Documentation and Mapping Out Bridges of Soran District

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Abstract—**Bridges are most commonly significant in the area of transportation for their role in conveying passengers and materials across streams and rivers as part of a particular road. Bridges became increasingly important for the development of regional economies, such as the discovery of oil in the area. Generally, the bridge should provide the full range of structural engineering services required to provide safe, economical and reliable structure for transportation. Soran District with its four sub-districts (Diyana, Khalifan, Rawanduz and Sidekan) has a large and impressive collection of bridges, with a number of structures that are extremely significant. The recent work provides a field survey, documentary research into Soran bridges: guide information on type, location, description, in addition to photographs of all the bridges including the historic ones. Documentation and mapping out the bridges of Soran is made in order to justify why the bridge is significant to the community, and to evaluate the bridges states as parts of the overall transportation network of the area. The key findings of the research will be shared with responsible people of Soran and Kurdistan government in order to find ways to make our bridges work better by implementation of comprehensive strategy that focuses on maintenance, rehabilitation and /or replacement toward improving safety and access across the district which bolsters economic growth.**

Key Words- Documentation; Mapping out ; bridges; Soran district

I. INTRODUCTION

A bridge is defined as a structure carrying a road, path, railway, etc. across a river, road, or other obstacle. From engineering point of view, a bridge is defined as a structure that spans horizontally between supports, whose function is to carry vertical loads. They are essential and integral components of a safe transportation system, they provide a means of crossing natural barriers, such as rivers, lakes, or gorges. Bridges are designed to carry railroad cars, motor vehicles, or pedestrians and also support pipes, troughs, or other conduits that transport materials, such as an oil pipeline or a water aqueduct. Humans have been constructing bridges since ancient times. The earliest bridges were probably nothing more than felled trees used to cross rivers or ditches. As civilization advanced, artisans discovered ways to use stone, rock, mortar, and other natural materials to construct longer and stronger bridges. Finally, as physicists and engineers began to develop the principles underlying bridge construction, they incorporated other materials such as iron, steel, and aluminum into the bridges they built. However, as transportation system ages, many bridges are becoming obsolete. This obsolescence is a result of natural deterioration, of the materials used in construction, and of earlier design standards that no longer accommodate the speed, dimensions, loads, and volume of modern traffic demands.

The type of bridge built for a particular crossing depend on myriad of factors including soil and topographical conditions, the length of span, the availability of materials, skills of local labor, the price and accessibility of pre-manufactured metal structure materials, and the political and economic forces of the region [1]. There are many different designs of bridges. Bridge design fall into the 7 main types according to their structural form, they are: 1. Beam bridge which is the simplest type that can be made stronger by adding more sections and support. 2. Arch bridge which can support heavier weights because they are made from stone or brick which strong in compression. 3. Girder bridge which is a strengthened beam bridge that uses girders to provide rigidity. 4. Suspension bridge which might have the towers made from concrete that is strong in compression and cables made from steel which are strong under tension. 5. Cantilever bridge that is made up of repeating sections held firm by cables, which are strong under tension. They can be supported on concrete towers which are strong in compression, like suspension bridges. 6. Cable styed bridge which is like a beam bridge, with additional strength provided by cables. 7. Movable bridges which are constructed over waterways to allow the passage of boat traffic.

Broadly speaking, under most conditions, engineers favored materials and designs that are economical to construct, and easy to maintain, thus stretching the available public finances to improve as many crossings as possible.

The factors must be taken into consideration in the design of a bridge are the forces operate on any bridge: the dead load, the live load, and the dynamic load. Dead load refers to the weight of the bridge itself. Like any other structure. Live load refers to traffic that moves across the bridge as well as normal environmental factors such as changes in temperature, precipitation, and winds. Dynamic load refers to environmental factors that go beyond normal weather conditions, factors such as sudden gusts of wind and earthquakes.

Bridges should be evaluated periodically in order to assure public safety while maintaining system continuity and integrity, as well as to find ways to make the bridges work better [2], [3]. Innovative technologies emerged for monitoring and inspection including remote sensors [4], and robots [5], [6]. Programs and comprehensive strategy should be planned to focuses on timely maintenance, rehabilitation and replacement [7], [8], [9]. Bridges preservation is a priority, to extend their usable lives and prevents costly repairs in the future. It makes the best use of limited funding and enables to upgrade the bridges faster.

Bridges Rehabilitation includes replacing decks or entire superstructure, increasing the vertical clearance of low bridges (jacking) to stop them by being hit bridges and rehabilitate superstructure. Replacement includes replacing an existing bridge with another bridge, or sometimes with a culvert or pipe. While, preservation includes resurfacing decks, painting structural steel, cleaning bearings/painting bearings and repairing/replacing expansion joints.

II. PURPOSE AND SCOPE

The purpose of this work was to identify and categorize Soran bridge structures. The research consisted of a field survey. A total of 45 bridges, were surveyed during this research. Data on type of bridge, its location, when it was built, its dimensions and other documentation and tabulation are included. The primary goal was to evaluate the bridges. To achieve that goal, each bridge was visited, field inspected and photographed. Field notes and photographs of the bridges and their setting were taken and documented. Most bridge overall length and out-to-out width measurements were taken from the database and were not measured in the field. Bridges to be surveyed were plotted on county map.

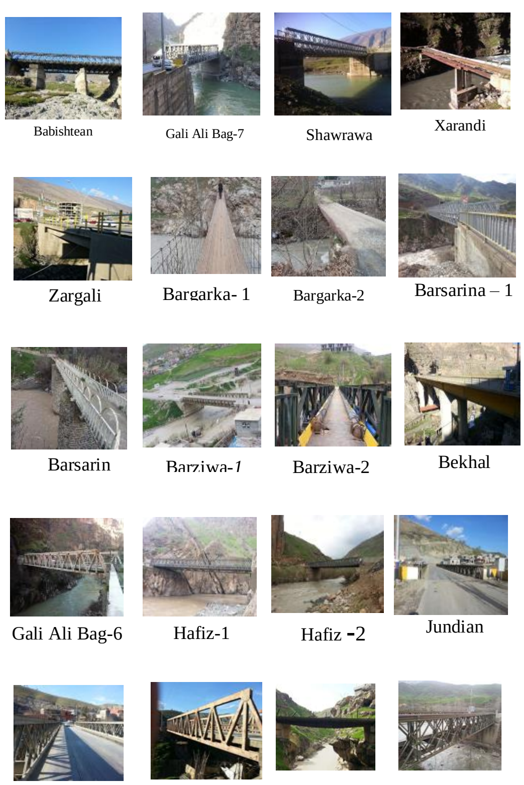
III. RESULTS AND DISCUSSION

Soran has a collection of bridges spreading out across the district. Some of the bridges are ancient. A total of 45 bridges, were surveyed during this research. Few of them couldn't be inspected because of difficulties to reach for security reasons. Most of the surveyed bridges are designed and constructed between 1970-1980, 6 bridges after 1990, while the survey covered 5 ancient simple bridges have been constructed before 1970. Table 1 shows the name, age, type, name of the river or road the bridge cross over and dimensions of the bridges. Table 2 represents type and state of the inspected bridges, while figure 1 shows the photos of the bridges.

Table 1: Soran bridges specifications

Khalifan Bridges Specifications							
No.	Name	Along road	River	Built year	L (m)	W (m)	H (m)
1	Gali Ali Bag 1	Khalifan Diayana	Gali Ali bag	1973	25	7.2	3.5
2	Gali Ali Bag 2	Khalifan Diayana	Seaso-nal	1973	6.5	8.4	3.5
3	Gali Ali Bag 3	Khalifan Diayana	Gali ali bag-	1985	10.2	8.7	10.2
4	Gali Ali Bag 4a	Khalifan Diayana	Gali ali bag-	1979	24.7	7.2	9
5	Gali Ali Bag 4 b	Just for tourists	Seaso-nal		4.7	3	2.8
6	Gali Ali Bag 5	Khalifan Diayana	Gali Ali bag-	1979	37	7	17.9
7	Khalan	Hareer Khalan	Khalan	1978	95	7.6	3.7
8	Khalan ancient		Khalan	1930-1940	51	3.7	7
Diana Bridges Specifications							
9	Gali Ali Bag 7	Khalifan Diyana	Gali Ali bag	1976	37.5	7.2	7.5
10	Zargali	Khalifan Diyana	Seasonal	1981	15.3	12.7	8.6
11	Babisht-ean	Babisht-ean Diana – Merga-sour	Babisht-ean	1984	41.5	7.5	8
12	kharandi bapsh-tean	Baphtian - Bekhal	Choman	1986	51	1	4.5
13	Shaw-rawa	Diana Shaw-rawa	Shaw-rawa	1986	36.5	4.3	7.3
Diana Bridges Specifications							
14	Gali Ali Bag 6	Erbil - Diana	Gali ali bag	1976	46	7.5	7
15	Bekhal	Erbil - Bekhal	Bekhal water	1988	108	9	14
16	Kawlok 1	Erbil - Diana	Kawlok	1976	45	7.5	3.5
17	Kawlok 2	Erbil - Jundian	Kawlok	1983	45.8	7.5	4
18	Jundian	Erbil - Jundian	Jundian	1983	77.3	7.5	7
19	Rezanok	Erbil Haj Omaran	Rezanok	1979	36.8	7.5	4.5
20	Prdashal	Prdashal Bargrka	Qandil	1960	14	3.8	10
21	Barsirn 1	Erbil Haj Omaran	Barsirn	1978	37	4.2	9
22	Barsirn 2	Erbil Haj Omaran	Barsirn	-	71	1.5	8.3
23	Barziwa 1	Erbil Dargala	Barziwa	1978	40.5	7.5	8
24	Barziwa2	=	Barziwa	2009	37	1	9
25	Khanaqa	Erbil Khanaqa	Khanaqa	1978	23.5	7.6	3.2
26	Bargrka1	Erbil	Qandil	2013	30	1.5	6

		Qandil					
27	Bargrka2	Erbil Qandil	Qandil	1986	10	3.4	6.7
28	khalkan	Erbil Qandil	Khalkan	1969	8.5	3	9.5
29	Warkon 1	Erbil Qandil	Barziwa	2011	40	4	9
30	warkon2	Erbil Qandil	Barziwa	1974	37	2	6
31	Hafiz -1	Erbil Qandil	Hafiz	-	10	4.5	13
32	Hafiz -2	Erbil Qandil	Hafiz	-	13	5	15
Sedakan Bridges Specifications							
33	Mjesar	Erbil Sedakan	Seaso-nal		7.7	7.6	3.1
34	Qaletan	Erbil Sedakan	Qaletan	1984	36	7.7	4
35	Berkman	Sidakan Berkman	Berkman	1986	19.8	2.8	3
36	Khua-kurk 1	-	-	-	-	-	-
37	Khua-kurk 2	-	-	-	-		-
38	Litan	Sedakan Litan	Litan-river	1988	23.3	4.3	4.5
39	Barmeza	Erbil Hayta	Barmeza	2006			
40	dolmarg	Merga-sour sidakan	Dolmarg	2013	83	1	3.9
41	Zana	Erbil Sedakan	Zana	2011	53	4.3	8.7
42	Azadi	-	Berkman	-	8	1.2	6
43	zhilya	-	Berkman	-	11	1	9
44	sukina	-	Berkman	-	8.5	1	7
45	Basakan	-	Berkman	-	7	1	6



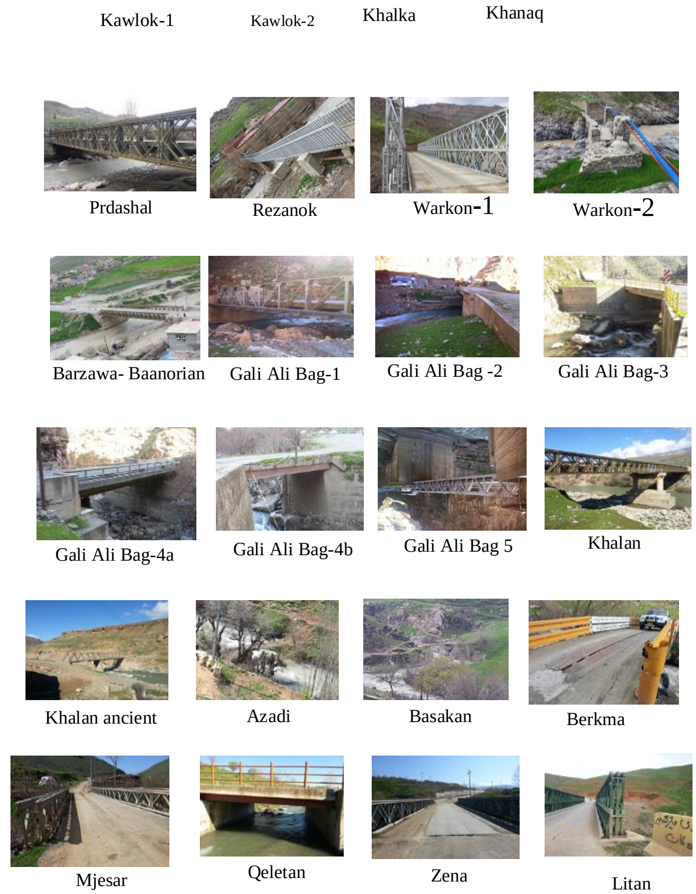


Figure 1: Photos for Soran's bridges

One of our objectives was to evaluate the bridges state. Generally, bridges are classified as structurally deficient, functionally obsolete or fracture critical. The fracture critical bridges could be considered as seriously damaged, and the bridges should be replaced by new ones. While, bridges may be rated deficient for a range of reasons and not all of them pose an immediate threat to public safety. However, allowing bridges to remain in serious need of repair can lead to the sudden closure of a critical transportation link or, far worse, a collapse that results in lives lost and a major economic impact to the affected region. Bridges are considered "structurally deficient" if a major defect has been identified in one of the three key components (The deck, the superstructure, and the substructure) as shown in figure 2. Structurally deficient bridges require significant maintenance, rehabilitation or replacement.

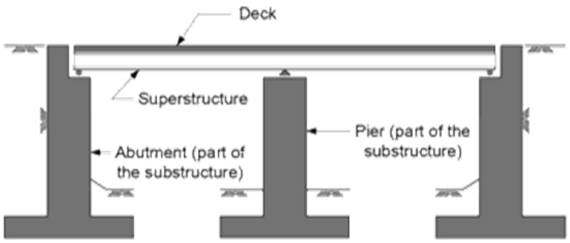


Figure 2: The primary component for a bridge

Bridge decks may expose to aggressive environmental factors or to increasing traffic loads. The deterioration of the deck affects the quality of the riding surface and traffic safety.

On another hand, poor design and /or construction and inadequate inspection and maintenance practices, as well as corrosion of reinforcement, freeze thaw cycles, traffic loading, are main factors that control the bridge durability. The reinforced concrete parts of the bridges may subject to reinforcement corrosion (Delamination) which causes a wedge-like stress on the concrete. Concrete spalling is usually caused by corrosion of the steel reinforcement bars embedded in the concrete matrix. The deterioration of the concrete causing chunks of the concrete to separate from the concrete structure.

Traffic loading is another major reason for bridges structural deficiency. Wheels of trucks cause fatigue cracking. Vehicle speed also plays a role. Slowly moving vehicles stress the road over a longer period of time, increasing ruts, cracking, and corrugations in the asphalt pavement [10]. The type of bridges and their state from visual inspection is summarized in table 2.

Table 2: Type and state of the inspected bridges

No.	Bridge Type	Bridge State
1	RC slab & Steel truss	Sound, needs repairing the corroded parts. Low bridge may expose to deck damage when water level increases.
2	Steel beams with RC slab	No barriers, the deck needs paving, the bridge slab needs painting.
3	Steel girders and RC Slab	Damaged barriers, modest abutment foundation, steel parts need painting.
4	3 Steel Beams and RC Slab	Sound, but needs changing the low steel barrier
5	RC slab & Steel truss	Even with good abutment, but not safe for cars and passengers because of lacking the steel barrier.
6	RC slab & Steel truss	Needs major repairing in the superstructure, deck repairing, painting the steel components, the electrical cable should be protected by a pipe or transferred.
7	Steel truss	Long bridge with serious corrosion, needs repairing for the corroded parts
8	RC slab & Steel truss	An ancient bridge, corroded parts, however still capable for transportation passengers and small cars. It's preferable to build new one instead.
9	RC slab & Steel truss	Sound, however, the corroded barriers and the abutment damaged regions should be repaired.
10	Overlapped steel plates	The steel barriers and the slab need repairing, wing walls are also needed. The deck needs repaving.
11	Steel Pinned connection	Sound, its steel deck and wing wall need repairing
12	Concrete pipe with steel and wood and soil long dick	Water pipeline holder, no steel barriers, narrow, for passengers only, not safe, not paved. New bridge should be constructed instead.
13	Steel truss with steel checker plate	Corrosion of steel barrier and parts of the abutment need repairing. Narrow; Wider bridge is preferable in the place.
14	Steel truss	Sound, but serious corrosion of the steel truss. Needs cleaning and painting
15	RC slab supported by 3 steel beams	The highest bridge, sound, however, the steel beams need painting, the damaged barriers need repair, the deck surface in some regions needs repaving.
16	Steel truss and steel checker plates as wearing surface	Sound, but needs repairing the corroded parts and the deck surface.
17	Steel truss with RC slab	Serious corrosion of the steel parts of the bridge
18	Steel Truss with steel checker plate	Sound, but corrosion of the steel parts, and the reinforced concrete of the abutments. Deck surface needs repair.
19	Steel Truss with steel checker plates	Low quality, for passenger only, may be damaged when water level rises.
20	Steel Truss with steel checker plates	Old bridge. Serious corrosion of the barriers and the steel parts of the deck. Unsafely region at the bridge end (missing enough barrier)
21	Steel Truss with steel checker plates	Sound, barriers corrosion, the deck needs repaving.
22	Stone with wood and steel	Sound with good abutments, needs barriers painting.
23	Steel Truss with steel checker plates	Sound, the truss needs painting
24	Steel truss with RC Slab	Used just for passengers, Includes water pipes, needs major repairing for the corroded parts
25	Steel Truss with steel checker plate	Sound, needs painting and cleaning of the steel deck
26	Suspension cables with wood	Although it is not heavy bridge, but it is sound and structurally efficient
27	Stone with steel , soil long dick	Needs replacement by new bridge. Safety standards are missed.
28	Steel truss with RC Slab	Old, the deck, superstructure and substructure components missed strength and safety standards. It needs replacement by new bridge.
29	Steel Truss with steel checker plate	New, sound
30	Stone with wood and steel	Old, as a link for water transportation only.
31	Steel Truss with steel checker plate	Sound
32	Steel with a concrete slab	Sound, but corrosion of some parts of the reinforced concrete substructure
33	RC slab supported by steel beams	Needs repairing the corroded barriers, steel beams and deck surface.
34	Steel truss with steel checker plates	Sound, but corrosion of the barriers, the reinforced concrete of the abutment, deck joints needs repair
35	Steel beams with steel plates	Needs painting and deck surface repairing.
36		Not Reachable
37		

38	Steel Truss with steel checker plate	Sound, but needs painting and repairing the corroded parts of the abutments, unsafely low barriers.
39	Steel truss with steel checker plate	
40	Suspension cable bridge	Needs two towers for suspending cables
41	Steel Truss with steel checker plate	Sound, needs wing wall
42	Stone and wood with soil	Old, not safe , should be replaced by new ones.
43	Stone and wood with soil	
44	Stone and wood with soil	
45	Stone and wood with soil	

The map of Soran bridges is illustrated in figure 3.

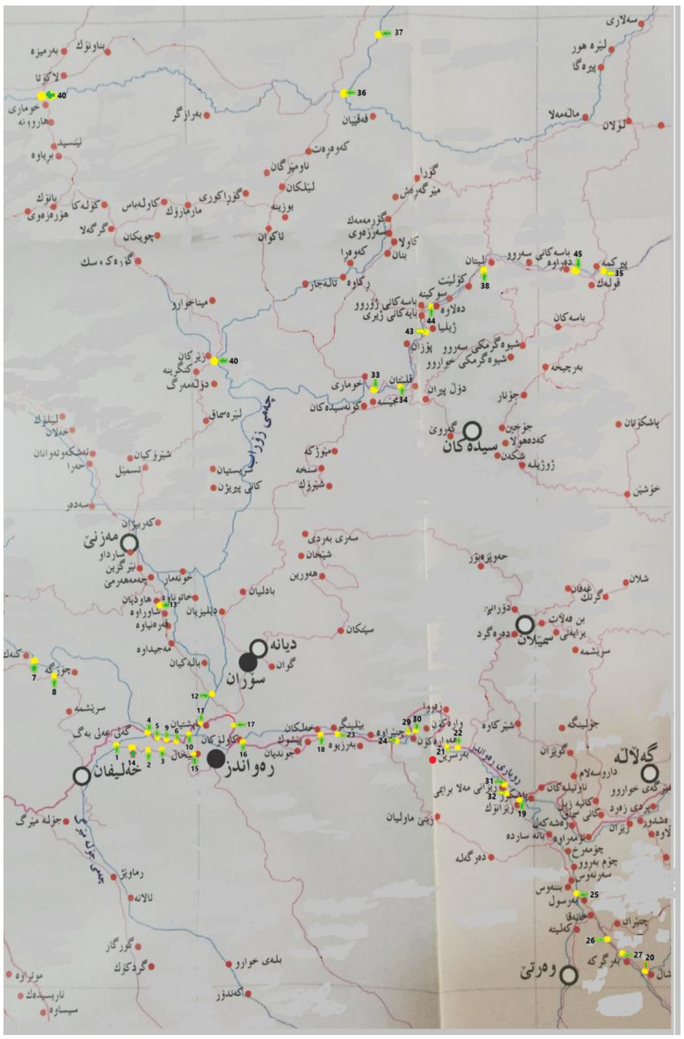


Figure 3: Map of Soran bridges (the bridges are represented by yellow bold circles)

The findings from field survey we have carried out on the bridges for the four sub-districts (Diyana, Khalifan, Rawanduz and Sidekan) of Soran are summarized as the following:

1. Most of the bridges appear to have been structurally sound. As part of the investigation, the inspection records as well as the damages notes and repairs should be made to the bridges are reviewed in Table 1. However, most of the bridges need lot of maintenance including cleaning and painting the corroded steel parts, repairing the steel deck surfaces and the asphalt joints as well as repaving the asphaltic surfaces. Corrosion of the reinforced concrete of the bridges abutments, piers and wing walls was serious and remarkable for some bridges (Fig. 3), thus needs urgent maintenance and proper repairing practices in order to improve the bridge structures durability.

2. Most of the bridges included in this study are constructed without wing walls (the short section of wall at an angle to a bridge abutment, used as a retaining wall and to stabilize the abutment), thus may affect negatively on the bridges performance.

3. Some bridges have low steel barriers (truss). Higher steel barriers may be required in order to avoid trucks accidents.

4. Pipelines for tap water supply are expanded along the deck surfaces of some bridges without appropriate protection against mankind accidents or environmental pollution, which may resulted in blocking tap water supply in case of trucks accident or pipe corrosion problems. Moreover, the water pipes are expanded on the internal part of the steel truss, while construction accurate insulated water pipes outside the steel truss is the safer and the proper approach.

5. High percentage of the bridges are narrow and of one-way traffic.

6. One of the interesting things in the present survey is the few ancient bridges we investigated. Those bridges are unique single-span bridges crossing the banks of the rivers. It is believed that those old bridges perhaps dating back to far-age times. Two of the bridges rest precariously on the edge of natural rock outcrop.

7. There is no bridge signs for most of the bridges under survey. Generally, two types of bridge signs exist, the bridge makers sign which advertises the bridge builders, the year built or the year of reconstruction, and the bridge plate sign which advertises the legal dimensions and weights limits for the transport infrastructure.

8. Across Kurdistan region, millions of dollars are consumed to the preservation of buildings, schools, and other cultural landmarks. Often, however, the local ancient historic bridges fail to make the list. Somehow we must elevate the importance of our ancient bridges that identify the communities of our nation.

9. Collapsing of some bridges apparently was the result of accidents such as a collision between the tractor-trailer's cargo and the bridge when a tractor-trailer hauling an oversized load hit one of the bridge's (superstructure).

10. Some villages in Soran are still in urgent needs of bridges.

11. Some bridges are not safe and should be renewed by new ones.

12. No cathodic protection system are used for bridges corrosion prevention.

CONCLUSIONS AND RECOMMENDATIONS

The recommendations could be derived from the present work are:

1. Focus is to specify available funds toward the specific needs of each bridge, improving safety and access across the district, which bolsters economic growth.

2. Make preserving bridges a priority, which extends their usable lives and prevents costly repairs in the future.

3. Before planning a complete bridge replacement, instead we should determines if parts of the bridge can be repaired or replaced. We use this information to evaluate whether it is more cost-effective to replace the bridge or if less expensive improvements will extend its useful life. By doing the right work, on the right bridge, at the right time, we can stretch our money further.

4. Saving bridges is frequently a complicated and time-consuming process. Governmental procedures should be in place to help according to the implanted governmental rules and regulations. Although replacement is almost always seen as the cheaper, and thus, best route, but for historic bridges the intrinsic value of the bridge itself will be lost.

5. Our recommendation concerning the historic bridges are: a. Inclusion the old historic bridges on the National Register of Historic Places. b. Identification of and communication with individuals and groups interested in the preservation of historic bridges. c. Consultation with public officials to devise reasonable alternatives to demolishing or adversely affecting historic bridges. d. Development of educational programs to promote awareness of historic bridge. e. Rehabilitation of the historic bridges should be carried out without affecting the historic integrity of the Bridge, but, if the bridge is so structurally deficient and/or it is seriously deficient geometrically, it could not be rehabilitated to meet minimum acceptable load requirements without affecting the historic integrity of the bridge.

6. When planning bridge construction, transportation planners and design engineers should work with interdisciplinary teams (biologists, hydrologists and ecologists) to consider designs that minimize impacts of bridge construction to fish, wildlife and movement corridors over space and time.

7. The challenge for Kurdistan governments is to increase bridge investments to address the budget in needs for deficient bridges across Soran.

8. Soran needs strong leaders dedicated to investing in its bridges.

9. Protection the bridges from corrosion is highly recommended using (polymer coatings and cathodic protection).

10. Routine inspection and maintenance such as drainage and joint systems and repair of cracks is recommended.

11. Wing walls for retaining wall and to stabilize the abutment of the bridges are highly recommended when construction new bridges.

12. Land scanning and general surveying should be held for the far villages to realize the actual number of bridges needed to link the villages within the transportation network of Soran district.

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