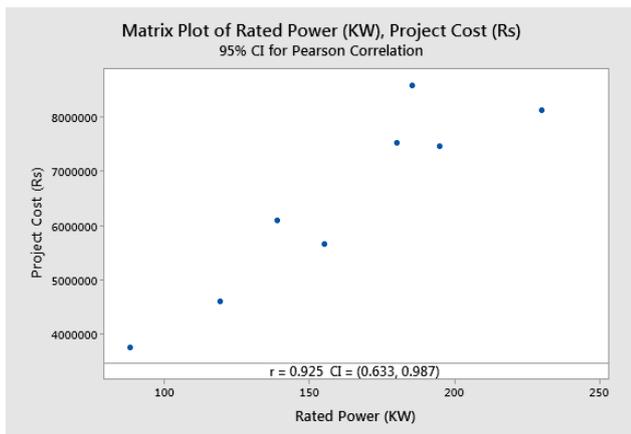| Rated Power (KW)	Project Cost (Rs)
P	P_c
230	8143274
185.4	8592458
119	4609490
87.9	3755189
180	7524729
195	7468876
139	6091913
155	5662465

Figure 4 Project Cost vs Rated Power Matrix Plot

Developed equation between project cost (Pc) of small canal base hydro power project and rated power (P) is shown in equation no. 1.

$$Pc = 792872 + 35240\ P \qquad (1)$$

Where, Pc is project cost in Rupees and P is rated power in kw.

VII. CONCLUSION

From the result of pearson correlation method it is concluded that there is significant relation between both (Project Cost and Rated Power) parameters. From the result of regression analysis, as the values of R^2 is 85.58%, for the values rated power of canal based small hydro power scheme the cost of can be find out utilizing the equation.

Pc = 792872 +35240 P, Where project cost is in term of Rupees and rated power is in term of kW. Developed equation is validated using T-test method. Value of T is 5.97 and T-critical for 99.9 % is 5.96. As value of T is greater than T-critical regression is significant.

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