



## WOODEN BRIDGES IN EGYPT DURING KHEDEIVE ABBAS HELMY II: AN ARCHAEOLOGICAL DOCUMENTARY STUDY OF SAMPLES

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### ABSTRACT

This study investigates wooden bridges established during the reign of Khedive Abbas Helmy II. These bridges are known solely through historical and archaeological documents preserved in the Egyptian National Archives. This investigation includes five wooden bridges in Lower Egypt, such as the Umm Galagil Canal Bridge. In Upper Egypt, three wooden bridges on the Magaga canal and the Aba Waqf wooden bridge. The research further revealed the interest of Khedive Abbas Helmy II in constructing bridges on the Nile and its branches, as well as the identity of their architects. The documentary study identified the types of wood used and their characteristics, as well as the reason for establishing these bridges, determining their location and cost, and identifying the date of their construction.

### المخلص

يهتم هذا البحث بدراسة الجسور (الكبارى) الخشبية التي أقيمت في عهد الخديوي عباس حلمي الثاني من خلال الوثائق التاريخية المحفوظة في دار الوثائق القومية المصرية. وتضمنت هذه الدراسة خمسة جسور خشبية منها ما هو بالوجه البحري مثل جسر ترعة أم جلاجيل، ومنها ما هو بصعيد مصر مثل ثلاثة جسور خشبية على ترعة مغاعة، وجسر أبا الوقف. وأظهرت الدراسة اهتمام الخديوي عباس حلمي الثاني ببناء الجسور على النيل وفروعه. وتمكنت الدراسة الوثائقية من تحديد هوية معماري هذه الكباري، وكذلك أنواع الأخشاب المستخدمة وخصائصها، وسبب إنشاء هذه الجسور وتحديد موقعها وتكلفتها وتحديد تاريخ تشييدها.

### Keywords:

Wooden Bridge, köprüler, Upper Egypt, Abbas Helmy II, The Nile River, Wooden architecture.

### الكلمات الدالة:

الجسور الخشبية؛ الكبارى؛ صعيد مصر؛ عباس حلمي الثاني؛ نهر النيل؛ العمارة الخشبية.

### INTRODUCTION

The family of Muhammad Ali Pasha was interested in digging canals and constructing bridges.<sup>1</sup> During that period, the materials used in building bridges varied between iron, stone, bricks, and wood. Iron and stone bridges were constructed on the banks of the Nile and its two branches. Examples of iron bridges include the Imbāba Bridge,

<sup>1</sup> Shafei Bey, *A'mal Almanafi' Al'ama*, 25-32; Eid, *Monshat Alnile*, 396-336.

Nag Hammadi Bridge, and Banha Bridge.<sup>1</sup> The El Qanater el Khayreya, Assiut<sup>2</sup>, Esna, Edfina,<sup>3</sup> and Bagouria Barrages are stone bridges.<sup>4</sup> Brick and wooden bridges were constructed on canals, and this study focuses on those made during the period of Abbas Helmy II<sup>5</sup> by using inductive analysis of the sources.

This study focuses on structures in Lower Egypt and others in Upper Egypt, which form the study's geographical framework during that period. Previous studies investigating bridge architecture and engineering during that period did not consider wooden bridges. Among these were the studies of Hassan Ahmed El-Sherbiny and Ahmed Mustafa Yassin (1970) entitled *Handasat al-Rayi wa al-Sarf*,<sup>6</sup> the study of Roshdy Said (2001) *Nahr al-Nil nash'atah wa istikhdam miahih fi almadi wa al mustaqbal*,<sup>7</sup> Gamal Fathi's doctoral thesis (2009) *Monshat miah al niyl fi Misr fi' ahd al usra al'alwya*.<sup>8</sup>

Unfortunately, most of the ancient wooden bridges made in Egypt during the time of Khedive Abbas Helmy II have been destroyed. The historical documents preserved in the Egyptian National Archives suggest their architecture, like engineering drawings, weather plans or vertical sections, and contracts signed between the government and the contractor (containing materials, cost, construction dates, and the architect's name) are included. The historical sources for that period, such as the Nile calendar by Amin Sami Pasha,<sup>9</sup> focused on studying the stone and iron bridges above the Nile and and its two main branches and neglected the wooden bridges, so this study tries to focus on wooden bridges.

## TYPES AND TERMINOLOGY<sup>10</sup> OF BRIDGES

Traditional bridge design includes wooden, pontoon, beam, suspension, and arched stone.<sup>11</sup> Wooden bridges were prominently used during Abbas Helmy II due to the ease and simplicity of construction and their suitability for the environment.

The most important technical terms are 'beams', 'planks', 'wheel guards', and 'vertical beams'. The term 'beam' refers to the thick cross-section of wooden pieces on the axis of the canal, which holds the longitudinal planks. 'Planks' refer to the slender wood pieces placed longitudinally on the canal axis and resting on the beams. 'Wheel guards' refer to a piece of wood set on either side of the bridge to secure the planks

<sup>1</sup> Tignor, *Modernization and British Colonial Rule*, 180-213; Samy, *Mulhaq taqwim alniyl*, 120-124; Eid, *Monshat Alnile*, pp. 396-336.

<sup>2</sup> Colvin, *The Making Of Modern Egypt*, 222-227, 255- 257, Shafei Bey, *A'mal Almanafi' Al'ama*, 47-58; Samy, *Mulhaq taqwim alniyl*, 87-88, 110.

<sup>3</sup> Leliavsky, *Irrigation Engineering – Canals and Barrages*, vol. 1, 203, 239, 276.

<sup>4</sup> B. Rivlin, *The Agricultural Police of Muhammad Ali*, 283; Badr, "The Bagouria Barrage", 1-52.

<sup>5</sup> Abbas Helmy II was born in Cairo in 1291 AH / 1874 AD, and he is one of the rulers of Egypt from the family of Muhammad Ali. He assumed the governance after the death of his father in 1309 AH / 1892 AD, and he continued to rule Egypt until 1333 AH / 1914 AD. He died in 1363 AH / 1944 AD. Zydani, *Tarajim mashahir*, vol. 1, 65-66; Fahmy, *Şafwat al 'asr*, 81-82.

<sup>6</sup> El-Sherbiny and Yassin, *Handasat al-Rayi wa al-Sarf*, 1970.

<sup>7</sup> Said, *Nahr al Niyl nash'atah wa istikhdam miahih fi almadi wa al mustaqbal*, 2001.

<sup>8</sup> Eid, *Monshat Alnile almayiya bimisr fi 'asr alousra al'alwiya "dirasa atharia muqarana*, (2009).

<sup>9</sup> Samy, *Mulhaq taqwim alniyl 'an aljusur walqanatir wa alkabary wa alkhazanat 'alaa al nile wa furu'oh bi misr wa alsuwdan min fajr altaarikh elaa alan*, (1936).

<sup>10</sup> The terminology adopted follows the one used by the architects of the wooden bridge in plans and sections; it is illustrated in Fig. 1

<sup>11</sup> Steinman, "Bridges", 61; Petersen, "Roman, Medieval or Ottoman: Historic Bridges", 175.

firmly. 'Vertical beams' refer to a longitudinal segment of wood with a pointed spear base fixed in the ground (Fig. 1).

Beam wooden bridges are the oldest and simplest bridge design.<sup>1</sup> It consists of vertical piers and horizontal beams - e.g. a simple plank. They are only suitable for short spans. Therefore, the bridge length ranged from 8.5 m on the Magaga Bridge<sup>2</sup> to 11.5 m on the Aba Al Waqf Bridge and 12 m on the Umm Galagil Bridge. The system can be used for wider crossings by adding additional piers.

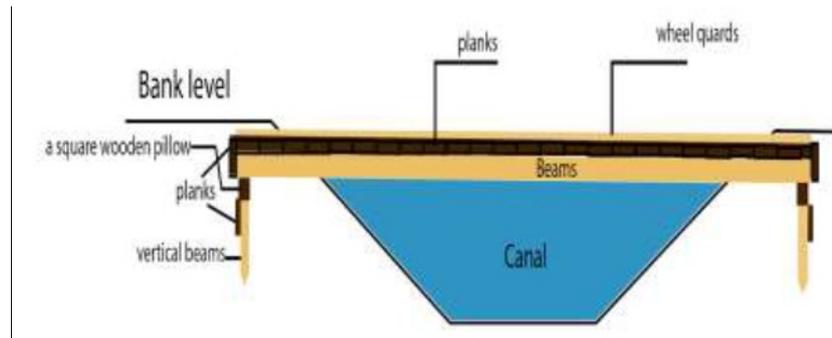


Figure (1) Technical terms for describing wooden bridges

## THE GEOGRAPHICAL FRAMEWORK OF THE STUDY

The Nile River is the primary water source for Egypt and extends from the south of Egypt to the north. It divides itself into two branches in Cairo, the Rashid branch and the Damietta branch.<sup>3</sup> During the era of the family of Muhammad Ali Pasha, the rulers of Egypt constructed bridges on the course of the Nile and its branches or canals.<sup>4</sup> Some bridges were built over canals emerging from the Nile to irrigate agricultural lands. Among the canals in the period under study, are the canals named Ibrahimiyya, Ismailia, Mahmudiya, Bahr Yusef, Mansuriyya, Sahel, Sharqawiya, Magaga, and Umm Galagil.<sup>5</sup> As stated, the study focuses on selected models throughout the country.

## HISTORY OF WOODEN BRIDGES IN EGYPT FROM THE MAMLUK ERA

The Mamluk sultans were interested in building bridges over the Nile and its branches to connect its banks. Sultan Baybars renewed bridge construction linking Rowda and Giza and between Rowda and the coast of Cairo. No such bridges were mentioned during the Ottoman era; perhaps the crossing of the Nile was restricted to boats.<sup>6</sup> The French campaign built two bridges of ships lined up next to each other, from Rowda

<sup>1</sup> Ritter, *Timber Bridge*, 7-97.

<sup>2</sup> Magaga: It is one of the centres of Minya Governorate. A decision was issued to establish this centre in 1890, and it is located on the western shore of the Nile River. Mubarak, *alkhutat altawfiqiya aljadida limisr alqahira*, vol. 15, p. 70; Ramzy, *Alqamous Algoghrifi Lilbilad ALmisria*, vol. 4, 26.

<sup>3</sup> Said, *Nahr al Nil*, pp. 9-13; El hosany, *Nahr alnil fi misr munhanyatih*, pp. 18-38.

<sup>4</sup> Samy, *Mulhaq taqwim alniyl*, pp. 1-130; Leliavsky, *Irrigation Engineering – Canals and Barrages*, vol. 1, p. 203, 239, 276.

<sup>5</sup> Eid, *Monshat Alnile*, pp. 83-105.

<sup>6</sup> El Shishtawy, *Mutanazahat alqahira fi al'asrayn almamluky wa aluthmany*, p. 83.

to Giza and the north of Al-Qasr Al-Aini to Al-Rowda. This last one did not last more than three years.<sup>1</sup>

Paintings of travellers and orientalists during the Nineteenth century show the design of wooden bridges in Egypt before Abbas Helmy II. Their design was simple, following the beam style, with wooden beams extending between the two banks and resting in the centre on stone pillars; wooden panels topped the beams. For instance, the paintings by the French artist Charles Théodore Frère, who visited Cairo in 1869 accompanied by Empress Eugénie,<sup>2</sup> show such wooden bridges in Cairo and Upper Egypt (Fig. 2.b). The Muhammad Ali Pasha Mosque (Fig. 2.a) appears in the background of the painting from Cairo. Wooden railings often used to protect pedestrians from falling into canals, are absent from the sides of the bridges. Some animals are crossing it, while the background shows palm trees.



Figure (2) two pictures of the French artist Charles Théodore Frère, a. Wooden bridge near the citadel of Salah Eldeen in Cairo, b. Wooden bridge in Upper Egypt

## SPECIFICATIONS OF WOODEN BRIDGES AS MENTIONED IN THE DOCUMENTS

The Umm Galagil canal bridge documents record the specifications for its woodwork.<sup>3</sup>

"1. Wherever woodwork is indicated in the drawings or ordered to be used in any work, in the absence of further orders, the timber required must be understood to be straight, thoroughly sound, well-seasoned yellow pitch pine of the best quality, free from cracks, flams, and other defects."<sup>4</sup>

"2. It must be dressed square and true to the dimensions required. Its section must be uniform along its length and fitted neatly and exactly into position, in a proper workmanlike manner."<sup>5</sup>

"3. All moderate lengths of timber must be in single pieces in the case of piles, beams, rafters, struts, ties, and all similar important pieces without exception

<sup>1</sup> El-Jabarti, *'aja'ip alathar fi altarajum wa alakhbar*, vol. 2, p. 267; El Shishtawy, *Mutanazahat alqahira fi al'asrayn almamluky wa aluthmany*, p. 84.

<sup>2</sup> She was invited by Khedive Ismail to attend the opening ceremony of the Suez Canal. She commissioned paintings of Egypt to Charles Theodore Frere. Stranahan, *Histoire de la Peinture Française*, p. 228; Bryant, *Images et Peintres Français*, 111.

<sup>3</sup> Documents of Umm Galagil canal bridge, Fig. 3.a, 3.b.

<sup>4</sup> Documents of Umm Galagil canal bridge, Fig. 3. a.

<sup>5</sup> Documents of Umm Galagil canal bridge, Fig. 3. a.

where, owing to the excessive length of pieces required or other special reasons, the use of more than one piece in a single length becomes necessary or desirable. The express approval of the government engineer in charge of the work to the arrangement proposed to be adapted must be previously obtained by the contractor. "<sup>1</sup>

"4. All woodwork fitting must be done by capable and experienced carpenters. Joints must be framed where necessary in the most approved manner suitable to the case and fitted with necessary iron bolts, ties, straps, nails, screws etc. Whether such be indicated on the drawings or not, these details are considered as forming an essential part of any woodwork, and their cost as well as that of fitting and erection, are included in the contract rate for woodwork."<sup>2</sup>

"5. Timber for rough outdoor work should not be planed unless expressly ordered and must receive one coat of the best coal tar or oil paint as ordered on all surfaces before, and another, with which has been mixed 6 pc of powdered lime. After erected, care was being taken to paint the last coat well into all cracks, joints, and corners of the work. "<sup>3</sup>

"6. Bridge flooring must be laid diagonally or transversally as may be ordered. The space between flooring planks must not exceed one centimetre. Bridges must be placed in position, such as to bring their flooring to a convenient level relative to the banks of the channel they cross, as fixed by the government engineer in charge of the work, and the earth approaches neatly made up to the required slopes as part of the cost of erection."<sup>4</sup>

"7. All piles must be shod with iron. "<sup>5</sup>

"8. The heads of piles should be hooped with (wrought iron) W.I. 2"  $\frac{3}{4}$ " thick, slightly wide at the bases, and fixed while hot on a notch cut in the head of the pile. The head of the pile must project 1.5" above the hoop".<sup>6</sup>

"9. The piles should be driven by a ram weighing 300 kilograms as a minimum: the set of the pile after 30 blows from a height of 1 metre should not exceed 0.20 metres."<sup>7</sup>

The wooden bridges' contracts indicated which wood had to be used (Documents of Aba al waqf canal bridge, fig. 16. b; general specifications for woodwork in Documents of Umm Galagil bridge, pp. 43-44, fig. 3. a). The architects used Pitch pine<sup>8</sup> (*Pinus rigida* Mill) which is found in North America (imported -not local wood).<sup>9</sup> Pitch pine was a major source of pitch and timber for shipbuilding, mine timbers, and railroad ties because it is resistant to cold, heat, and rain. It was therefore used for elaborate wood constructions, such as radio towers.<sup>10</sup> The contract between

<sup>1</sup> Documents of Umm Galagil canal bridge, Fig. 3. a.

<sup>2</sup> Documents of Umm Galagil canal bridge, Fig. 3. a.

<sup>3</sup> Documents of Umm Galagil canal bridge, Fig. 3. a.

<sup>4</sup> Documents of Umm Galagil canal bridge, Fig. 3. b.

<sup>5</sup> Documents of Umm Galagil canal bridge, Fig. 3. b.

<sup>6</sup> Documents of Umm Galagil canal bridge, Fig. 3. b.

<sup>7</sup> Documents of Umm Galagil canal bridge, Fig. 3. b.

<sup>8</sup> Pitch Pine: pitch pine belongs to Pinaceae family, *Pinus Gnu*s. Masternak and other, 1.

<sup>9</sup> Masternak and other, 1.

<sup>10</sup> Gluck, Pitch Pine–Scrub Oak Barrens, 10.

the contractor and the General Inspector of Irrigation for Upper Egypt included that the Aba al Waqf wooden bridge had to be constructed with Pitch Pine.

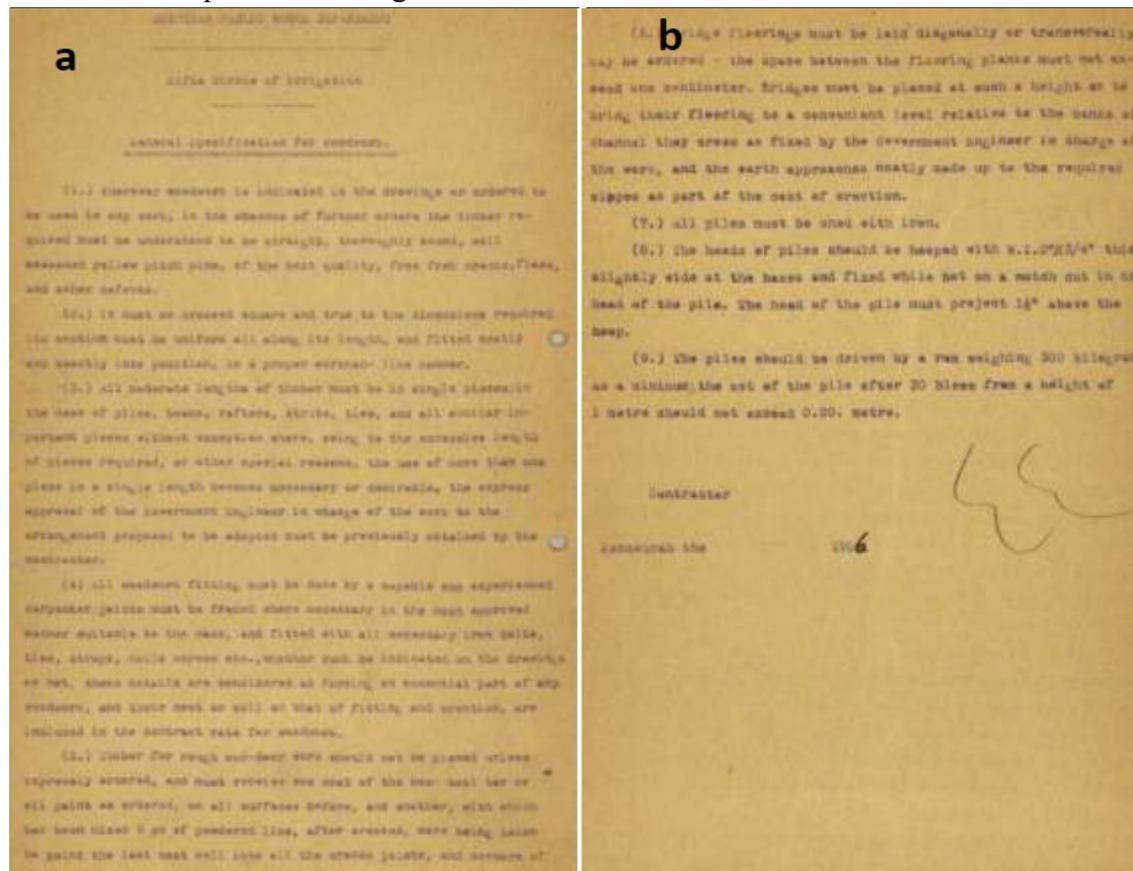


Figure (3) a. b. general specifications for woodwork in the Um Galagil bridge (Documents of Umm Galagil canal bridge, code no. 4003-025247).

## The Architecture of Wooden Bridges

The architecture of wooden bridges built during the rule of Khedive Abbas Helmy II is presented.

### The Umm Galagil canal Wooden Bridge

The bridge is located on the Umm Galagil canal, which branches from the Ismailia canal starting from the village of Sinita and extending to the city of Mansoura for more than 20 km. Umm Galagil is parallel on the east with the Damietta branch, as the distribution of 16 bridges on this canal through the map of Great Britain War Office/U.S. Army Map Service dating to 1941 reveals (Fig. 4). The study focuses on one of these bridges in the town of Sebennytos<sup>1</sup> (Fig. 4,5), located in front of the Sewage transport company (Fig. 5,6).

<sup>1</sup> Sebennytos: It is one of the centres of the Gharbia Governorate. A decision was issued to establish this centre in 1826, and it is located on the western shore of the Damietta branch. Mubarak, *alkhutaf altawfiqiya aljadida limisr alqahira*, vol. 12, 46-47; Ramzy, *Alqamous Algoghrafi Lilbilad ALmisria*, vol. 2, 9.

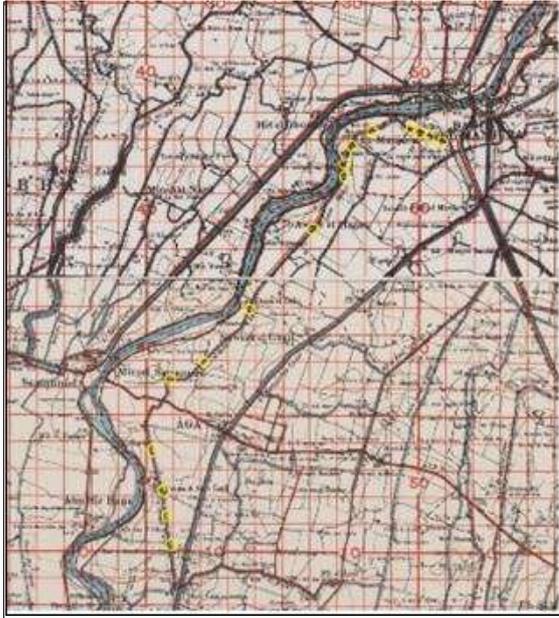


Fig.4.Map of Umm Galagil canal and its bridges, Great Britain War Office/U.S. Army Map Service, 1941.

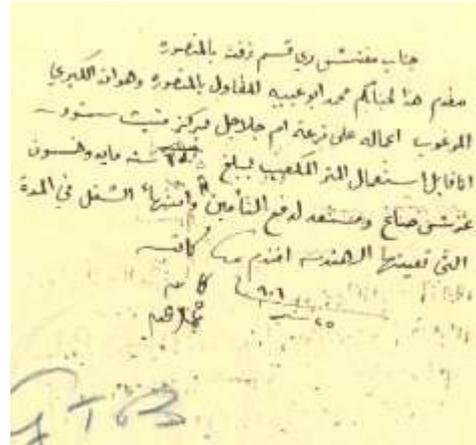


Figure (5) A letter sent to the irrigation inspector of the Zefta department in Mansoura mentioning the Umm Galagil Canal Bridge site in the city of Samanoud (Documents of Umm Galagil canal bridge, code no. 4003-025247, p. 18).

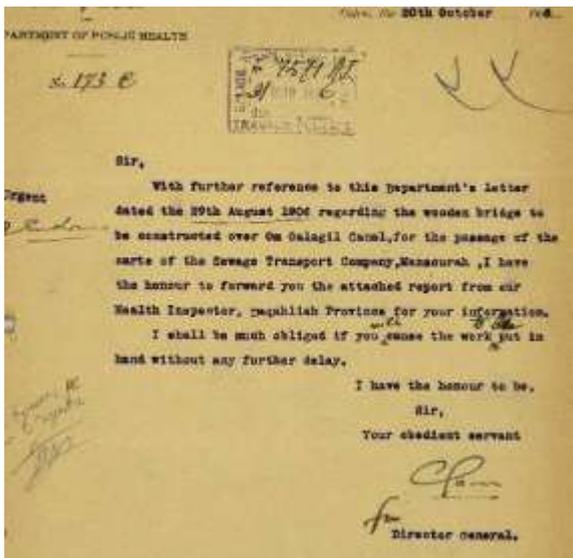


Figure (6) A letter from the Public Health Department of the Egyptian Ministry of Interior clarifies that the Umm Galagil Canal Bridge is in front of the Sewage transport company (Documents of Umm Galagil Canal Bridge, code no. 4003-025247, p. 33).

Umm, Galagil Canal Wooden Bridge	Long 12 m	3 beams <b>12 m long, 20 x 30 cm thick</b>	Span between beams 1.5 m	Planks (3 m wide, 20 x 10 cm thick).	Two wheel guards (12 m long, 15 x 15 cm thick)	Three vertical beams with pointed spear bases (each 1 m high, 20 x 20 cm thick)
	<b>Wide 3 m</b>					
	<b>Cube 8 m<sup>3</sup></b>					

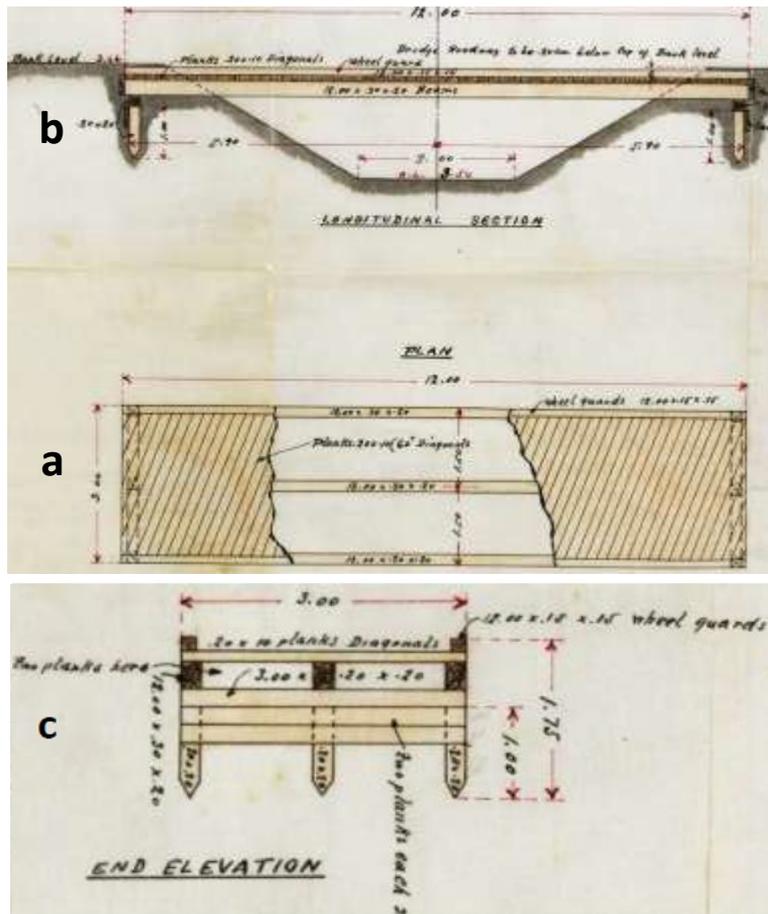


Figure (7)  
 a. Plan of Umm Galagil bridge,  
 b. Longitudinal section of Umm Galagil bridge,  
 c. end elevation of Umm Galagil bridge  
 (Documents of Umm Galagil canal bridge, code no. 4003-025247).

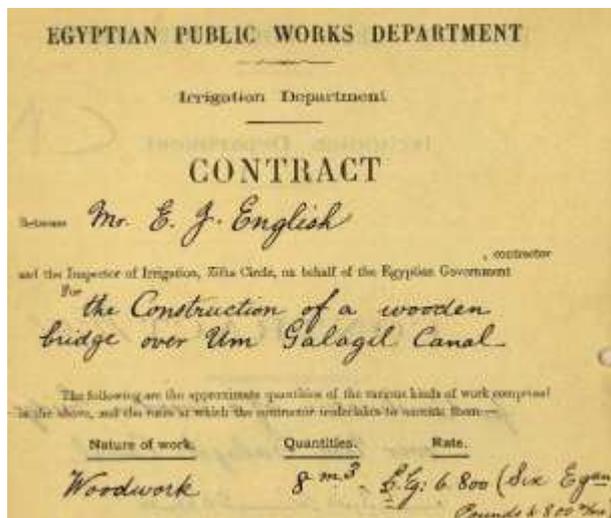


Figure (8) a. b. c. d.  
 Contract of a wooden bridge over Umm Galagil canal  
 (Documents of Umm Galagil canal bridge, code no. 4003-025247).

### Magaga canal Wooden Bridges

Three wooden bridges have the same design on the Magaga canal, which branches from the Ibrahimiyah canal starting from Magaga centre and extending to the city of El Fashn, according to a map from the Great Britain War Office/U.S. Army Map Service (1941) (Fig. 9). The first bridge is located at kilometre 1.200 (Fig.9), The second bridge is located at kilometre 1300, and the third wooden bridge is located at kilometre 4.700.

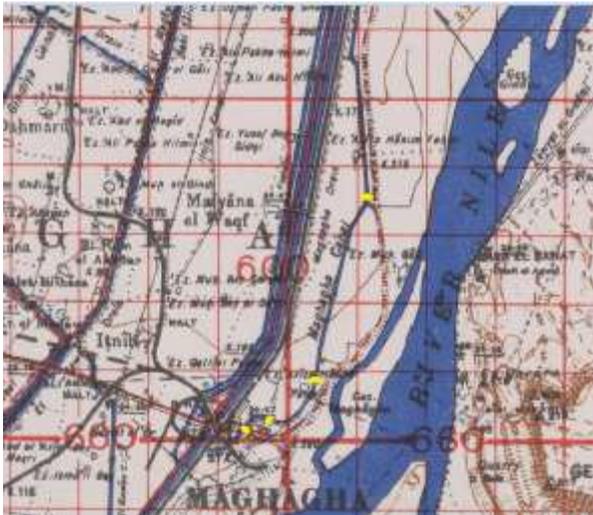


Figure (9) Map of the Magaga canal and its bridges, Great Britain War Office/U.S. Army Map Service, 1941.

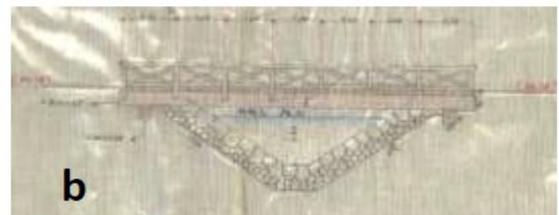
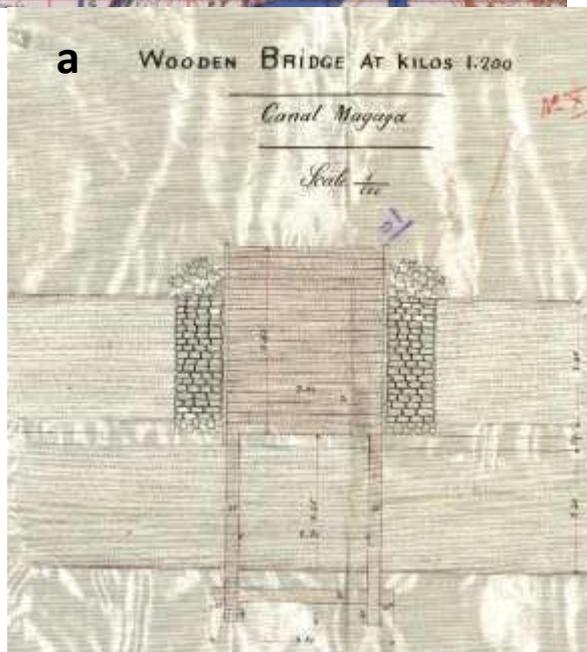


Figure (10) a. plan of the Magaga bridge at kilometre 1.200, b. longitudinal section of the Magaga bridge, c. end elevation of the Magaga bridge (Documents of Umm Galagil Canal Bridge, code no. 4003-030479).

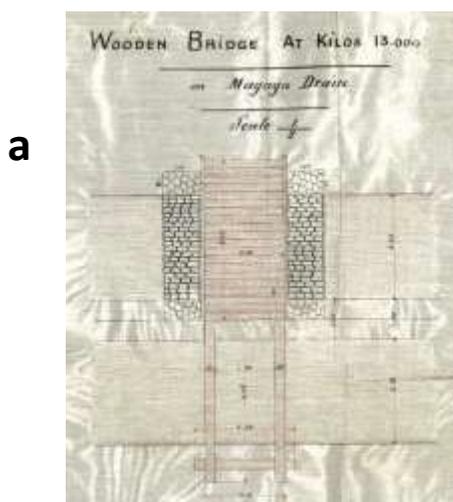


Figure (11) a. plan of Magaga bridge at kilometre 1.300, b. Longitudinal section of Magaga bridge, c. end elevation of Magaga Bridge (Documents of Magaga Canal Bridge, code no. 4003-030479).

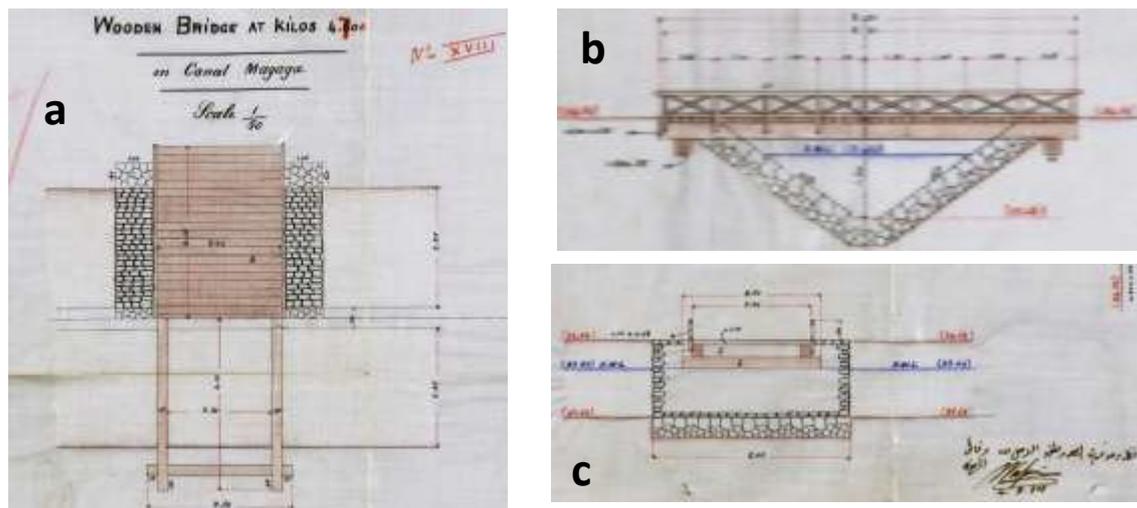


Figure (12) a. plan of Magaga Bridge at kilometre 4.700, b. Longitudinal section of Magaga Bridge, c. end elevation of Magaga Bridge (Documents of Magaga Canal Bridge, code no. 4003-030479).

	Long	Wide	Beams	Span of beams	Planks	Railing	Deepest point of canal, and side stone
Magaga canal Wooden Bridges at kilometre 1.200 (Fig.10) <sup>1</sup>	7.25 m	3 m	two beams (7.25 m long, 25 x 30 cm thick)	middle 2.5 m, and 25 cm side	(3 m wide, 20 x 10 cm thick)	7 sections through 8 wooden columns, with a distance of 1 m, except for the distance between the two side columns (1.10 m). Every column has a height of 50 cm and a thickness of 10 x 8 cm	1.60 m, side stone 60 x 100 cm
Magaga canal Wooden Bridges at kilometre 1.300(Fig.11) <sup>2</sup>	8.1 m	2 m	two beams (8.1 m long, 25 x 30 cm thick),	middle 1.5 m, and 25 cm side	(2 m wide, 20 x 10 cm thick)	8 sections of 9 wooden columns (50 cm high and 10 x 8 cm thick), with a 1 m interspace	2.62 m side stone 60 x 100 cm
Magaga canal Wooden Bridges at kilometre 4.700 (Fig.12) <sup>3</sup>	8.2 m	3 m	two beams (8.2 m long, 25 x 30 cm thick)	middle 2.5 m, and 25 cm side	(3 m wide, 20 x 10 cm thick)	8 sections of 9 wooden columns (height 50 cm and thickness 10 x 8 cm), a distance of 1 m from one another. Only the two side columns are distant by 1.05 m	1.9 m side stone 60 x 100 cm

<sup>1</sup> Documents of Magaga Canal Bridge, plans, longitudinal section, and end elevation Fig.10.

<sup>2</sup> Documents of Magaga Canal Bridge, plans, longitudinal section, and end elevation Fig.11.

<sup>3</sup> Documents of Magaga Canal Bridge, plans, longitudinal section, and end elevation Fig.12.

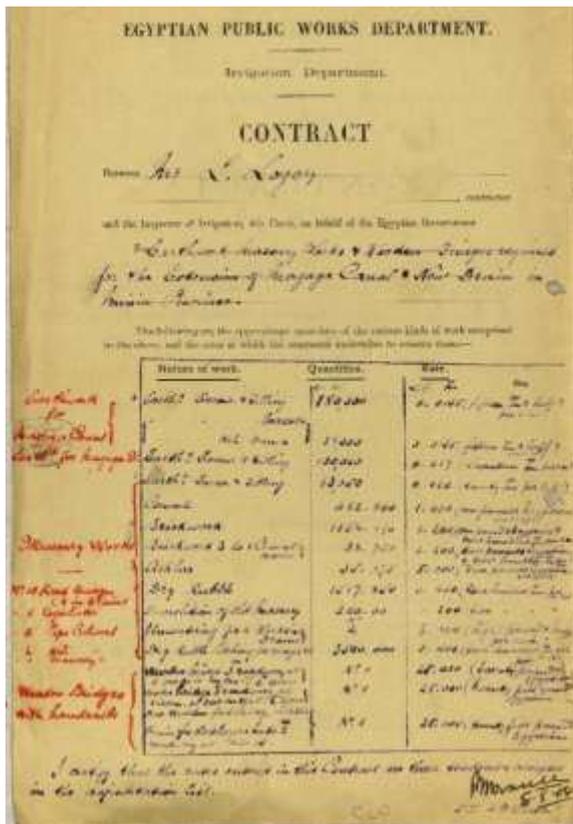


Figure (13) Contract of the wooden bridge over the Magaga canal Bridge (Documents of Magaga canal bridge, National Archives of Egypt, the Egyptian Public Works Department, Store 10, Conservation unit 189, Shelve 1, Code no. 4003-030479).

### Aba Al-Waqf Wooden Bridge

The Aba Al-Waqf wooden bridge was located on the Al-Saayda canal, which runs through the El-Minya Governorate in Upper Egypt. The bridge was located in the village of Aba Al-Waqfi, in Magaga County (Fig. 14), in front of Aba Al-Waqf market<sup>1</sup> and Mister Kraver Foraiqa (Factory), as mentioned in the documents.<sup>2</sup>

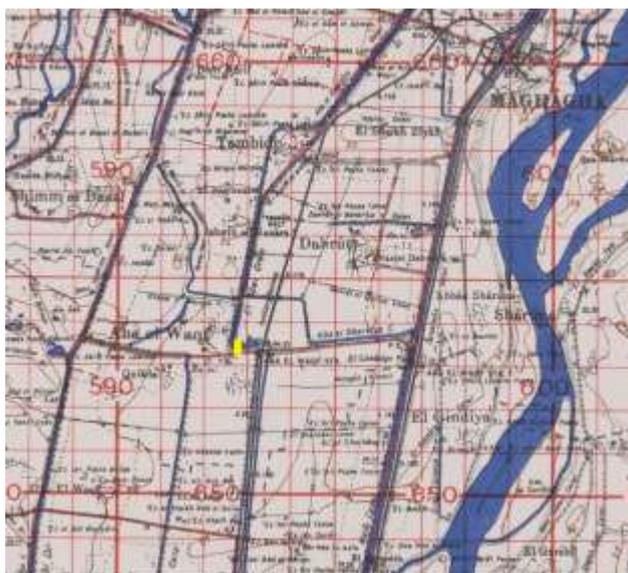


Figure (14) A map of Al-Saayda Canal, Great Britain War Office/U.S. Army Map Service, 1941.

<sup>1</sup> Department of Aba market wooden bridge canal file, Fig.15.

<sup>2</sup> Department of Aba market wooden bridge canal file, Fig.16.

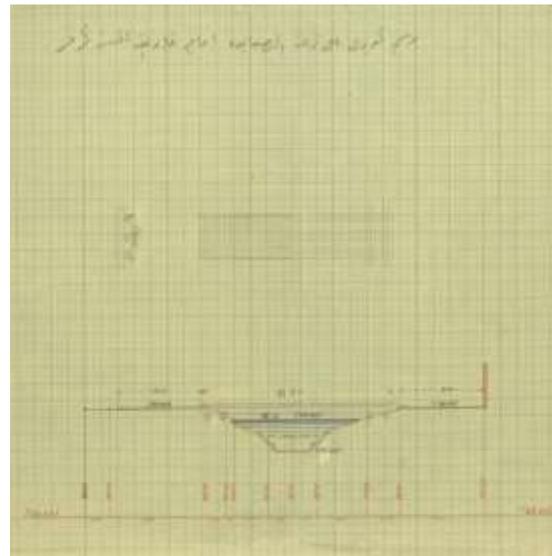
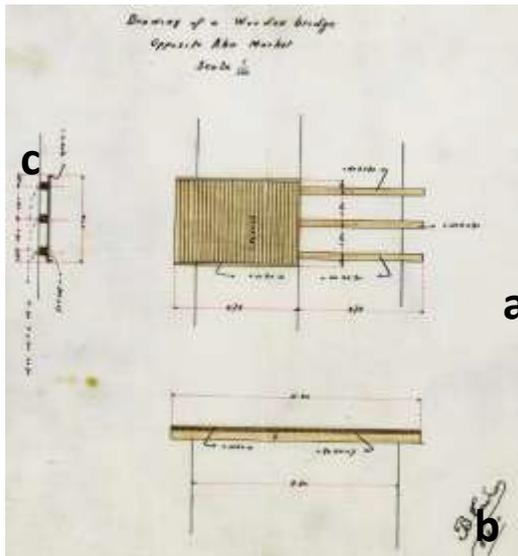


Figure (15) a. plan of Aba al Waqf bridge, b. longitudinal section of Aba al Waqf bridge, c. end elevation of Aba al Waqf bridge (Documents of Aba al Waqf Canal bridge, code no. 4003-009213).

Figure (16) plan of Aba al Waqf bridge and Water level in the Al-Saayda canal (Documents of Aba al Waqf Canal bridge, code no. 4003-009213).

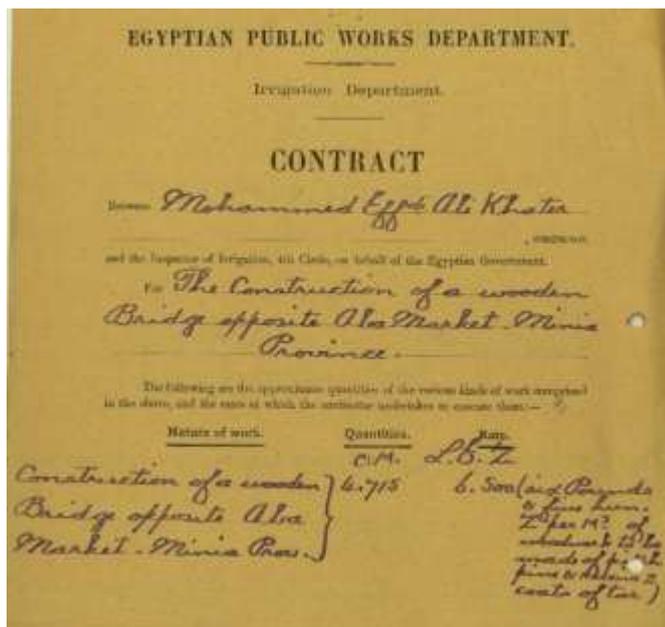


Figure (17) contract of a wooden bridge over the Aba al Waqf Canal (Documents of Aba al Waqf Canal bridge, code no. 4003-009213).

Aba al waqf Wooden Bridge <sup>1</sup>	Long	Wide	Cube	3 beams (11.5 m long, 30 x 40 cm thick)	Span between beams middle 1.5 m, side 50 cm	Planks (4 m wide, 20 x 7 cm thick).	Two-wheel guards (11 m long, 15 x 15 cm thick)
	11.5	4 m	4.715 m <sup>3</sup>				

<sup>1</sup> Department of Aba market wooden bridge canal file, code no. 4003-009213, Fig.15.

## DISCUSSION

The study presents a selection of the now disappeared wooden bridges in Egypt during the period of Khedive Abbas Helmy II. They are exclusively built over the canals because their depth and resistance to the water current's strength are proportional to the characteristics of the wood<sup>1</sup>. The architect used a beam style for the wooden bridges, as it is easy to build and relatively inexpensive compared to other types<sup>2</sup>. However, they have a limited span and do not allow large boats or vehicles to pass underneath. Regarding their structural dynamics, when the bridge is loaded, the beams bend, which causes the top surface to be compressed and the bottom surface to be stretched or put in tension.<sup>3</sup> This simple design is commensurate with the function of the bridge that covers a canal and the nature of the place in which it is situated.

The architects placed handrails on the three wooden bridges of the Magaga canal to protect all who used the bridges from falling. They may have been built differently from the Umm Galagil Canal and the Aba Alwaqf bridges, as the three bridges on the Magaga Canal serviced the city of Magaga, which has a large population density. Additionally, the bridges of the Umm Galagil and Aba Al-Waqf canals were built to transport carts loaded with weights, often protruding from the carts' perimeter. The panels of the bridge of the Umm Galagil Canal are placed diagonally to increase its strength and match its job, which was to carry carts loaded with weights for the Sewage transport company.<sup>4</sup> This panel placement is unlike the three wooden bridges above the Magaga canal, where the panels are placed transversely as the weight to be carried was not as excessive.

The canal was lined in the area where the three Magaga Canal bridges were constructed. This is a general trend due to the strength of the water current in Upper Egypt, unlike Lower Egypt.<sup>5</sup> The decreased current strength in the Lower Egyptian region of the Umm Galagil Canal explains the absence of lining under the Sebennytos Bridge. It may also be that the earth is less compact under the three wooden bridges in Magaga than under the Umm Galagil and Aba El- Waqf wooden bridges.

The Ministry of Irrigation represented the financing party for the construction of the five wooden bridges. On behalf of the Egyptian government, the Irrigation Inspector of the Zifta circle and the Inspector General of Irrigation for Lower Egypt signed with the contractor of the Umm Galagil Wooden Bridge, while the Inspector of the 4<sup>th</sup> Circle of Irrigation and the Inspector General of Irrigation for Upper Egypt signed with the contractor for the three wooden bridges at Magaga and Aba Al-Waqf.

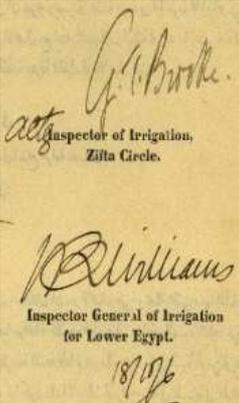
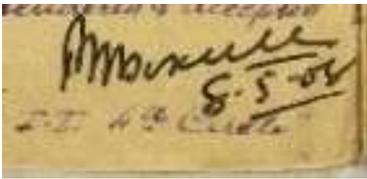
<sup>1</sup> Ritter, *Timber Bridge*, 2-2,3; 7-97,98,99.

<sup>2</sup> Raju, *Design of Bridges*, 111-112.

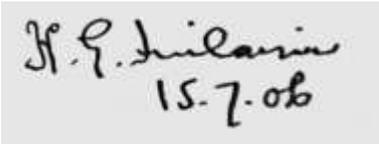
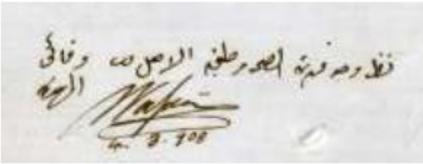
<sup>3</sup> Ritter, *Timber Bridge*, p. 2-2,3; 7-97,98,99; Raju, *Design of Bridges*, 111-112.

<sup>4</sup> Documents of Umm Galagil canal bridge, code no. 4003-025247, Fig. 7.

<sup>5</sup> Abu Al-Atta, *Nahr el Nil el maḍy elhadīr*, 36.

The name of inspectors of irrigation and their signatures		
Um galagil <sup>1</sup>	Magaga <sup>2</sup>	Aba Al-Waqf <sup>3</sup>
		

The signature of the architects designing bridges on the engineering panels of the five wooden bridges follow.

The name of the Designer Engineer and its signature		
Um galagil	Magaga (Fig. 12,13)	Aba Al-Waqf (Fig. 16)
		

Each department of the Egyptian Ministry of Irrigation, whether the zifta or the fourth section, announced the construction of its own wooden bridge. Each contractor submitted his offer to win the bridge construction tender.

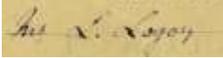
Name of Bridge	The names of the contractors and the value of their offer		The winner contractor	Daily delay fine
Um galagil <sup>4</sup>	Name of the contractors	The value is in Egyptian pounds for each M3	 (Fig. 8)	One L.E
	Mustafa Abdul-Motleb	7.500		
	Mr. E. G. English	6.800 One LE (fig. 9.b)		
	Mohammed Abu-Abaya	6.500		

<sup>1</sup> Documents of the Umm Galagil canal bridge, code no. 4003-025247.

<sup>2</sup> Documents of the Magaga canal bridge, Code no. 4003-030479.

<sup>3</sup> Department of Aba market wooden bridge canal file, code no. 4003-009213.

<sup>4</sup> Documents of the Umm Galagil canal bridge, code no. 4003-025247.

	Hassan Mohsn	7.500			
	Saad Sayed Ahmed El-Ashry	6.500			
Magaga <sup>1</sup>	L. logory	—————	 L. logory (Fig. 13)	49 L.E	
					
Aba Al-Waqf <sup>2</sup>	Ahmed Hassan Gad (from Beni Suef)	7.300	Mohammed Ali Khater	One L.E	
	Badawy Mohammed el-Nagar (from Beni Suef)	9.000			
	Mohammed Ali Khater (Fig.17)	6.500			

	Cubic meter cost	Volume	Total cost
Umm galagil bridge <sup>3</sup>	6.80 LE	8 m <sup>3</sup>	54,400 LE
Magaga Bridge (each) <sup>4</sup>	—————	—————	25 LE
Aba al waqf canal <sup>5</sup> bridge	6.55 LE	4.715 m <sup>3</sup>	30.6475 LE

As for a reason for choosing the sites of wooden bridges, one of the documents of the Umm Galagil Bridge in the Egyptian Public Works Department included the reason behind the establishment of this bridge was the passage of carts in front of the Sewage transport company in Sebennytos city<sup>6</sup>. The Magaga canal wooden bridges above the Magaga canal were used for pedestrians and cart crossings. The Aba Al-Waqf bridge was located at the Al-Saayda canal, which runs through the Minya Governorate in Upper Egypt. The bridge was located in the village of Aba Al-Waqf, which belongs to the Magaga Centre. In front of Aba Al-Waqf market and Mister Kraver Foraiqa (Factory)<sup>7</sup>. Therefore, this bridge was used for pedestrians and carts.

<sup>1</sup> Documents of the Magaga canal bridge, code no.4003-030479.

<sup>2</sup> Documents of the Aba al waqf canal bridge, code no. 4003-009213.

<sup>3</sup> Documents of the Umm Galagil Canal bridge, code no. 4003-025247, Contract for a wooden bridge over the Umm Galagil Canal, Fig. 8.

<sup>4</sup> Documents of the Magaga canal bridge, code no.4003-030479, contract for a wooden bridge over the Magaga canal, Fig. 13.

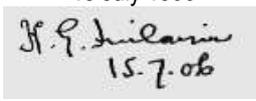
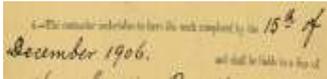
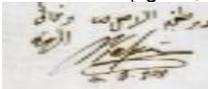
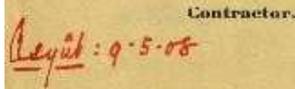
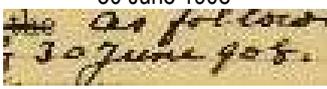
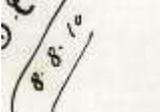
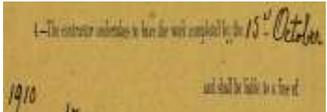
<sup>5</sup> Documents of the Aba al-Waqf canal bridge, code no. 4003-009213, contract for a wooden bridge over the Aba al-Waqf canal, Fig. 17.

<sup>6</sup> Documents of the Umm Galagil canal bridge file, code no. 4003-025247, Fig. 7.

<sup>7</sup> Department of the Aba market wooden bridge canal file, code no. 4003-009213, Fig.15-16.

The thickness of the wooden bridges being studied is understandably similar and proportional to the loads and the function performed by these bridges, whether used by crossing pedestrians or carts. Their lengths are related to the width of the canals over which they are built.

The completion dates for the wooden bridges from this study were recorded on the engineering panels. In contrast, the start and end dates for the wooden bridges were recorded in the contracts between the contractor and the Public Works Department.

Name of Bridge	The date of completion of the design	Construction start date	Construction finish date
Um galagil <sup>1</sup>	15 July 1906 	8 Oct. 1906 	15 Dec. 1906 
Magaga <sup>2</sup>	4 March 1908 (fig. 12,13) 	9 May 1908 	30 June 1908 
Aba Al-Waqf <sup>3</sup>	8 August 1910 (fig. 16) 	28 Sep. 1910 	15 Oct. 1910 

## CONCLUSION

This study investigated the wooden bridges from the reign of Khedive Abbas Helmy II. The bridges were established to allow the crossing of either people or carts. The selected bridges all followed the building techniques used for beam bridges. Pitch pine wood (imported -not local wood) was used to construct these bridges due to its strength and durability. The sites for these bridges were selected because they were in front of companies, markets, or vital landmarks. This study has identified the funding body, contractors and architects for the construction of the wooden bridges and estimated the cost of building them. The study also identified the date of construction of these wooden bridges.

<sup>1</sup> Documents of the Umm Galagil canal bridge, code no. 4003-025247.

<sup>2</sup> Documents of the Magaga canal bridge, code no.4003-030479.

<sup>3</sup> Documents of the Aba al-Waqf canal bridge, code no. 4003-009213.

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