International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 8, pp: 190-202 www.ijaem.net ISSN: 2395-5252

User's perception on Selected (Vivekananda Setu, Vidyasagar Setu, Nivedita Setu & Howrah Bridge) bridges in kolkata - A Social & Environmental Insight

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Date of Submission: 10-10-2020 Date of Acceptance: 27-10-2020

ABSTRACT: Building infrastructure is a capital intensive process, with large initial costs and low operating costs. It requires long-term finance as the gestation period for such projects is often much longer than, say for a manufacturing plant. Infrastructure projects are characterised by non-recourse or limited recourse financing, that is, lenders can only be repaid from the revenues generated from the project. This paper tries to show the user's perspective by taking their views through a structured questionnaire & through proper analysis. Moreover, to support the results a post-hoc test is done i.eTukey's Honestly Significant Difference Test to identify the exact difference. This paper also tries to make a comparative study among the old & non – toll way bridges and the new & toll way bridges with the help of "Paired two sample T-test" and "One-way Anova Test"

Key words : Infrastructure, capital intensive, Tukey's Honestly S ignificant Difference, Paired two sample T-test & One-way Anova Test etc

I. INTRODUCTION

Emerging economies, meanwhile, urgently need new infrastructure such as sanitation, potable water and drivable roads. Formerly, many governments – by far the largest source of financing for infrastructure projects – supported the infrastructure and project finance markets with cash and/or guarantees. But this support is no longer sustainable due to the significant deficits and sovereign debt levels in developed countries.
Furthermore, infrastructure stimulus packages will understandably reverse as governments look to bring their finances under control. Now, a brief overview of the bridges are given below:-

Vivekananda Setu – (Old /Non-toll way Bridge)

The amazing looking bridge made up of steel provides a great place or position affording a good view on the Hooghly River, and that body of water that flows along the western edge of Kolkata.

Walking, driving, going for a morning exercise or taking the train across the impressive Bally Bridge that is standing with one leg on either side of the Hooghly River. This multiple span bridge crossing links Dakshineswar in Kolkata with Bally in the Howrah district. The colossal steel structure is 2,887 feet (880 meters) long and took six years to build, being completed in 1932.

Source:- https://www.expedia.co.in/Bally-Bridge-Dakshineswar.d6106968.Attraction

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The bridge was originally named Willingdon Bridge after Viceroy of India, Freeman Freeman-Thomas, 1st Marquess of Willingdon, who inaugurated it at that point of time. It was eventually renamed Bally Bridge, before officially becoming known as Vivekananda Setu.

The erection and Commissioning(i,e construction work including placing equipment and cable installation including their accessories of the bridge was done by noted Kutchi-Mestri railway contractor and Industrialist Rai Bahadur Jagmal Raja. His nameplate is still visible on each girder of the bridge. The construction of bridge started in year 1926 and was completed in year 1932. The fabrication of the bridge was done at works of Braithwate& Company, Calcutta.

VidyasagarSetu (New/Toll way Bridge)

Vidyasagar Setu is the longest cable-stayed bridge in India and one of the longest in Asia with a total length of 823 metres (2,700 ft). It was the second bridge builds across the Hooghly River; the first, the Howrah Bridge (also known as Rabindra Setu) 3.7 kilometres (2.3 mi) to the north, was completed in 1943. This bridge named after the educationist reformer Pandit Ishwar Chandra Vidyasagar, it cost Indian Rupees 3.88 billion to build.

Source:-https://www.bbjconst.com/featured-vidyasagar-setu-bridge.html#:~:text=Vidyasagar%20Setu%20is%20the%20longest,north%2C%20was%20completed%20in%201943.

The construction of this bridge began on 3 July 1979, and the bridge was commissioned on 10 October 1992 by the Hooghly River Bridge Commission. The bridge is under the control of the Hooghly River Bridge Commissioners. The bridge is used by around 30,000 vehicles daily, considerably less than the bridge's capacity of 85,000.

Vidyasagar Setu, also known as the Second Hooghly Bridge, is a toll bridge over the Hooghly River in West Bengal, India, linking the cities of Kolkata (previously known as Calcutta) and Howrah.The project was a joint effort between the public and private sectors, under the control of the Hooghly River Bridge Commissioners (HRBC).

NiveditaSetu (New/Toll way Bridge)

Nivedita Setu (also called Second Vivekananda Setu) is a multi-span extradosed bridge completed 2007 over Hooghly River connecting Howrah with Kolkata, in West Bengal. It runs parallel to and about 50 m downstream of the old Vivekananda Setu opened in 1932. The bridge is named after Sister Nivedita, the social worker-disciple of Swami Vivekananda. Belghoria Expressway that connects the meeting point of NH 16 with NH 19 at Dankuni to NH 12, NH 112, Dumdum/ Kolkata Airport and northern parts of Kolkata passes over the bridge. The bridge is designed to carry 48,000 vehicles per day

Twin bridges: 2007 Nivedita Setu (left) and 1932 Vivekananda Setu (right), from the Hooghly River
Source:- https://www.sbp.de/en/project/second-vivekananda-bridge-nivedita-setu-checking/

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The 1932 Vivekananda Setu had become weak as a result of ageing and with heavy traffic even repairs became difficult. There was need for a second bridge.

The main challenge was to design and construct a new bridge that did not mar the view of the old Vivekananda Setu, did not dwarf the historically important Dakshineswar Kali Temple which is located well within visible distance, and carry substantially higher levels of fast traffic for around half a century.

Howrah Bridge

The Howrah Bridge is located between the twin cities of Howrah and Kolkata in West Bengal, India. The 705m long and 30m wide bridge was built in 1943 over the Hooghly River. It was rechristened as Rabindra Setu in June 1965, after the first Indian Nobel laureate Rabindranath Tagore. The bridge is commonly called Howrah Bridge.

The Howrah Bridge was commissioned in February 1943. The final cost of the bridge was estimated at INR25m. The bridge carries a daily traffic of around 80,000 vehicles and over 1m pedestrians. Howrah Bridge is the sixth longest cantilever bridge in the world.

Source:-
https://www.roadtraffictechnology.com/projects/howrahbridge/#:~:text=The%20Howrah%20Bridge%20is%20located,Indian%20Nobel%20laureate%20Rabindranath%20Tagore.

The Howrah Bridge is a suspension type balanced cantilever bridge. It has a central span of 1500ft between the main towers. The anchor and cantilever arms are 325ft and 468ft long respectively. The suspended span has a length of 564ft. Main towers are 280ft high above the monoliths and 76ft apart at the top. The bridge deck measures 71ft in width and features two footpaths of 15ft on either side.

Objectives of the study :

1. To analyze the satisfaction level(through various factors) & credibility of the selected bridges from the perspective of the users
2. To show the effect of the bridges on the social & environmental factors
3. To make a comparative study among the Old/non-toll way bridges & New/Toll way bridges through certain factors.

II. BRIEF REVIEW OF LITERATURE

Mor et al. (2006) in their study stated thatInfrastructural growth is very much important to meet the growth requirements of the country. Government had many infrastructure financing plans but their execution also cannot meet all needs in an optimal manner and there is more need of finance so we need to engage more investors for meeting these needs. Even though the Indian financial system has adequate liquidity, the risk aversion of Indian retail investors, the relatively small capitalisation of various financial intermediaries requires adoption of innovative financial structures and revisiting some of the regulations governing the Indian financial system. The risk capital required in the infrastructure sector can be understood as they are the Explicit Capital brought in as equity by the project sponsors and the Implicit Risk Capital provided by the project lenders. ImplicitCapital providers seek to manage their risk-return reward by ensuring availability of adequate Explicit Capital and diversification across various projects.

Ramakrishnan (2014) discussed the basic aspects of Public &Private Partnership (PPP) and how it works in India. Financing infrastructures is always one of the most important issues. This paper explained various issues such as excessive dependence on commercial banks for debts; inadequate financing from infrastructure finance companies; issues in external commercial borrowing; non- availability of mezzanine financing; partial availability of insurance,

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pension, and provident funds; and non-financing issues that are creating terrible problems in infrastructure finance in India. The recent improvements such as infrastructure debt bonds, relaxed norms for external commercial borrowing, and reasonable exit options are also examined. This particular paper also suggested various financial reforms that are needed forPPP financing in India such as tapping into savings, allowing foreigndirect investment, increasing the cap on viability gap funding, allowingballoon payments, giving impetus for corporation bonds, and buildinginfrastructure corpus.

Inderst (2009) stated that as the need for investment in infrastructure will continue to grow in future, private sector financing for infrastructure projects has developing all around the world. Given the long-term growth and low correlation aspects of infrastructure investments, pension funds have also shown interest in increasing their exposure to this area, along with their move into alternative assets. Such investments cover a wide spectrum of projects – from economic infrastructure such as transport, to social projects such as hospitals –and involve different forms of financing. The data

explained in this particular paper shows the size, risk, return and correlations of this diverse asset class is therefore limited, which may be making pension fund investors cautious. Given investing in such assets also involves new types of investment vehicles and risk for pension funds to manage – such as exposure to leverage, legal and ownership issues, environmental risks as well as regulatory and political challenges –such caution may well be justified. However, if governments wish to help infrastructure developers tap into potentially important sources of financing such as pension funds, certain steps can be taken. The paper is actually designed as an overview piece, discussing if pension funds should invest in infrastructure on a theoretical basis, whether they do in practice, and, if not, how regulators can encourage and assist them to do so.

Ehlers (2014)stated that the supply of properly planned and structured projects seems to be a major problem in channelling available finance into infrastructure. Overcoming this requires substantial expertise. Without a proper plan of investable projects, the fixed costs of building up this expertise are often become too high for potential investors. Governments, the concessionaire for many types of infrastructure projects, have a critical role in setting up investable projects. Countries and local governments which have established proven mechanisms for infrastructure projects, for instance by introducing binding legal frameworks for public private partnerships or by setting up specialised government agencies, tend to be more successful in closing infrastructure projects. The promotion of private sector infrastructure finance hinges above all on a sensible transfer of risks and returns. If done properly, the involvement of the private sector can lift efficiency – it should not be seen merely as a source of financing. As returns from projects are generated only over a long period of time, the focus needs to turn more to the operational aspects of infrastructure, rather than merely its construction.

Jacobson et al. (1995) presented a summary of the rich and varied experiences of both private and public sector entities in the provision of urban services in the United States, France, and Great Britain over the last hundred years. The main focus of this work was on private, profit seeking firms, shifts back and forth between the private and public sectors and other forms of operational and fiscal arrangements. According to this study, trade-offs are unavoidable, their magnitude cannot always be easily ranked in advance, and matters do not always play out exactly as expected. From this study, it is clear that for any evaluation of different private and public alternatives for the provision of infrastructures to have even a chance of producing realistic results, local contexts and the affects of time, change, and other contingencies should be taken into account.

III. RESEARCH METHODOLOGY:

• At first a pilot survey has been conducted here within 30 respondents to gather a basic knowledge about the customers' perception regarding ferry service.

• Then on the basis of the factors identified a structured questionnaire in 5 point Likert scale has been prepared to conduct the market survey within 520 respondents (130 of each bridge)

• The time period of this study is 3 months i.e. june'20 to Aug'20.

• Data thus gathered has been analysed by using the two-sample t-test at 5% level of significance and confidence Interval also has been used here to analyse the data

•The effects of the various factors on the bridge has also been analysed by exercising One Way Anova at 5% level of significance

- Tukey Honestly Significant Difference Post Hoc Test has also been conducted here to identify the exact difference.

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IV. DATA ANALYSIS &INTERPRETATION

Convenience:

H_0: There is no significant difference between the old bridges & new bridges relating to convenience
H_1: There is a significant difference between the old bridges & new bridges relating to convenience

Table – 1a

t-Test: Paired Two Sample for Means		
	Old Bridge	New Bridge
Mean	2.31	2.28
Standard deviation	1.11	1.10
Variance	1.24	1.23
Observations	260	260
Pearson Correlation	0.198089088	
Margin of error	0.13	0.13
Confidence Interval- Upper Bound	2.44	2.41
Confidence Interval- Lower bound	2.18	2.05
Hypothesized Mean Difference	0	
Df	259	
t Stat	0.396	
P(T<=t) two-tail	0.69247249	
t Critical two-tail	1.96	

Observation: Relating to convenience no significant difference can be observed between the old bridges & new bridges as the t-statistics $_{(0.05,259)}$= 0.396 are lower than the tabulated value= 1.96. So, the null hypothesis is accepted here against the alternative hypothesis which signifies that people gets more or less same kind of convenience satisfaction from both the bridges.

Even the result of the confidence interval depicts that the upper bound value and the lower bound valuesof old bridges & new bridges lies between 2.44 to 2.18 & 2.41 to 2.05 respectively which is quite similar. Therefore, this result is also portraying that there is no significant difference between the bridges relating to convenience.

The factors which are considered under the convenience are as follows:
1. Width, 2. Road condition,3. Beams' condition, 4. Railing, &5. Pavement

H_0: The effects of different factors on convenience are same
H_1: The effects of different factors on convenience are not same

Table – 1b

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
width	520	1278	2.457692	1.339247
road condition	520	1236	2.376923	1.260353
beams' condition	520	1261	2.425	1.31999
Railing	520	1260	2.423077	1.296576
Pavement	520	1185	2.278846	1.157162

ANOVA

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Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	10.08846	4	2.522115	1.978648	0.095098	2.375357
Within Groups	3307.758	2595	1.274666			
Total	3317.846	2599				

Observation: From this Anova table it can be observed that the P- value (0.095098) is more than the α-value i.e. 0.05 therefore null hypothesis is accepted here against the alternative hypothesis which signifies that the effects of the different factors (1. Width, 2. Road condition, 3. Beams' condition, 4. Railing, 5. Pavement) on the convenience of the bridges are same.

Safety:
H_0: There is no significant difference between the old bridges & new bridges relating to safety
H_1: There is a significant difference between the old bridges & new bridges relating to safety

Table – 2a

t-Test: Paired Two Sample for Means		
	SAFETY B1 old	SAFETY B2 new
Mean	3.48	2.68
Standard deviation	1.54	1.28
Variance	2.39	1.64
Observations	260	260
Margin of error	0.19	0.15
Confidence Interval- Upper Bound	3.67	2.83
Confidence Interval- Lower bound	3.29	2.53
Pearson Correlation	0.134888777	
Hypothesized Mean Difference	0	
Df	259	
t Stat	6.84	
P(T<=t) two-tail	5.84279E-11	
t Critical two-tail	1.96	

Observation: Relating tosafety significant difference can be observed between the old bridges & new bridges as the t-statistics (0.05, 259) = 6.84 is greater than the tabulated value =1.96. So, the null hypothesis is rejected here in favor of the alternative hypothesis which signifies that the safety satisfaction from both the bridges are not same.

Even the result of the confidence interval depicts that the upper bound value and the lower bound values of old bridges & new bridges lies between 3.67 to 3.29 & 2.83 to 2.53 respectively which is entirely different from each other. Therefore, this result is also portraying that there is a significant difference between the bridges relating to safety.

The factors which are considered under the convenience are as follows:
1. Risk of accident, 2. Traffic maintenance, &3. CCTV supervision
H0: The effects of different factors on safety are same
H1: The effects of different factors on safety are not same

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Table – 2b

Anova:
Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Risk of Accident	520	1992	3.830769231	1.620631392
Traffic Manintenance	520	1096	2.107692308	1.213813547
CCTV Camera usage	520	1224	2.353846154	1.111545872

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	903.2205128	2	451.6102564	343.3436199	3E-124	3.001504
Within Groups	2047.969231	1557	1.31533027			
Total	2951.189744	1559				

Observation: From this Anova table it can be observed that the P- value= (3E-124) is less than the α-value i.e. 0.05 therefore null hypothesis is rejected here in favor of the alternative one which signifies that the effects of the different factors (1. Risk of accident, 2. Traffic maintenance, 3. CCTV supervision) on the safety of the bridges are not same. Therefore, post hoc analysis has been conducted through the Tukey's Honestly Significant Difference Test to identify the exact difference.

Tukey's Honestly Significant Difference Test
The Tukey Criterion(T)= [$q_{\alpha\ (c,\ n-c)}$ * √MSE/n_i] = [3.314*√1.31/520] = 0.16
Where,$q_{\alpha\ (c,\ n-c)}$ = Studentized range distribution, based on c & n-c df
n= Total sample size
c= Number of treatments (i.e. number of columns)
MSE= Mean square error (from Anova table)
n_i= Sample size of the treatment group with the smallest number of observations

Table – 2c

Factors	N	Mean	s.dev	Mean difference	Q value	T Value	Decision
Risk of accident (X1)	520	3.83	1.27	X1-x2 = 1.72	3.314	0.16	Significant Difference
Traffic maintenance(x2)	520	2.11	1.1	X2-x3= 0.05	3.314	0.16	Insignificant Difference
CCTV Supervision(x3)	520	2.35	1.05	X1-x3 = 0.22	3.314	0.16	Significant Difference

Observation: The test result indicates that the effects ofRisk of accident (x1) is significantly different from Traffic maintenance (x2) & CCTV Supervision(x3). In contrast, theeffectofTraffic maintenance(x2) & CCTV supervision (x3) on the safety of the bridges are not significantly different from each other.

Maintenance
H_0: There is no significant difference between the old bridges & new bridges relating to maintenance
H_1: There is a significant difference between the old bridges & new bridges relating to maintenance

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Table – 3a

t-Test: Paired Two Sample for Means		
	Maintenance B1 OLD	Maintenance B2 NEW
Mean	2.53	1.88
Standard deviation	1.00	0.88
Variance	1.01	0.78
Observations	260	260
Margin of error	0.06	0.05
Confidence Interval- Upper Bound	2.59	1.93
Confidence Interval- Lower bound	2.47	1.83
Pearson Correlation	0.021715732	
Hypothesized Mean Difference	0	
Df	259	
t Stat	7.97	
P(T<=t) two-tail	4.96573E-14	
t Critical two-tail	1.96	

Observation: While considering the maintenance factors, significant difference can be observed between the old bridges & new bridges as the t-statistics (0.05, 259) = 7.97 is greater than the tabulated value=1.96. So, the null hypothesis is rejected here in favor of the alternative hypothesis which signifies that maintenance factors of both the bridges are not same.

Even the result of the confidence interval depicts that the upper bound value and the lower bound values of old bridges & new bridges lies between 2.59 to 2.47&1.93 to 1.83 respectively which is very much different from each other. Therefore, this result is also portraying that there is a significant difference between the bridges relating to safety.

The factors which are considered under the convenience are as follows:

1. Maintenance done by the Authority 2. Drainage system of the bridge& 3. Lighting system

H0: The effects of different factors on maintenance are same

H1: The effects of different factors on maintenance are not same

Table – 3b

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Maintenance by Authority	520	1318	2.53	1.3321328
Drainage System	520	1301	2.5	1.240844079
lightning system	520	1261	2.43	1.319990366

ANOVA

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	3.293589744	2	1.65	1.269053733	0.281388079	3.001503587
Within Groups	2020.45	1557	1.3			

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Total	2023.74359	1559

Observation: From this Anova table it can be observed that the P- value= 0.2813 is more than the α-value i.e. 0.05 therefore null hypothesis is accepted here in favor of the alternative one which signifies that the effects of the different factors (Maintenance done by the Authority 2. Drainage system of the bridge& 3. Lighting system) on the maintenance of the bridges are same. Therefore, post hoc analysis is not required

Socio-Economic Impact

H_0: There is no significant difference between the old bridges & new bridges relating to socio-economic impact

H_1: There is a significant difference between the old bridges & new bridges relating to socio-economic impact

Table – 4a

t-Test: Paired Two Sample for Means		
	SE B1 OLD	SE B2 new
Mean	3.34	2.67
Standard deviation	1.22	1
Variance	1.49	1.00
Observations	260	260
Margin of error	0.07	0.06
Confidence Interval- Upper Bound	3.41	2..73
Confidence Interval- Lower bound	3.27	2.61
Pearson Correlation	0.072984066	
Hypothesized Mean Difference	0	
Df	259	
t Stat	7.09	
P(T<=t) two-tail	1.25486E-11	
t Critical two-tail	1.96	

Observation: While considering the socio-economic factors, significant difference can be observed between the old bridges & new bridges as the t-statistics (0.05, 259) = 7.09is greater than the tabulated value=1.96. So, the null hypothesis is rejected here in favor of the alternative hypothesis which signifies that there is a significant difference between the old bridges & new bridges relating to socio-economic impact.

Even the result of the confidence interval depicts that the upper bound value and the lower bound values of old bridges & new bridges lies between 3.41 to 3.27& 2.73 to 2.61 respectively which is entirely different from each other. Therefore, this result is also portraying that there is a significant difference between the bridges relating to safety.

The factors which are considered under the socio-economic aspects are as follows:

1. Daily Transportation, 2. Surrounding Areas & 3. Standard of Living

H0: The effects of different factors on socio-economic aspects are same

H1: The effects of different factors on socio-economic aspects are not same

Table – 4b

Anova: Single Factor

SUMMARY

Groups	**Count**	**Sum**	**Average**	**Variance**
Daily Transportation	520	1331	2.559615385	1.229579813

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Surrounding Area	520	1247	2.398076923	1.261267971
living standard	520	1185	2.278846154	1.157162443

ANOVA

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	20.65128205	2	10.32564103	8.491457302	0.000214869	3.001503587
Within Groups	1893.317308	1557	1.216003409			
Total	1913.96859	1559				

Observation: From the aboveAnova table it can be observed that the P- value (0.0002) is less than the α-value i.e. 0.05 therefore null hypothesis is rejected here in favor of the alternative one which signifies that the effects of the different factors (1. Daily Transportation, 2. Surrounding Areas & 3. Standard of Living) on the socio-economic factors of the bridges are not same. Therefore, post hoc analysis has been conducted through the Tukey's Honestly Significant Difference Test to identify the exact difference.

Tukey's Honestly Significant Difference Test
The Tukey Criterion(T)=[$q_{\alpha(c,\ n-c)}$* √MSE/n_i] =[3.314*√1.31/520]= 0.15

Table – 4c

Factors	N	Mean	s.dev	Mean difference	Q Value	T Value	decision
Daily Transportation(X1)	520	2.56	1.11	X1-x2 = 0.16	3.314	0.15	Significant difference
Surrounding Areas(x2)	520	2.40	1.12	X2-x3= 0.12	3.314	0.15	Insignificant difference
Standard of living(x3)	520	2.28	1.07	X1-x3 = 0.28	3.314	0.15	Significant Difference

Observation: The test result indicates that the effects of Daily transportation (x1) is significantly different from Surrounding areas(x2) &Standard of living(x3). In contrast, the effect of Traffic maintenance(x2) & CCTV supervision (x3) on the safety of the bridges are not significantly different from each other.

Environmental Issues

H_0: There is no significant difference between the old bridges & new bridges relating to environmental factors

H_1: There is a significant difference between the old bridges & new bridges relating to environmental factors

Table – 5a

t-Test: Paired Two Sample for Means		
	ENV B1 OLD	ENV B2 new
Mean	1.97	2.03
Standard deviation	1.02	1.07
Variance	1.05	1.14
Observations	260	260
Margin of error	0.06	0.07
Confidence Interval- Upper Bound	2.03	2.10
Confidence Interval- Lower bound	1.91	1.96
Pearson Correlation	0.510223369	

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Hypothesized Mean Difference	0	
Df	259	
t Stat	-0.84	
P(T<=t) two-tail	0.40382673	
t Critical two-tail	1.96	

Observation: While considering the environmental factors, no significant difference can be observed between the old bridges & new bridges as the t-statistics $_{(0.05,\ 259)}$ =-0.84 is lower than the tabulated value= 1.96. So, the null hypothesis is accepted here against the alternative hypothesis which signifies that there is no significant difference between the old bridges & new bridges relating to environmental factors

Even the result of the confidence interval depicts that the upper bound value and the lower bound values of old bridges & new bridges lies between 2.03 to 1.91& 2.10 to 1.96 respectively which is quite similar. Therefore, this result is also portraying that there is no significant difference between the bridges relating to convenience.

The factors which are considered under the environmental factors are as follows: -

1. Air Quality, 2. Noise Levels, & 3. Vibration

H0: The effects of different factors on environmental aspects are same

H1: The effects of different factors on environmental aspects are not same

Table – 5b

Anova: Single Factor

SUMMARY

Groups	**Count**	**Sum**	**Average**	**Variance**
Air Quality	520	1363	2.621153846	1.395698088
Noise Levels	520	1219	2.344230769	1.158733511
Vibration	520	1361	2.617307692	1.319545724

ANOVA

Source of Variation	**SS**	**Df**	**MS**	**F**	**P-value**	**F crit**
Between Groups	26.22051282	2	13.11025641	10.15255536	4.16202E-05	3.001503587
Within Groups	2010.594231	1557	1.291325774			
Total	2036.814744	1559				

Observation - From this Anova table it can be observed that the P- value (4.16202E-05) is less than the α-value i.e. 0.05 therefore null hypothesis is rejected here in favor of the alternative one which signifies that the effects of the different factors (Air Quality, 2. Noise Levels, & 3. Vibration) on the environmental factors of the bridges are not same. Therefore, post hoc analysis has been conducted through the Tukey's Honestly Significant Difference Test to identify the exact difference.

Tukey's Honestly Significant Difference Test

The Tukey Criterion(T)=[$q_{\alpha(c,\ n-c)}$* $\sqrt{MSE/n_i}$] =[3.314*$\sqrt{1.31/520}$]= 0.16

Table – 5c

Factors	**N**	**Mean**	**s.dev**	**Mean difference**	**Q value**	**T Value**	**decision**
Air Quality (X1)	520	2.62	1.18	X1-x2 = 0.28	3.314	0.16	Significant difference
Noise Levels(x2)	520	2.34	1.07	X2-x3= -0.27	3.314	0.16	Insignificant difference
Vibrations(x3)	520	2.62	1.15	X1-x3 = 0.003	3.314	0.16	Insignificant

							Difference

Observation: The test result indicates that the effects of Air quality (x1) is significantly different from Noise level (x2) however its effect relating to the environmental issues of the bridges is not significantly different from vibration(x3).Likewise, the effect of Noise level (x2) &Vibration (x3) on are not significantly different from each other.

V. CONCLUSION:

The analysis of this paper reveals that:

- In case of Convenience no difference can be observed between the old bridges and the new bridges. Even the result of confidence interval also supports this statement. However, the values of the upper bound & lower bound level in both cases are quite lower (below the neutral value 3). Therefore, the bridges have to take necessary measures to improve their convenience satisfaction.

The Anova results also depicts that the effects of the different factors (1. Width, 2. Road condition, 3. Beams' condition, 4. Railing, 5. Pavement) on the convenience of the bridges are same.

- Relating to safety significance difference can be observed between the old bridges and the new bridges. Even the result of confidence interval also supports this statement. Because the upper bound & lower bound value of old bridges is higher than the neutral value 3 whereas in case of new bridges it is lower than the neutral value 3. This is due to the Howrah bridge because according to the respondents though it is an old bridge, established in British period still the architecture of this bridge is much stronger than the other new bridges

The Anova results portrayed that the effects of the different factors (1. Risk of accident, 2. Traffic maintenance, 3. CCTV supervision) on the safety of the bridges are not same. Therefore, post hoc analysis has been conducted through the Tukey's Honestly Significant Difference Test to identify the exact difference. The test result of tukey reveals that the test result indicates that the effect of Risk of accident (x1) is significantly different from Traffic maintenance (x2) & CCTV Supervision(x3). In contrast, the effect of Traffic maintenance(x2) & CCTV supervision (x3) on the safety of the bridges are not significantly different from each other.

- Regarding to maintenance similar result can be observed like the safety

Though the ANOVA result signifies that the effect of different factors (Maintenance done by the Authority 2. Drainage system of the bridges & 3. Lighting system) on the maintenance of the bridges are same. Therefore, post hoc analysis is not required

- According to Socio- economic impact a similar result can be observed like the Safety & maintenance of the bridges.

Though in this case the ANOVA result portraying that the effects of the different factors (1. Daily Transportation, 2. Surrounding Areas & 3. Standard of Living) on the socio-economic effect of the bridges are not same. Therefore, post hoc analysis has been conducted through the Tukey's Honestly Significant Difference Test to identify the exact difference. The test result of tukey reveals that the test result indicates that the effects of Daily transportation (x1) is significantly different from Surrounding areas (x2) &Standard of living (x3). In contrast, the effect of Surrounding areas(x2) &standard of living (x3) on the socio-economic impact of the bridges are not significantly different from each other.

- Lastly, in case of environmental factor a similar result can be observed like the convenience

Though in this case the ANOVA result portraying that the effects of the different factors (1.Air Quality, 2. Noise Levels, & 3. Vibration) on the socio-economic effect of the bridges are not same. Therefore, post hoc analysis has been conducted through the Tukey's Honestly Significant Difference Test to identify the exact difference. The test result of tukey reveals that the test result indicates that the effects of Air quality (x1) is significantly different from Noise level (x2) however its effect relating to the environmental issues of the bridges is not significantly different from vibration(x3). Likewise, the effect of Noise level (x2) & Vibration (x3) on are not significantly different from each other.

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