Assessment of Geomorphic Characteristics and Analysis at the Existing Bridge Site in Puerto Rico

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Abstract

The scour on bridges is considered one of the main reasons for bridge failures. Scour is the consequence of the erosion action that is cause by the water flow. In pursue of a possible direct relation to a water stream behavior a geomorphic analysis was conducted to a total of 26 bridges in Puerto Rico. A geomorphic analysis studies the plan and profile of a stream to understand the stream morphology of the river. The outcome will show if lateral of vertical movement has occurred on the river. After the analysis 88% of the bridges were meandering, 46% were classify as fair, 42% poor classification and only 12% were rated as good. The 46% lateral movement, 54% vertical movement, and none were stable.

Introduction

Geomorphology it is the study of landforms and the processes responsible for making and modifying the land throughout time. In Puerto Rico 26 bridges suffered from scour on piers and abutments. As a result of this findings a geomorphologic analysis was conducted on each of the bridges in pursue of a relation of possible lateral of vertical movement on the water stream in order to prepare a efficient solution that consider the movement of a water stream prior to the construction of a bridge.

Background

Active erosion on the riverbanks can ocurre at anytime. Some water stream are more likely to erode than others. The erosion on the rive banks could be for many reasons that involve landform, type of material on the riverbed, and mainly lateral and vertical movement of the water stream.

Figure 3
Active Bank Erosion Illustrated by Vertical Cut Banks

Figure 6
Google Earth Image 2006 Lateral Movement

Problem

The bridge scour in Puerto Rico it is a main concerned to maintain the safety of roads in compliance of the US Department of Transportation. The consequences of not preparing or mitigating against bridge scour could treat human life, affect the economy of a city or state, and damage the infrastructure of the roads downstream of a water stream when extreme events occur.

Methodology

The geomorphic factors that affect stream stability consider 11 parameters. Those parameters will obtain a score, and finally the procedure will dictate if lateral or vertical movement occurred.

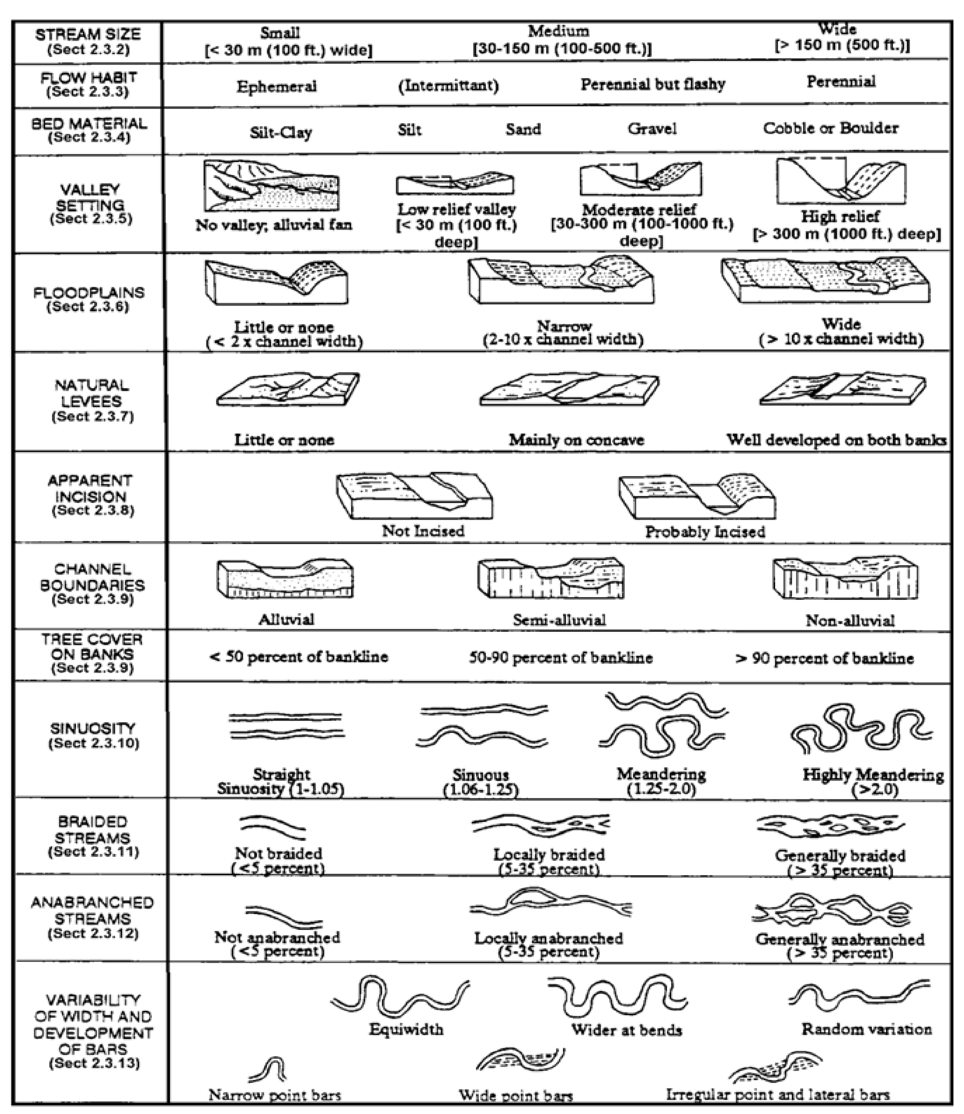


Figure 2
Geomorphic Factors that Affect Stream Stability

Table 5.6. Overall Scores for Three Classifications of Channels.

Category	Score, R		
	Pool-Riffle, Plane-Bed, Dune-Ripple, and Engineered Channels	Cascade and Step-Pool Channels	Braided Channels
Excellent	R < 49	R < 41	N/A
Good	49 ≤ R < 85	41 ≤ R < 70	R < 94
Fair	85 ≤ R < 120	70 ≤ R < 98	94 ≤ R < 129
Poor	120 ≤ R	98 ≤ R	129 ≤ R

Table 5.7. Stability Ratings for Streams in Figures 5.11 – 5.14.

Stream	Indicator													Total	Rating Based on Table 5.5
	1	2	3	4	5	6	7	8	9	10	11	12	13		
Figure 5.11	12	4	6	12	11	10	10	12	12	11	12	12	3	127	Poor
Figure 5.12	9	12	10	7	11	8	3	11	8	10	6	7	8	110	Fair
Figure 5.13	8	2	4	5	3	5	5	8	5	2	2	2	6	57	Good
Figure 5.14	3	2	3	3	4	3	3	4	5	4	4	1	5	44	Excellent

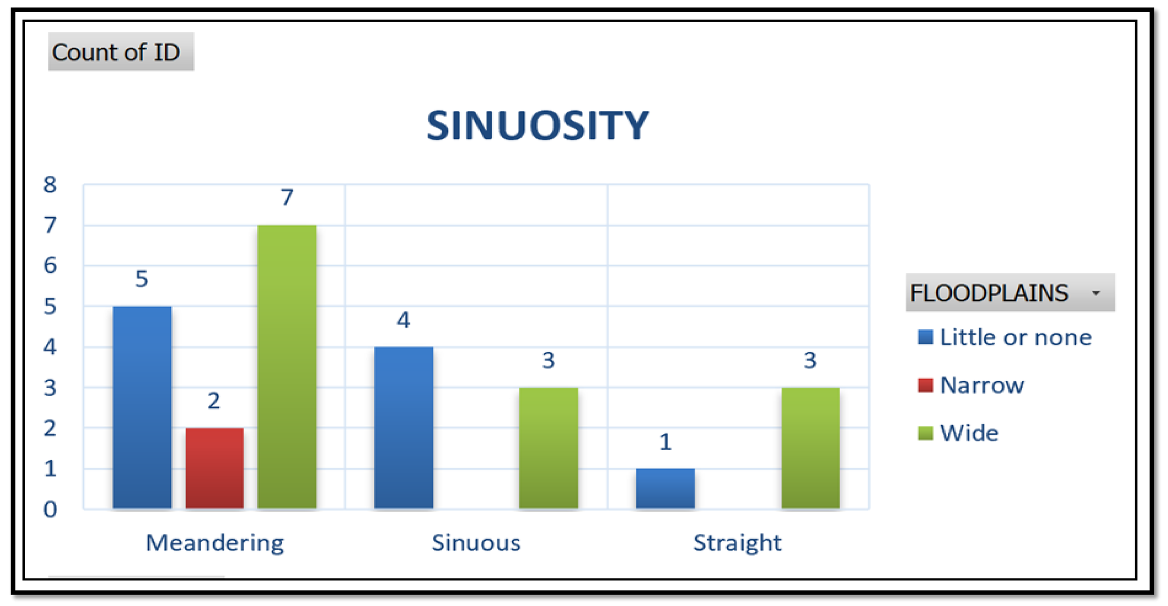
Table 5.8. Lateral and Vertical Stability for Streams in Figures 5.11 – 5.14.

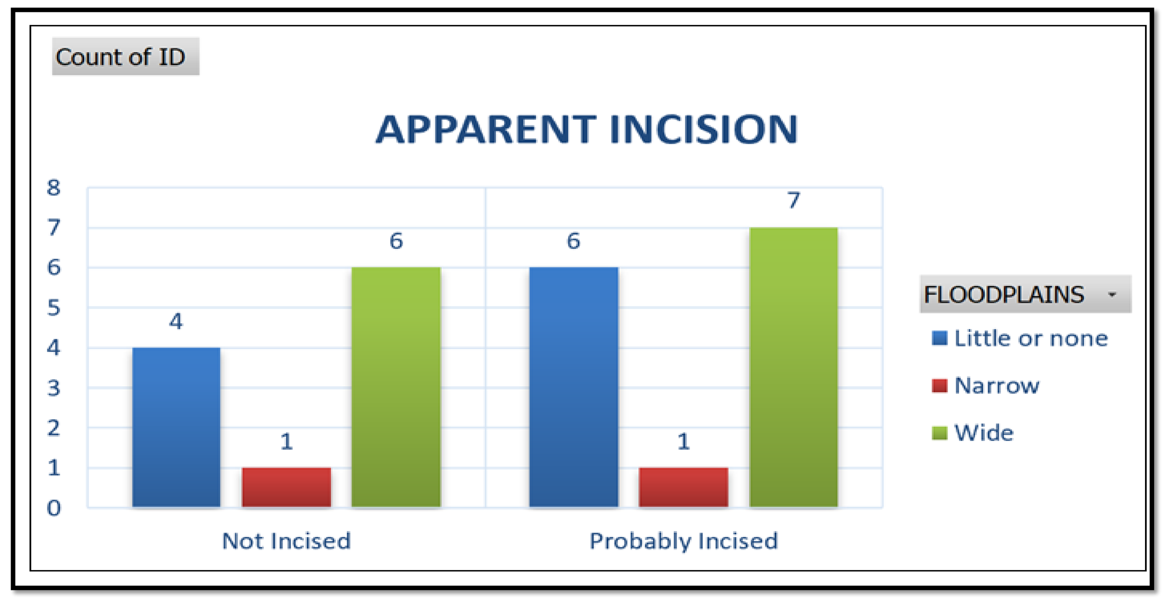
Stream	Lateral	Vertical	Lateral Fraction	Vertical Fraction
Figure 5.11	62	33	0.86	0.92
Figure 5.12	50	26	0.69	0.72
Figure 5.13	25	13	0.35	0.36
Figure 5.14	23	10	0.32	0.28

Indicator									
Vertical Movement				Lateral Movement					
4	5	6	7	8	9	10	11	12	13

Results and Discussion

The results obtained on the study showed that all of the bridges had lateral or vertical movement by conducting the geomorphic analysis. None out of the 26 bridges were classify stable when a lateral or vertical movement analysis was conducted. This findings show a direct relation with the scour occurred at this locations. The stability analysis which is the second part of the geomorphic analysis provides the result of lateral or vertical movement.





Channel Stream Category in Bridges

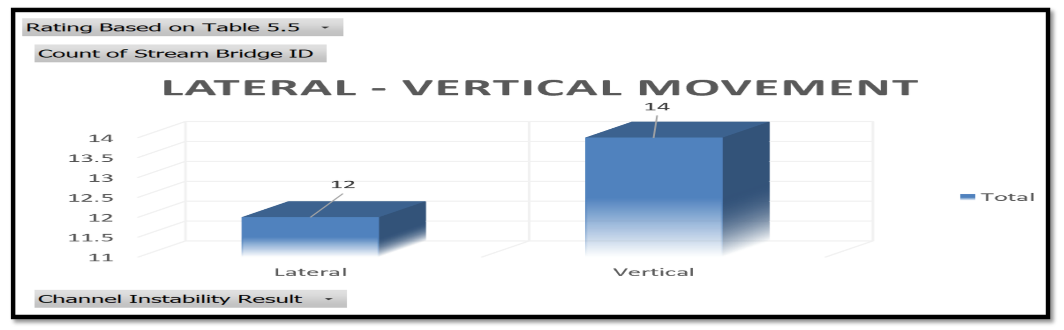
Parameter	Num. of Stream
Poor	11
Fair	12
Good	3
Excellent	0

Channel Instability Result

Parameter	Num. of Stream
Lateral	12
Vertical	14

Conclusions

The goal of the study was achieved by conducting a geomorphic analysis. The results found on the study showed that none of the bridges analyzed on the study were classified stable. A stable classification states that there is no lateral or vertical movement on the water stream. Out of all the 26 bridges 12 were classified as lateral movement, and 14 were classified as vertical movement. It is a priority to enforce on future proposed bridges to conduct a geomorphic analysis because it can provide quality information to analyze the when studying a site due to its landform, plan, material, sinuosity, and slope among other parameters.



Future Work

The next steps to take into consideration are relating the geomorphic analysis with the location, water stream velocity, and site quarry because it promotes the incipient motion because the river stream always balances its course.

- Integrate GIS software's as an important tool to determine landforms on river streams.
- Establish, implement, and maintain a process of a geomorphologic analysis for future proposed bridges.
- Evaluate bridges located on critical locations in order to determine lateral or vertical movement in order to prevent or mitigate future scour on bridge.

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