The International Journal of Engineering and Information Technology

journal homepage:www.ijeit.misuratau.edu.ly

The Impact of Increased Traffic and Explosion Loads on the Concrete Bridges Baniwalid Bridge - Case Study

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Abstract— **The Baniwalid Bridge is located at the entrance of the city. This bridge was implemented during the seventies of the last century and was opened to traffic in the eighties. It is considered the main artery for traffic, linking the two sides of the city. Its length is about 500m, and its width is 20m. It has two directions; each direction is 8 meters wide. The construction system of the bridge consists of 31 average spans, each of which is 14.5 meters long, and each span consists of 18 pre-stressed beams, with a height of 0.72 meters and a width of 1.00 meters. Traffic increased within the city in previous years as a result of the closure of the coastal road, which led to a change in the movement of freight and land transport to eastern and southern Libya through the cities of Baniwalid and Gharyan, where the bridge was subjected to very high traffic loads that far exceed the design loads. In this study, the bridge was inspected, some previous reports were reviewed, and the construction status of the bridge was determined in general. There are many cracks in the bridge due to water, shells and increased traffic. The foundations were also exposed to erosion due to torrential rains. In general, the bridge needs immediate maintenance.**

Index Terms: **Traffic, Concrete bridges, explosion loads, visual inspection**.

I. INTRODUCTION

The need for bridges has arisen since antiquity and has developed with the development of mankind, and has witnessed a remarkable development in conjunction with the scientific progress in the field of structural engineering and the possibility of implementing bridges of reinforced concrete or steel or both together.

Bridges and tunnels are among the basic and important elements in any of the various transport networks, especially road networks. Despite this known importance, bridges have often received less attention as if they are those facilities that never need maintenance, repair, and can serve for many years in this case. This way of thinking leads to the wheel of damage becoming greater than the wheel of repair, where the structure becomes in need of replacing some elements and sometimes completely re-constructing in order to be able to perform the function [1]. A bridge is defined according to paragraph (1-2) of the Bridge Design Manual (MA-100-D-V1/2&V2/2) as any structure with a span of not less than 6.1 m, and that forms part of the road or passes under or over it. Bridges are a means for the continuity of roads across waterways, valleys, or roads perpendicular to them, where a clear passage is provided for vehicles with shortening the time required for traffic lights at crowded intersections [2].

The Baniwalid Bridge is located at the entrance of the city. This bridge was implemented during the seventies of the last century and was opened to traffic in the eighties. It is considered the main artery for traffic, linking the two sides of the city. Its length is about 500m, and its width is 20m. It has two directions; each direction is 8 meters wide. A median berth and on each side a berth for pedestrian movement. The construction system of the bridge consists of 31 average spans, each of which is 14.5 meters long, and each span consists of 18 pre-stressed beams, with a height of 0.72 meters and a width of 1.00 meters [3].

This facility is considered one of the most important vital facilities within the city, as it is not possible to pass from the northern part to the city center, which is the link between the north, south and west. The bridge is in a critical stage in which it needs great care and evaluation of the structural condition to start the restoration operations to avoid any collapses or going into a critical stage that makes it difficult to maintain.

Received 26 Oct , 2021; revised 6 Nov, 2021; accepted 6 Nov, 2021.

Available online 19 Nov, 2021.

II. STUDY PROBLEM

1. The most important problems facing the assessment of damages in concrete structures damaged by explosions is the lack of specialized technical teams in all Libyan cities, which are qualified to carry out the necessary visual inspections and tests.
2. Unavailability of architectural and construction maps for the bridge.
3. The bridge has exceeded its design life and has never been maintained for periodic preventive maintenance.
4. The bridge is subjected to traffic loads that exceed the design loads due to commercial trucks, as the drivers not complying with the permitted standard weights
5. The bridge was exposed to many shells and explosions.
6.Throwing garbage and setting fires next to the foundations.
7.Soil erosion under the bridge foundations due to torrential rains.

III. STUDY OBJECTIVES

Assess the current status of the bridge as an important part of the city's infrastructure and is a vital component due to its geographical location

IV. METHODOLOGY

The system of field visits and visual inspection was only used, in addition, some previous reports regarding to the bridge was reviewed.

V. CONCRETE BRIDGES DAMAGE TYPES

Damages of concrete bridges are classified according to their location in the bridge structure as follows:

5.1 Abutments and Piers damage

Damage to concrete cracking by rusting of rebar, and perhaps this is one of the most common types of damage to city bridges, and the reason is due to the method of irrigating crops, and there are other reasons, including the lack of insulation for concrete, in addition to the insufficient concrete cover for rebar.

5.3 Bearing damage

The bearings are the element that connects the upper part of the bridge with the lower part and they transfer the loads from the upper part of the bridge to the lower part of it, and allow the rotation of the upper part of the bridge due to the dead load and the live load, as well as allow the horizontal movement of the upper part of the bridge as a result of expansion and contraction.

5.4 High Truck crash damage

It often occurs in bridges with irregular heights intended for vehicles to cross under the bridge structure, and the damage caused by the impact is often localized and does not affect the safety of the vehicle neither the bridge.

5.5 Expansion joints damage

It usually occurs in bridges with conventional joints or without joints, where the voids are filled with dirt and gravel, prevent movement of the slabs, and lead to cracking of the asphalt layer over these expansion joints.

5.6 Protective barriers damage

This is a common and uncontrollable damage. The bridge guardrails are maintained by replacing the side guard panels with new ones or by increasing the lateral support for these sideboards and guardrails [1].

VI. EXPLOSIONS LOADS AND FIRE

Explosions are considered to have destructive effects on building facilities, and when damage occurs in a particular building as a result of an explosion, a set of basic principles of work must be known from the point of view of entering the building and its description and knowing the facts from the effects and evidence at the site of the accident [4].

Explosion sources are classified into two basic types, conventional explosions and nuclear explosions. Table No: (1) shows the sources of each type of explosive:

Table 1. The sources of explosives

conventional explosions	**nuclear explosions**
Chemicals and fuel	Accidents at nuclear facilities
steam	Nuclear weapons in wars and explosions
combustible powders	Nuclear explosions
pressure vessels	
Explosives	
High explosives	

6.1 The destructive factors of the explosion:

The explosion results four main effects as shown in figure 1 and in the form:

6.1.1 The shock wave:

It is a great pressure in the air that affects things in the form of a pressure wave of a very large force, followed by a disturbance, especially in the circle near the site of the explosion.

6.1.2 The high temperature:

The explosio n within the circle near the site of the explosion generates high thermal energy represented by a burning flame at high temperatures.

6.1.3 The fragments:

The explosion also produces, due to high pressure, flying fragments of the explosive material, in addition to fragments and parts of the explosion site flying randomly, which are of great danger to neighborhoods and facilities.

6.1.4 The sound wave:

The fourth effect that results from the explosion is the loud sound, which is not a very destructive effect compared to the previous three effects.

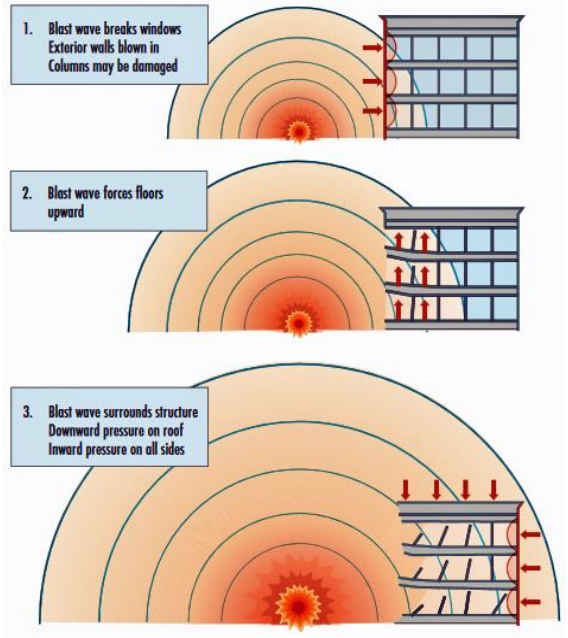

Figure 1. The main effects of the explosions [1]

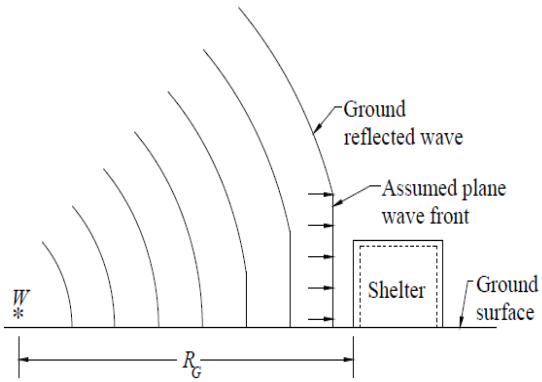

Figure 2. . Explosive factors at the Earth's surface[6]

6.2 The effect of fire on concrete structure

Fire and the rise in temperatures it causes are phenomena that must be given special importance due to their impact on the durability of concrete structures, In order to properly assess the durability of structures and the durability of the various structural elements. It is necessary to determine the specifications of the structural materials after being exposed to high temperatures, as there is a change in the physical and mechanical properties of concrete and steel reinforcement depending on its type, the temperatures to which it is exposed and the duration of its impact.

Metal	Melting Point in Deg. F.
Aluminum	1220
Barium	1562
Bismuth	520
Boron	4172
Brasss	1823
Bronze	1841
Calcium	1490
Chromium	2939
Cobalt	2696
Copper	1981
Gold	1945
Iridium	4262
Iron cast	2000
Iron wrought	2750
Lead	621
Magnesium	1204
Manganese	2300
Molybdenum	4748
Nickel	2651
Platinum	3224
Silver	1761
Steel, Carbon	2500
Telurium	846
Tin	449
Titanium	3272
Tungsten	6098
Vanadium	3110

Figure 3. Melting point of metals [6]

VII. BANIEALID BRIDGE

Figure 4. Baniwalid Bridge

7.1 Bridge Components

Asphalt layer, bridge beams, medial pilings, bridge shoulders, rubber pads, metal floors and curbs, bridge foundations, expansion joints, control joints, metal fencing, lighting system, rainwater drainage channels and approach slab.

7.2 Visual inspection

In this paper, the bridge was examined ostensibly (Visual inspection) only, in order to identify the problems of the bridge components.

7.2.1 Traffic

As previously reported, the bridge is the vital artery of the city of Baniwalid, and as shown in figure 4, it is the only entrance to and from the city to the south and east of Libya. The traffic within the city has increased in last

years because the coastal road has been closed. The freight and road traffic for eastern and southern of Libya through has changed to the cities of Baniwalid and Garyan, where the bridge has been being subjected to very high traffic loads that exceed the design loads, where in some marble trucks it has reached approximately 60 tons [8]. This has been detrimental to the appearance of many fractures, cracks and construction problems, as shown in figure 5 and figure 6

Figure 5. Traffic load

Figure 6. Traffic load

7.2.2 Asphalt

It has been observed that there are many problems, where longitudinal cracks parallel to traffic, occasional and crocodiles cracks are spreading, and some parts of the road above the bridge are swollen. There is also some damage because of explosions and shells, as shown in figure 7 and figure 8.

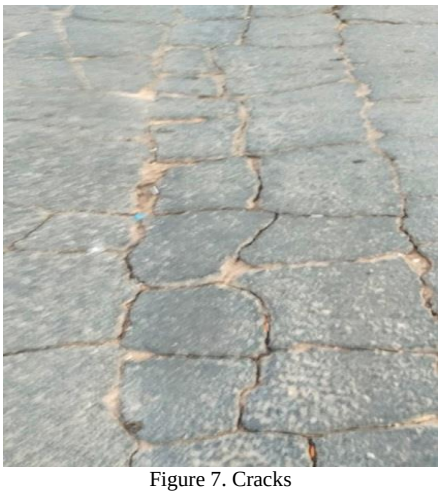

Figure 7. Cracks

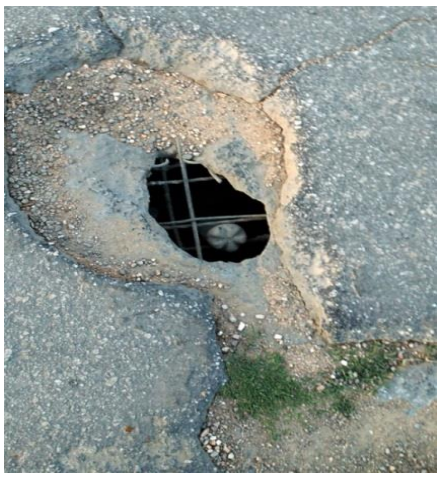

Figure 8. Explosion holes

7.2.3 Bridge beams

As shown in figure 9, 10. The metal cables of the box beams suffer greatly from rust, and there are breaks in some metal cables, in addition to the corrosion of the end of some of the beams. There are also longitudinal cracks parallel to the reinforcing wires in most of the beams due to high traffic stresses and water leakage from the top of the bridge because of the damage of the expansion joints and blockage of rainwater drainage holes.

Some of the beams were disintegrated due to explosions and direct exposure to missiles, which led to the occurrence of gaps and stripping of rebar and exposure to weather factors, which led to its corrosion and exposure to rust and thus cracks in the concrete cover.

Figure 9. Reinforcement steel rust

Figure 10. Collapse of concrete cover

7.2.4 Concrete pillars:

The cracks are widely spread due to the same reasons mentioned above, in addition to the impact of the piles in high temperatures due to the dumping of garbage and the setting fire next to them as shown in figures 11, 12.

Figure 10. Bridge Pillars.

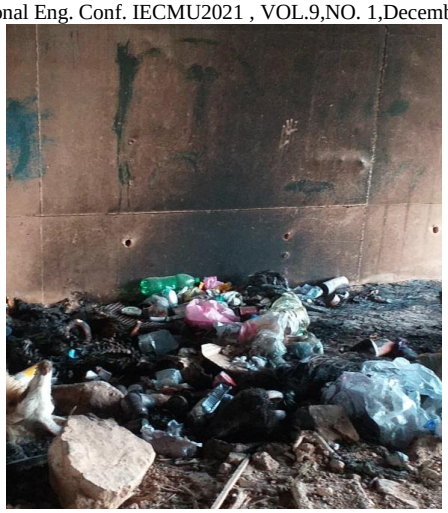

Figure 11. Setting fire under the bridge.

7.2.5 Rubber pillows:

They are rubber pieces used to allow the beams to move on top of concrete pillars, and suffer from lack of maintenance and cleaning, as dust accumulates on them due to damage to the expansion joints and prevents them from performing their function.

7.2.6 Bridge foundations:

The soil surrounding the foundations is eroded annually due to torrential rains and floods, which led to the appearance of some foundation concrete completely and exposed to high temperatures due to garbage and fires.

There are many cracks varying between shallow and deep, and there is obvious corrosion in the reinforcement steel.

7.2.7 Expansion joints:

All bridge expansion joints suffer partial or complete damage due to long service life and lack of renewal and maintenance; It is currently filled with dust and dirt and causes rainwater to leak into the concrete bridge body and as shown in figures 12, 13.

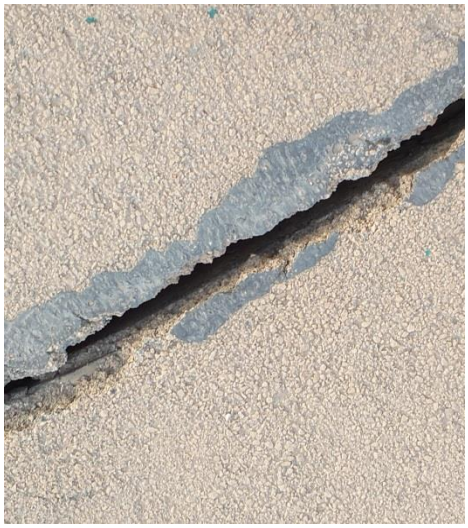

Figure 12: Expansion joints.

Figure 13. Expansion joints.

7.2.8 Sidewalks and footpaths:

Figure (14) shows that the Sidewalks and pedestrian paths suffer from the same reasons mentioned above, where some sidewalks were exposed to rocket and missile explosions, weather erosion and rain water accumulation.

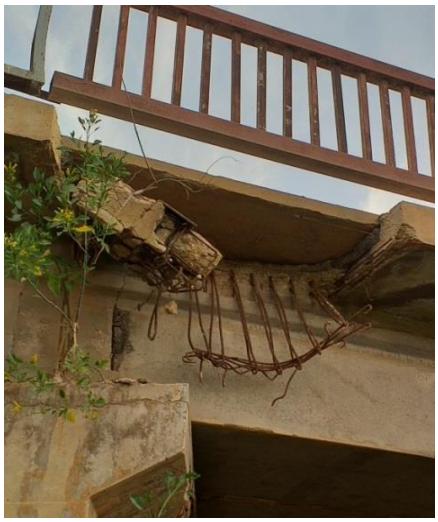

Figure 14. Sidewalk explosion.

7.2.9 Protection metal fence

There are many deformations, collapses and corrosion in the iron fence body for various reasons, including traffic accidents, missiles, acts of sabotage and theft, as shown in figures 15, 16.

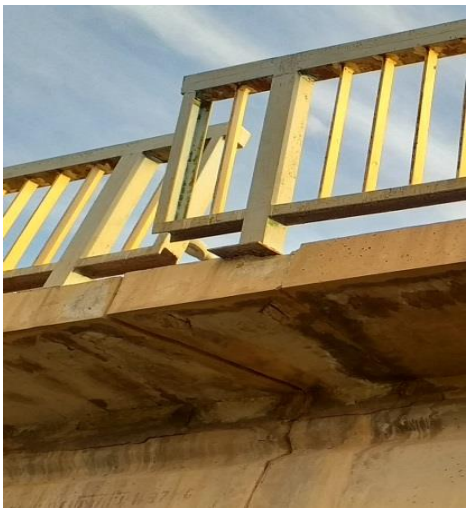

Figure 15. Iron fence slope.

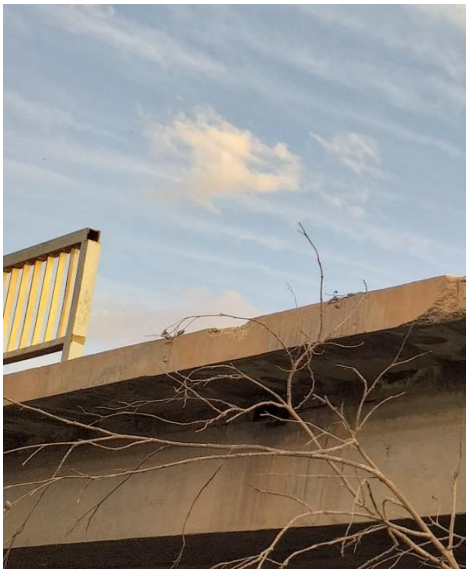

Figure 16. Metal fence robbery.

7.2.10 Rainwater drainage channels

All rainwater drainage holes and pipes need maintenance and cleaning in order for the water to drain well.

7.2.11 Approach slab

There is obvious horizontal creep in the approach slab at the south end of the bridge; it can be seen in figure 17.

Figure 17. Horizontal crawling of the approach slab.

VIII. RESULTS DISCUSSION

1. The spread of cracks on the surface of box beams, piles, asphalt and foundations due to several factors, the most important of which are the chronological age of the bridge, the absence of periodic maintenance, increased traffic loads, explosions and fires.
2. The presence of some holes in the bridge body and box beams due to the fall of the shells.
3. The foundations of the bridge were exposed to erosion factors due to rain and torrential rain.
4. Most expansion joints are completely damaged and do not perform the role for which they were created.
5. Rainwater seeps into the bridge beams due to the blockage of the water drainage holes and the wear of the expansion joints, which negatively affected the concrete bridge body.
6. There is obvious horizontal creep in the approach beam.

IX. RECOMMENDATION

1. Adjust traffic and traffic weights as a first step in the bridge straightening and maintenance process.
2. Do more examinations and laboratory tests to determine the exact structural position.
3. Rapid maintenance of rainwater drainage holes.
4. Rapid maintenance of expansion joints.
5. Re-backfilling the foundations and implementing a stone tamping to reduce the drift process.
6. Treating cracks and rust on reinforcement steel.

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