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## Modeling of Motorists' Reactions on the Use of Second Niger Bridge in Southern Part of Nigeria

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### ABSTRACT

This study analyzed motorists' reactions to the use of the Second Niger Bridge. It focused on safety perceptions, driving behavior, and traffic flow dynamics. Data were collected through field observations during peak and off-peak hours. Surveys were distributed to motorists using the bridge, either directly or through online platforms. Experimental data were also collected by observing driver responses. Data analysis used Response Surface Methodology (RSM) to model relationships between independent variables (e.g., expansion joint condition, corrosion level, traffic density) and dependent variables (e.g., motorist reactions, traffic flow). Results showed that most users perceive safety risks due to visible deterioration, insufficient safety features, and poor maintenance. Regarding travel time, 58% acknowledged a significant reduction due to the bridge. Improving expansion joints will also help achieve fuel savings, as 78% of users reported. Motorists adapt by reducing speed, changing lanes, and avoiding damaged sections. However, this behavior results in increased travel time, higher fuel consumption, and traffic inefficiency. 81% believe that accident risk rises during congestion, and 51% believe traffic improves when the bridge is in good condition. The study concludes that the bridge is crucial for regional transport. Still, its current state undermines safety, efficiency, and public confidence. Stronger maintenance policies, better safety features, and improved user engagement are essential for sustainability. The peak of the curve, located at a deviation of 0.000, signifies the highest design precision at that specific set of factor levels.

### INTRODUCTION

Bridges are critical components of transportation infrastructure, providing essential connectivity for economic, social, and industrial activities. The Second Niger Bridge was conceived to alleviate chronic traffic congestion and relieve pressure from the aging first Niger Bridge that was constructed in 1965, and improve traffic flow across the Niger River, which for decades served as the primary link between Nigeria's southeastern and southwestern regions (Nnaemeka & Adelekun 2023). As a major engineering project, its long-term performance and user experience are of paramount importance. Motorist reaction to bridge conditions such as the smoothness of the ride across expansion joints, visible signs of deterioration, and changes in traffic flow is a vital but often underexplored aspect of performance evaluation (Kim, *et al.*, 2005). These reactions can influence speed patterns, lane usage, and even the overall perception of safety (Ogunjiofor, *et al* 2023) and structural adequacy (Anene *et al.*, 2022; Anene, 2022; Anene *et al.*, 2023) While the new bridge promises enhanced connectivity and improved traffic flow, concerns have arisen regarding the long-term performance of its structural components particularly the expansion joints, which are prone to degradation due to repetitive traffic loads, environmental exposure, and corrosion (Jean-Charles, *et al.*, 2011).

One of the most significant elements affecting the performance and longevity of modern bridges is the expansion joint system. Expansion joints accommodate structural movements due to thermal expansion, traffic loads, and seismic activities, thereby preventing damage to the bridge structure (Ogunjiofor & Umeonyiagu, 2025). However, these joints are often susceptible to wear, corrosion, and failure, especially in regions with high traffic volumes and challenging environmental conditions. The degradation of expansion joints not only poses safety risks but also influences driver comfort and traffic behavior. Corrosion protection of metallic bridge components, particularly within expansion joints, is also a key durability concern. Moisture, salts, and pollutants can accelerate corrosion, leading to costly maintenance and reduced structural integrity (Koch *et al.*, 2001). Effective corrosion protection strategies are vital in extending the service life of bridge components and ensuring safe usage by motorists (Ogunjiofor *et al.*, 2025). Furthermore, the influence of these structural conditions on driver behavior has not been systematically studied (Kohm *et al.*, 2023). Many motorists unconsciously adjust their driving patterns such as speed reduction, lane switching, or erratic maneuvers when encountering damaged or uncomfortable bridge joints. Such reactions can in turn affect traffic flow efficiency, increase the risk

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of accidents, and undermine the perceived safety of the infrastructure (AKM *et al.*, 2014). Existing studies often isolate structural assessments from human-centered traffic behavior, creating a gap in understanding the interaction between bridge performance and motorist response. There is a critical need for an integrated analytical approach that considers the complex relationship among expansion joint durability, corrosion resistance, traffic conditions, and driver behavior (Camara Reyes-Aldasoro, 2024; Chen *et al.*, 2009).

This study seeks to address this gap by applying Response Surface Methodology (RSM) to model and analyze the influence of these interacting variables on motorist reactions. Without such analysis, infrastructure planners and engineers may lack the insights needed to make informed decisions about maintenance priorities, traffic management strategies, and design improvements that enhance both structural longevity and user safety.

To analyze such complex interrelationships, Response Surface Methodology (RSM) provides a powerful statistical and mathematical tool. RSM is particularly useful for modeling and analyzing problems in which multiple variables influence a response of interest and the goal is to optimize this response (Myery *et al.*, 2016; Ogunjiofor & Ayodele, 2023). In the context of the Second Niger Bridge, RSM can be employed to model how factors like expansion joint durability, corrosion conditions, and traffic density affect motorist reactions, offering insights that traditional analysis might miss.

The study also considers real-time traffic characteristics, including vehicle density and flow rates, as they interact with the condition of the bridge infrastructure. Geographically, the scope is limited to the Second Niger Bridge corridor, and the analysis will not extend to other bridges or road networks. While it includes observational assessments and statistical modeling, it does not cover long-term predictive structural deterioration or extensive material testing of all bridge components. The primary focus remains on the short- to medium-term interaction between bridge joint conditions, corrosion factors, traffic patterns, and driver response, using RSM as the analytical framework.

## MATERIALS AND METHODS

### Research Design

The research design for this study follows a quantitative research approach aimed at systematically analyzing the effects of bridge condition, specifically expansion joint durability and corrosion protection, on motorist reactions and traffic flow using Response Surface Methodology (RSM). This design is chosen because it enables efficient exploration of the relationships among multiple variables (e.g., joint condition, traffic density, motorist behavior) and provides a means to optimize these factors in real-world conditions. The study utilized experimental design techniques to manipulate different variables and observe their impact on the response variables (motorist reactions and traffic flow). This design is suitable for generating

predictive models that can inform bridge maintenance and improve traffic management strategies.

### Design of Study

This study adopts a cross-sectional research design, where data were collected at specific points in time to analyze the current conditions of the Second Niger Bridge and the resulting motorist reactions. The study employed a combination of surveys and observations to collect relevant data. Surveys were used to collect subjective data on drivers' perceptions of safety and comfort, while observational data tracked traffic flow under varying conditions. This design allows for the collection of both qualitative and quantitative data, which were analyzed through RSM.

### Area of Study

The area of study is the Second Niger Bridge, located in Nigeria, which serves as a major transportation link between the southeastern and southwestern parts of the country. The bridge is an important infrastructure that facilitates the movement of people and goods, but it is also exposed to heavy traffic volumes and environmental conditions that may affect its structural integrity, particularly in the areas of expansion joints and corrosion protection. The area of study is crucial for the analysis as it represents a real-world scenario where infrastructure conditions directly affect traffic behavior and safety.

### Population of Study

The population of this study consists of all motorists who use the Second Niger Bridge during the study period. This includes private vehicle owners, commercial vehicle drivers, and public transport operators who traverse the bridge. Given the bridge's role in connecting different regions, the population is diverse, with varying driving behaviors influenced by factors such as vehicle type, speed, and traffic density. The exact population size will be determined based on traffic volume data for the bridge, which will be obtained from traffic management authorities or the Nigerian Federal Ministry of Works.

### Sample and Sampling Technique

A stratified random sampling technique was used to select the sample for this study. The samples were drawn from the motorist population, with different strata based on vehicle type (private vehicles, commercial vehicles, etc.) and traffic flow categories (peak and off-peak hours). This technique ensures that the sample adequately represents the diversity of motorists who use the bridge. A sample of approximately 500 motorists was targeted, ensuring a wide representation of different driver categories and conditions.

### Instruments for Data Collection

The following instruments were used for data collection:

1. Questionnaires: Structured questionnaires were administered to motorists to gather subjective data

on their perceptions of the bridge’s condition, safety concerns, and behavioral responses. The questionnaires include both closed-ended and Likert scale questions to capture various aspects of driver behavior and risk perception.

2. Observation Checklist: An observation checklist was used by field researchers to record visual assessments of bridge condition, such as the extent of expansion joint deterioration and corrosion. This data will be correlated with traffic behavior observations to evaluate the impact of infrastructure quality on driver reactions.

3. Experimental Set-Up for RSM: A designed experiment, based on Response Surface Methodology (RSM), was used to manipulate the structural conditions of the bridge and monitor corresponding changes in motorist behavior and traffic flow.

either through direct interaction or via online platforms. Experimental data was collected through observing the responses of drivers.

Data analysis was conducted using Response Surface Methodology (RSM) to model the relationships between independent variables (e.g., expansion joint condition, corrosion level, traffic density) and dependent variables (e.g., motorist reactions, traffic flow). The RSM approach allowed for the identification of optimal conditions that minimize negative driver reactions and maximize traffic flow efficiency. Statistical analysis was carried out using Analysis of Variance (ANOVA) to test the significance of different factors on motorist behavior and traffic performance. Additionally, regression analysis was performed to determine the strength and nature of the relationships between variables.

**Method of Data Collection and Analysis**

Data were collected through a combination of field observations, surveys. Field observations were made during peak and off-peak traffic hours to assess the flow and motorist reactions under different conditions. Surveys were distributed to motorists using the bridge,

**RESULTS AND DISCUSSIONS**

The results and findings of the study are hereby presented in accordance to the research hypothesis guiding the study.

**Demographic Information**

**Table 1:** Demographic Information

Variable	Categories	Frequency	Percentage (%)
Age	Below 20	2	6
	21 – 30	14	42
	31 – 40	13	39
	41 – 50	4	12
	Above 50	0	0
Gender	Male	18	55
	Female	15	45
Type of Vehicle	Private Car	14	42
	Commercial Vehicle	15	45
	Motorcycle	3	9
	Others	1	3
Driving Experience	Less than 1 year	7	21
	1 – 5 years	10	30

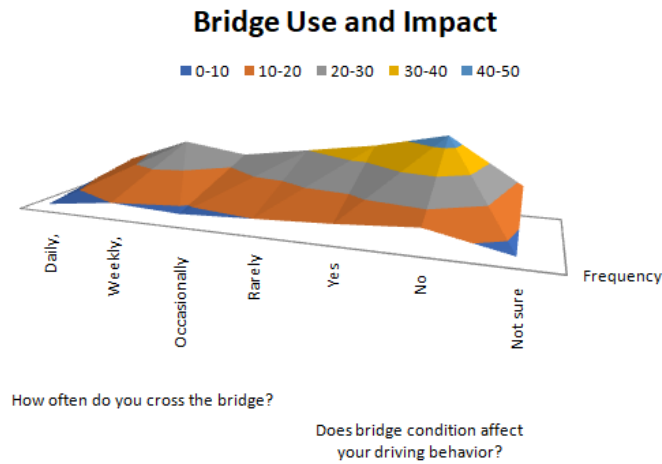
The demographic data (Table 1) shows that 81% of respondents are aged between 21–40 years, which implies a young and active user base. This age group is likely more exposed to daily commutes, and thus, their responses reflect current usage realities. Gender distribution shows a fair balance (55% male, 45% female), ensuring diverse representation in driving behavior and risk perception. Vehicle type is nearly evenly split between private (42%) and commercial vehicles (45%), indicating that both individual and business transport users are affected by the bridge’s condition. Driving experience ranges widely: 30% have 1–5 years and 27% have 6–10 years, suggesting that most respondents have sufficient experience to assess road safety and infrastructure quality.

**Bridge Use and Impact**

Based on the findings presented in Figure 1, only 15% of users cross the bridge daily, while 30% use it weekly and another 30% rarely. This shows a mixed level of dependence on the bridge. Notably, 36% agreed that bridge conditions affect their driving behavior, indicating a significant safety concern. Experiences of physical discomfort are high: 27% reported very frequent bumps, while 45% experience them occasionally. This indicates that the bridge surface or expansions joints require attention.

**Safety and Structural Confidence**

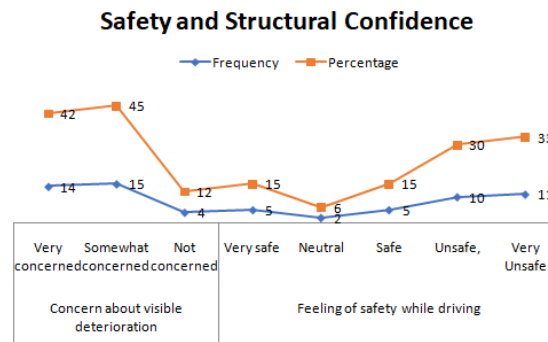
It was found during the study that visible deterioration



**Figure 1:** Bridge Use and Impact

is a major concern—42% of respondents are very concerned, while 45% are somewhat concerned. Only 12% are not concerned, confirming that structural appearance influences user confidence. Findings about the commuters feeling while driving on the bridge in Figure 2 shows that, 63% reported feeling either

unsafe or very unsafe and only 21% felt safe. Although 48% expressed confidence in the structural integrity, the remaining 52% were neutral or not confident, highlighting a public perception gap regarding safety and structural soundness.



**Figure 2:** Safety and Structural Confidence

**Safety Features and Risks**

Safety features such as signs, barriers, and lighting are considered insufficient by 33% of respondents, while 18% are uncertain as reported in Table 3. Over half

(54%) believe the expansion joints pose either a slight or significant safety risk. These perceptions are critical, as expansion joints are essential for load transfer and smooth traffic flow.

**Table 2:** Safety Features and Risks

Question	Response Categories	Frequency	Percentage (%)
Are current safety features sufficient?	Yes	16	48
	No	11	33
	Somewhat	6	18
Does current state of expansion joints pose safety risk?	Significant risk	8	24
	Slight risk	10	30
	Not a risk	5	15
	Not sure	10	30
Does bridge condition affect travel time?	Significantly,	7	21
	Slightly	18	55
	No	5	15
	Not sure	3	9

Moreover, 76% of respondents noted that the bridge condition affects travel time, either significantly or slightly, suggesting a direct link between structural performance and travel efficiency.

### Driving Behavior

Driving patterns are clearly influenced by the bridge's physical state. As in Table 3, a combined 72% of drivers reduce speed either always or frequently when crossing

**Table 3:** Safety Features and Risks

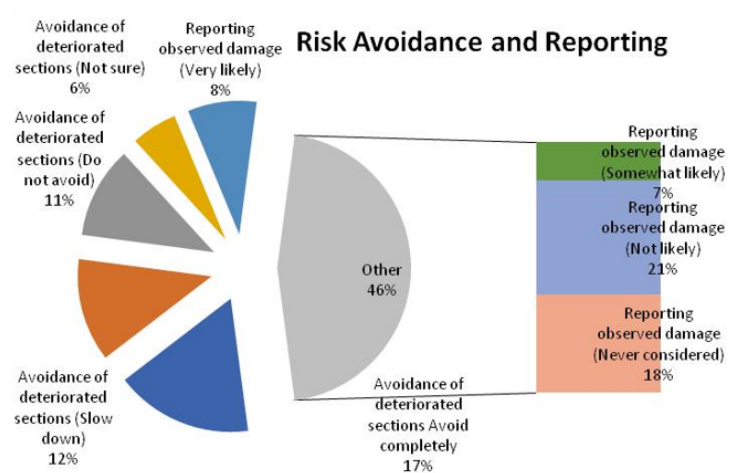
Question	Response Categories	Frequency	Percentage(%)
How often do you reduce speed on bridge?	Always	12	36
	Frequently	12	36
	Occasionally	3	9
	Never	6	18
Do you change lanes when noticing deterioration	Always,	11	33
	Sometimes	15	45
	Never	7	21
How does expansion joint condition affect speed?	Slow down considerably	7	21
	Slightly, Maintain	14	42
	Speed up	12	36

the bridge, and 78% change lanes when noticing visible deterioration.

Additionally, 63% of respondents adjust their speed based on the condition of the expansion joints, with 21% slowing considerably. This adaptive behavior reflects users' efforts to navigate safety risks independently.

### Risk Avoidance and Reporting

Avoidance behavior is evident, as 36% of users completely avoid deteriorated sections and 27% slow down. These are defensive actions in response to perceived danger. Only 24% continue unaffected as in Figure 3, which suggests the majority of users do perceive risk.



**Figure 3:** Risk Avoidance and Reporting

However, reporting of issues is low—only 18% are very likely to report damage, while 45% are not likely and 30% have never considered it. This shows a lack of public engagement or perhaps a lack of confidence in the effectiveness of reporting mechanisms.

### Government Effort and Maintenance

The perception of government response is predominantly negative as in Table 4. Only 24% believe enough has been done to maintain the bridge, while 58% believe not enough effort has been made. Similarly, only 12% consider

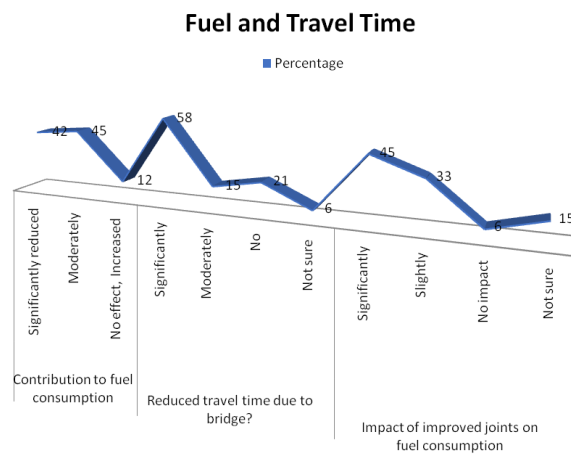
the government “very proactive” in maintenance. However, 52% believe the government should significantly invest in maintenance, reflecting public demand for better infrastructure management and consistent repair.

### Fuel, and Travel Time

Respondents in Figure 4 strongly associate bridge quality with fuel efficiency. A combined 87% (42% significantly, 45% moderately) say the bridge has increased fuel consumption due to frequent slowing, braking, or detours. Regarding travel time, 58% acknowledged a significant

**Table 4:** Government Effort and Maintenance

Question	Response Categories	Frequency	Percentage (%)
Has government done enough?	Yes	8	24
	No	19	58
	Not sure	6	18
Has government been proactive in maintenance?	Very proactive	4	12
	Somewhat proactive	10	30
	Not proactive	14	42
	Not sure	5	15
Should government invest more in maintenance?	Significantly	17	52
	Small amount	10	30
	No	2	6
	Not sure	4	12



**Figure 4:** Fuel and Travel Time

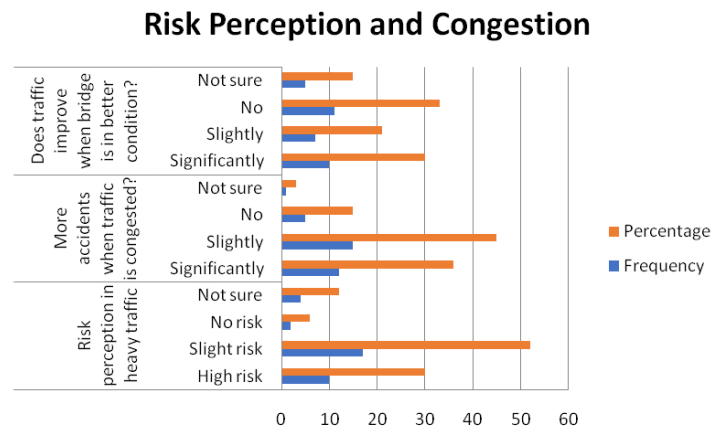
reduction due to the bridge, which highlights its importance in easing regional movement—but ongoing issues reduce its efficiency. Improved expansion joints were also linked to fuel savings by 78% of users.

**Risk Perception and Congestion**

Risk perception during heavy traffic or poor conditions

is high: 30% rated the risk as high and 52% as slight, indicating that 82% associate danger with congestion or deterioration (Figure 5).

Additionally, 81% believe that accident risk increases during traffic congestion, and 51% believe traffic improves significantly or slightly when the bridge is in good condition



**Figure 5:** Risk Perceptions and Congestion

### Modeling of the Motorist Experience

The model equation in terms of coded factors is presented in Equation (1) and can be used to make predictions about the response for given levels of each factor. By default, the high levels of the factors are coded as +1 and the low levels are coded as -1. The coded equation is useful for identifying the relative impact of the factors by comparing the factor coefficients.

$$\text{Traffic Flow} = +87.00 + 0.3119A + 0.8220B - 3.22C[1] - 1.89C[2] + 0.7500AB + 0.0202AC[1] - 0.2083AC[2] + 2.53BC[1] - 0.9988BC[2] + 0.5000A^2 + 0.2500B^2 \quad (1)$$

Where A = Drivers,  
B = Experience and

C = Vehicles.

Graphs of the Traffic models are presented in figure 6. Figure 6(a) shows the graph of Residual Vs Run of the traffic flow, where the lowest point of the traffic flow indicated by the colour blue is 75 and the highest point of the traffic flow in the graph is indicated by the colour red which is 96. The traffic flow does not follow a uniform pattern.

Figure 6(b) shows a graph of Traffic flow which has its unit in percentage against “A” which is the code factor for Drivers. The graph has its lowest point indicated with the colour code blue at 1, and has its highest point indicated with the colour code red at 27. The flow doesn't follow a particular trend.

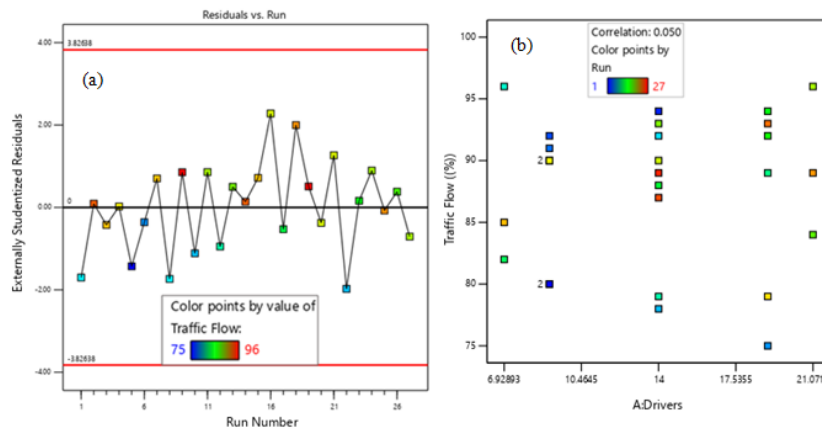


Figure 6: Graph of Traffic Flow Residual Vs Run (a) and Drivers Experience (b)

The contour plot in Figure 7 illustrates the relationship between “Bridge Durability (%)” and two variables: “A Drivers” and “B Experience,” while “C Vehicles” is

held as an actual factor. The plot uses a color gradient to represent bridge durability, ranging from lower values (red/orange) to higher values (green).

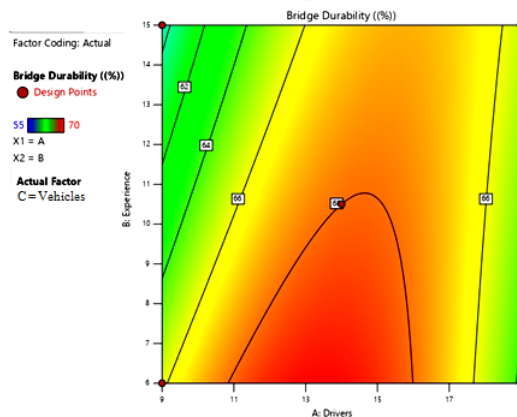


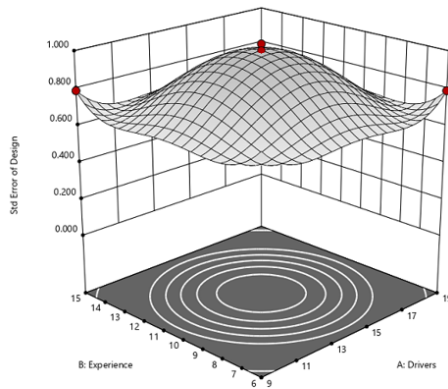
Figure 7: Contour Plot

Observing the plot, higher bridge durability, indicated by the green regions, appears to be achieved with a combination of higher “B Experience” and moderate to higher “A Drivers.” Conversely, lower durability, shown in red and orange, is associated with lower “B Experience” and varying levels of “A Drivers.” There is a distinct peak in durability, represented by the darker green area,

suggesting an optimal combination of “A Drivers” and “B Experience” for maximizing bridge durability. The contours also reveal that the impact of “A Drivers” on durability seems to be more pronounced at lower levels of “B Experience,” where changes in “A Drivers” lead to steeper gradients in durability. As “B Experience” increases, the contours become less steep, indicating a

more stable or less sensitive response of durability to changes in “A Drivers”.

The three dimensional plot in Figure 8a visually represents the relationship between “Std Error of Design” and two input factors, “A: Drivers” and “B: Experience.” The plot demonstrates a response surface where the standard error of design is minimized within a specific range of the independent variables. The lowest point on the surface, indicating optimal conditions for minimizing the standard error, appears to be centrally located within the displayed range of drivers and experience. The concentric circles



on the base of the plot further highlight the contours of this response surface, illustrating how the standard error changes as the levels of drivers and experience vary. The design points, marked in red, indicate specific combinations of drivers and experience where data was collected to construct this model. This visualization is crucial for understanding the interplay between the two factors and their combined effect on the standard error of design, guiding decisions towards achieving a more robust and reliable design.

This perturbation plot in Figure 8b illustrates the impact

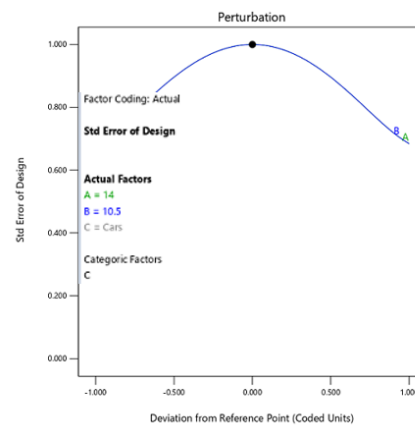


Figure 8: 3-D Plot of the model and Perturbation

of individual factors on the Standard Error of Design, with all other factors held constant at a reference point, typically the center of the design space. The x-axis, “Deviation from Reference Point (Coded Units),” represents the change in a specific factor from its nominal or central value in a standardized unit, while the y-axis, “Std Error of Design,” indicates the precision of the estimated response.

The parabolic shape of the curve suggests a non-linear relationship between the factor’s deviation and the standard error, indicating that moving away from the reference point, either positively or negatively, generally leads to an increase in the standard error of the design. This implies that the model’s prediction precision diminishes as the system moves further from the optimal or central operating conditions. The peak of the curve, located at a deviation of 0.000, corresponds to the reference point where the standard error is minimized, signifying the highest precision in the design at that specific set of factor levels. This analysis is crucial for understanding the robustness of a design and identifying the ranges within which factor variations have the least impact on the experimental precision.

## CONCLUSIONS

The study examined motorists’ perceptions of the Second Niger Bridge using survey data. Results indicate that the condition of the bridge strongly influences driver behavior, safety perception, and travel efficiency.

Many motorists expressed concerns about visible deterioration, inadequate safety features, and poor maintenance. Drivers responded by reducing speed, changing lanes, and avoiding damaged sections to minimize risk. Response Surface Methodology (RSM) analysis showed that driver experience, traffic volume, and vehicle type significantly influence traffic flow and perceived safety. While the bridge remains crucial for regional connectivity and mobility, structural concerns—particularly faulty expansion joints—have contributed to safety risks, increased fuel consumption, and longer travel times. These findings highlight the need for systematic maintenance and improved safety measures to enhance traffic performance and restore motorists’ confidence.

## Implications

The findings suggest important implications for infrastructure management and policy. Perceived poor maintenance reduces public trust in transport infrastructure. Motorists’ adaptive behaviors, such as speed reduction and lane switching, reflect underlying infrastructural deficiencies that may increase accident risks. In addition, bridge deterioration contributes to higher fuel consumption and extended travel times, resulting in economic implications for road users and transport operators. The limited willingness of motorists to report defects further indicates weak stakeholder engagement and emphasizes the need for more effective communication and feedback channels.

## Recommendations

Regular inspection and proactive maintenance of expansion joints, barriers, and pavement surfaces should be prioritized. Safety improvements, including better lighting, clear road markings, and traffic monitoring systems, are also necessary. Establishing public reporting platforms would encourage early detection of structural defects, while governments should allocate dedicated funding for long-term bridge management and traffic safety education.

## Limitations

The study relied on a relatively small sample size and self-reported perceptions. The RSM model considered limited variables and excluded factors such as weather conditions and enforcement. The absence of long-term accident and congestion data also limited validation.

## Suggestions for Further Studies

Future studies should expand the sample size, include diverse bridge users, and integrate real-time traffic and accident data. Comparative analyses with other Nigerian bridges and cost-benefit evaluations of maintenance strategies are also recommended.

## Acknowledgements

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