Assessment of Markham Bridge Concrete Deck's Health by Schmidt Hammer Test

Alak Kumar Patra[1*], Nichodemous Romo[2]

School of Civil Engineering, PNG University of Technology,
Private Mail Bag, Lae 411, Morobe Province, PNG.

*Corresponding author email: alak.patra@pnguot.ac.pg

Abstract: This paper strives to assess the current health condition of the concrete of the bridge deck of Markham bridge of Papua New Guinea (PNG). The existing quality of concrete is tested through non-destructive testing (NDT) method. Schmidt hammer is used to assess the health condition. Vertical values were used for calculation of the in-situ compressive strength of concrete at 24 locations spanning along the entire length and breadth of the bridge deck. The compressive strengths at various locations related to the surface hardness based on empirical and statistical approach were calculated. The current quality of concrete in most of the locations is typically fair, not good. At one location, the compressive strength is calculated to be 18 MPa which is not acceptable for reinforced concrete construction and indicates need of immediate attention of the authority for pre-emptive measures to protect the bridge from further deterioration and untoward event in future. The School of Civil Engineering may be engaged with the Department of Works and Highways (DOWH) of PNG for more rigorous studies on the rehabilitation or replacement issues with the cost escalation for this purpose.

Keywords: Non-destructive test, Markham bridge, current health, concrete bridge deck, Schmidt hammer.

1. INTRODUCTION

Existing health condition of the concrete of the bridge deck of Markham bridge of Papua New Guinea (PNG) is assessed through non-destructive testing method. It is the longest bridge in Papua New Guinea and across the largest river in PNG. It connects mines with Lae, the largest sea port in the country (PNG). The steel-concrete composite bridge spans across the Markham River and is situated on the Wau-Bulolo highway which connects Bulolo to Lae, the second largest city and the largest sea port of Papua New Guinea. The road is the only medium of communication for over 200000 people who lives in the adjacent area and depend on it for communication with Lae. It is an important road for transportation of local raw and extracted materials like wood, gold or coffee and that of industrial products like furniture also. The length of the bridge is 560 m. It is the longest bridge of PNG and was worst affected by flood in 2004. The approach road on Lae side was washed out by 2004-flood. Pier no. 3 was subsided due to scouring caused by flood water. Japanese organization came into action after subsiding of pier no. 3 to reinforce pier no. 1 to 4 to protect the bridge from complete failure. In 2006, repair of approach road and bank protection was done by AusAID. The objective of the project by Japanese organization was to revive essential functions for some decades with repair and strengthening of piers and abutments.

The project was completed successfully but Japan International Corporation Agency (JICA) team mentioned for substantial measures for better operation of the highway. Different agencies worked on this Bridge ranging from British, Australian to the Japanese agencies across the largest river Markham in PNG. Different study groups addressed the river system and effects of flood on the infrastructure and especially on bridges in PNG. Gibson et al. studied on bridge failures in Papua New Guinea induced by floods (Gibson & Matsumoto, 2019). Study on the social impact of highway construction on Markham valley has been conducted by N.T. Ha (2022). Implication of dynamic geodic datum has been studied (Stanaway, 2004). El-

Alak Kumar Patra, Nichodemous Romo | 2 (2) : 196 - 201 | Received: 31/05/2025 | Reviewed: 12/08/2025 | Accepted: 02/09/2025 | DOI: https://doi.org/10.63900/fm3jyh60
Assessment of Markham Bridge Concrete Decks Health by Schmidt Hammer Test

nino and climatic risk assessment as well as mitigation measures for PNG has been reported (Bang et al., 2002). Governance issues in the construction of bridges and roads have been published by another study group (Hughes, 2000). Benefits of rehabilitation of roads in six provinces of PNG has been studied and reported (Jusi et al., 2007).

Role of other nations on the sustainability issue of PNG is addressed (Huettmann, 2023). The erosion and drainage problems in Lae has been studied and reported (Atkins, 2013). JICA published a short communication on the urgent rehabilitation of Markham bridge after disastrous flood damage in 2004. A comprehensive report on proposed design of Markham bridge was published by Takaue (2010). Estimation of flood vulnerability zone with geo-spatial technology has been studied by Morea and Samanta (2020). Issues related to mining in Morobe Province, and a major tributary of Markham River in PNG has been addressed (Roche & Mudd, 2014). But a study on the existing health condition of the concrete in the bridge deck slabs of Markham bridge is yet to be noticed and that is addressed in this paper.

2. MATERIALS AND METHODOLOGY

The existing hardened concrete is tested by non-destructive technique with the help of Schmidt Hammer. The original version of the Schmidt hammer used for the investigation is shown in Fig. 1.

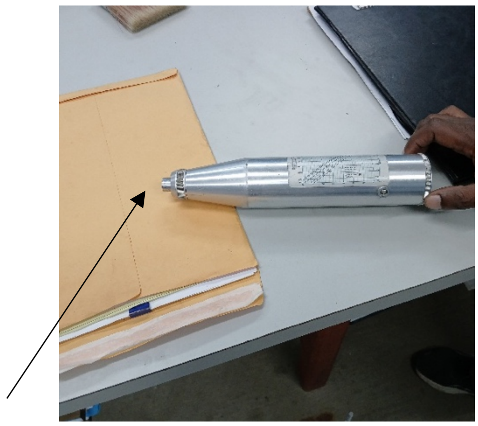

Fig. 1 Schmidt Hammer

The plunger was placed perfectly vertical [Fig. 2] at each location. At each location, there was a grid of 15 rectangular boxes at centre of which the readings were recorded after hitting the concrete surface and rebounding of the hammer. The average value of the readings was calculated as per the procedure published in the booklet of the manufacturer. There were 24

Fig. 2 Vertical position of the plunger during hitting the concrete surface.

locations and at each of such locations, 15 readings from the rectangular grid were recorded. As such the total number of readings recorded were 15X24 = 360. The plunger was hit
against the concrete surface at each location and it was locked after each rebounce. The hammer values were recorded after stability with the help of the scale attached to the hammer. These are the rebound values of the hammer. In this way total 360 hammer values were recorded along the full 560 meters length of the bridge. These readings were based on the surface hardness of the concrete surface and the hammer values were recoded for further calculation and analysis of the readings.

3. LOCATION PLAN AND DATA OBTAINED FROM THE SITE

3.1 Location Plan

The length of the bridge was measured with the help of the wheel meter which was observed to be 560 m. The width of the bridge was measured with the steel tape and was found to be 6 metres. The entire surface of the bridge deck of 560 m length from expansion joints at the extreme edges of the bridge was divided into 24 locations. The centre to centre (C/C) distance of each division along length was 50 metres and that between the edge and the first line of measurement was 0.6 m from the breadthwise edges; while the C/C distance between the location along width was 4.8 meters as shown in Figure 3 on the next page.

3.2. NDT Data

The non-destructive testing data (Schmidt rebound values) from 360 points (from 15 boxes at each of the 24 locations) were recorded sample data of 5 such locations are presented in the tables for location 1 through 4 and location 24 on next page.

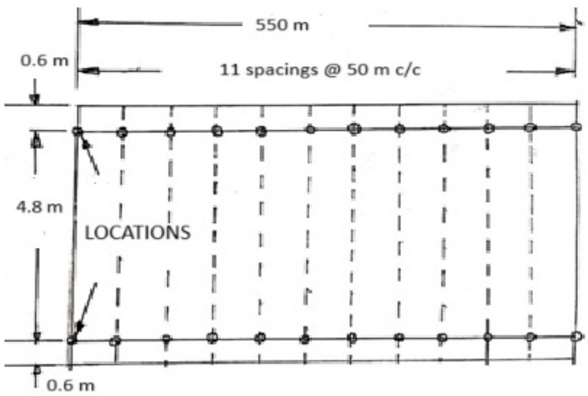

Fig. 3 Location of the test grids

NDT Data:

Locaton 1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
27	18	32	22	26	25	45	32	26	38	27	29	26	44	22

Locaton 2

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
23	30	26	32	36	28	28	30	34	26	32	28	44	34	26

Locaton 3

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
26	20	28	20	26	32	26	28	32	38	26	24	26	38	24

Location 4

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
30	24	26	26	24	28	28	22	28	32	28	32	32	30	28

Locaton 24

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
24	25	27	28	25	22	27	25	21	25	29	24	26	24	22

3.3 Calculation of Average Schmidt Rebound Values

The sample calculation for the average Schmidt rebound value of the Schmidt hammer rebound values is furnished below:

1. Preliminary average =29
2. No of values other than 29 = 14
3. Upper limit = 29+14 = 43
4. lower limit = 29-14 = 15
5. No. of usable values = 13
6. Total of usable values = 439-44-45 = 350
7. Average value = 350/13 = 26.92 ~ 26

The average Schmidt rebound values for the first 12 locations and the next 12 locations are tabulated in Table 1 and Table 2 on the following page.

3.4 Compressive Strengths Calculation

The compressive strength from the average Schmidt hammer rebound values were. The compressive strength from the average Schmidt hammer rebound values were determined from the conversion graph provided by the manufacturer. The cube compressive strength values were calculated in MPa from the plot of the compressive strength versus hammer values.

Table 1 Average rebound values for first 12 locations

Location No	Ave. Rebound Values
1	26
2	29
3	27
4	28
5	27
6	26
7	26
8	27
9	23
10	27
11	27
12	25

Table 2 Average rebound values for the next 12 locations

Location No	Ave. Rebound Values
13	26
14	28
15	29
16	29
17	29
18	25
19	28
20	28
21	27
22	25
23	29
24	25

The compressive strengths are tabulated in Table 3 and Table number 4.

Table 3 compressive strengths of concrete for Average rebound values for first 12 locations		
Location No	Ave. Rebound Values	Comp. strength (Mpa)
1	26	22
2	29	26.5
3	27	24
4	28	25
5	27	24
6	26	26
7	26	26
8	27	27
9	23	18
10	27	24
11	27	24
12	25	21

Table 4 compressive strengths of concrete for Average rebound values for next 12 locations		
Location No	Ave. Rebound Values	Comp. strength (Mpa)
13	26	22
14	28	25
15	29	26.5
16	29	26.5
17	29	26.5
18	25	21
19	28	25
20	28	25
21	27	24
22	25	21
23	29	26.5
24	25	21

4. RESULTS AND DISCUSSION

It is to be noted that the Schmidt hammer rebound values are based on the surface hardness of the concrete surfaces. Schmidt correlated these rebound values to the existing compressive of the concrete himself also. Some correction for the values were also recommended. It is also to be observed from the aforementioned tables that the strengths at various locations were significantly low. As per the practices, the quality of concrete is poor if the average rebound number is below 20 and very good if the average value is above 40. The quality is regarded as fair if the average rebound number is between 20 to 30 and good if it is between 30 to 40. The quality of concrete at a number of locations are fair but not good or very good for the safety of the traffics. Moreover, the bridge is vibrating during passage of each heavy vehicle severely, which is also not acceptable from serviceability point of view. It can also be noted that none of average rebound number is below 20. Hence the quality is not poor but at location 9 it was 23 and the compressive strength corresponding to that value was calculated to be 18 MPa. As per Indian Standard also, the concrete grade for reinforced concrete should not be below M20 with characteristic compressive strength 20MPa. From that point of view, the quality of concrete at location 9 is not acceptable for reinforced concrete construction.

5. CONCLUSION

The existing quality of concrete is tested by Schmidt hammer. Vertical values were used for calculation of the in-situ compressive strength of concrete at 24 locations spanning along the entire length and breadth of the bridge deck. The compressive strengths at various locations related to the surface hardness based on empirical and statistical approach were calculated. A better approach may be a hybrid testing with Schmidt hammer and Ultrasonic pulse velocity through the concrete deck. The current quality of concrete in most of the locations is typically fair and not good. Moreover, the bridge was severely vibrated during passage of each heavy vehicle which not acceptable from serviceability point of view. At one location, the compressive strength is calculated to be 18 MPa. Even as per Indian standard the minimum grade of concrete needed for the reinforced concrete construction is M20 with the characteristic compressive strength of 20 N/mm^2 (20 MPa) which indicates, this concrete is not acceptable for reinforced concrete construction and indicting need of immediate attention of the authority for pre-emptive measures to protect the bridge from further deterioration and untoward event in future.

6. ACKNOWLEDGEMENT

We acknowledge the assistance of all local persons for the successful completion of the field work within a very short time.

REFERENCES

Atkins, G. P. (2013). Erosion and drainage problems in the environs of Lae: a disaster waiting to happen–again. In *The Proceedings* (p. 92).

Bang, S. K., Poloma, S., & Allen, B. (2003). *Stabilization of upland agriculture under El Nino-induced climatic risks: impact assessment and mitigation measures in Papua New Guinea*. CGPRT Centre.

Gibson, A. H., & Matsumoto, T. (2019). Flood-induced Bridge Failures in Papua New Guinea. In *MATEC Web of Conferences* (Vol. 258). EDP Sciences.

Ha, N. T. (2022). Social Impact Analysis on Road Construction Project in Papua New Guinea: A case of Highlands Highway.

Huettmann, F. (2023). Role of Outside Nations in Papua New Guinea's Sustainability Model: China, US, UK, the EU, Russia, Australia, NZ and Japan Need Bob Marley and the Dalai Lama Coming to the Rescue. In *Globalization and Papua New Guinea: Ancient Wilderness, Paradise, Introduced Terror and Hell* (pp. 515-545). Cham: Springer International Publishing.

Hughes, P. (2000). Issues of governance in Papua New Guinea: building roads and bridges.

Jusi, S., Asigau, W., & Laatunen, N. (2007). Social Impact Benefits of Road Rehabilitation Projects in Six Provinces in Papua New Guinea, South Pacific. In *Choice for Sustainable Development. Pre-Proceedings of the 23rd PIARRC World Road Congress World Road Association (PIARC)*.

Morea, H., & Samanta, S. (2020). Multi-criteria decision approach to identify flood vulnerability zones using geospatial technology in the Kemp-Welch Catchment, Central Province, Papua New Guinea. *Applied Geomatics*, *12*(4), 427-440.

Roche, C., & Mudd, G. (2014). Mining in Morobe, Papua New Guinea.
Stanaway, R. F. (2004). Implementation of a dynamic geodetic datum in Papua New Guinea: a case study.

Takaue, A. Applied design codes on international long-span bridge projects in Asia.