Historical Limestone Bridges in Diyarbakir, Turkey

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Abstract-As well known, the historical structures reflect the language, cultures, religions, and development levels of ancient civilizations. In other words, each historical structure can be qualified as an evidence of its civilization’s history. Furthermore, such structures give information about early age hydrological, meteorological, and geological characters of their region. Therefore protecting such historical structures and recording their information are essentially important. Consequently, 14 of the historical limestone bridges located in Diyarbakir province have been detected and mapped. The architectural, geological, and hydrological properties of these bridges have been briefly presented.

Keywords- Historical Bridges; Diyarbakir; Limestone Bridges; Stream Flow

I. INTRODUCTION

Halifeoglu et al. stated that the historical structures particularly, historical bridges not only reflect the cultures, religions, language, trade, military, and development levels of civilizations those lived in the past, but also, give many important traces about the climatic and meteorological features, hydrological characteristics, and geological structure of the region [1]. For instance, the authors give an example as summer-winter and family-guest parts in a house that give the knowledge about the cultural properties as well as the religion of the people had lived in such historical houses in the past. Since it is too hot in summer and too cold in winter, in terrestrial climate regions the families use for living the northern and southern parts of their house in summer and in winter, respectively. At the region, due to religious culture when somebody has guests the ladies and gentlemen sit separately. On the other hand, the architecture of any house roof at any region can reflect climatic or meteorological features of the region and give another example as the terraced roof shows that the region was hot and people were regularly using the roof especially for sleeping in the past. Similarly, a house with small windows, thick walls, and fitting roof shows that the region was cold, snowy in winter, and people were not sleeping at the floor. Further, the materials used for construction give knowledge about the geological structure of the region in old ages. For example the materials used for construction show that those materials were easy found at region. Other important information provided by the historical bridges is about the flow and other hydrological properties of the stream on the bridges were crossing [1]. It is possible to say that many old bridges are engineering/architectural marvels which reflect the development level of old civilizations in the construction and architectural sectors [1].

Anatolia is rich in historical structures such as houses, khans, baths, caravansaries, bridges, etc. Diyarbakir is one of the richest provinces located at the South Eastern of Anatolia. Unfortunately, a few of these structures, that are meeting the requirements of housing, security, governmental offices, worship, education, transportation, health, water supply, and sanitation, have survived until now. After studying the current literature, only few published studies are available.. Dalkılıc and Halifeoglu [2] and Halifeoglu et al. [3] give an overall view on the historical bridges built in Diyarbakir Province. However the above mentioned two works discussed and mapped only 11 of the historical bridges located in the province. Twenty nine of the historical bridges were detected by Halifeoglu et al. [1] and 25 of these bridges, which their coordinates are exactly defined, were indicated on a map of the province. Furthermore the authors classified the historical bridges into two main classes as basalt and limestone bridges, but only seven of restored historical basalt bridges were discussed in details. Up to date, the authors have detected more than 40 of old bridges in the field. Eleven of the determined bridges were previously studied without any classification by Halifeoglu et al. [2]. According to the classification made in Halifeoglu et al. [1], 7 of these bridges were definitely determined as basalt. These bridges were examined in details and their details were tabulated including their location, construction material, and hydrological characteristics. These bridges are Karakopru (Karasu), Sancar (Sancak), Ongozlu (Dicle), Karakopru (on Mardin Road), Halilviran, Devegecidi, and Tashelva I, II, III. Due to security issues, the coordinates of the bridges were not presented in the study. It can be clearly understood from the study that all of them were built on Dicle (Tigris) River or on its distributaries [1]. In the current study, the historical bridges which are made of limestone were studied. The historical limestone bridges which are located (built) in Diyarbakir province have been mapped. Then, they have been architecturally, hydrological, and geologically interpreted. In another words, the features, the structural materials, and streams of the bridges are architecturally, geologically, and hydrologically examined, respectively. The limestone historical bridges are namely Malabadi, Haburman, Gideren, Hoşan, Çüngüş, Sinek, Roke, Onbaşlar, Hüseyinyağa, Değirmen, Kalemdan, Ambar, Hazro, and Perpira. For details refer to Table 1.

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II. HISTORICAL RICHNESS OF THE STUDY AREA

Diyarbakir Province (Amid, Amed, Amida, Diyarbekir) is located at the Southeast Anatolia Region of Turkey. The city is located at junction of important trade ways and has become the centre of trade, education, management, literary, cultures art, and science of the region for thousands years. Diyarbakir Province together with the city centre is rich of historical structures (i.e. houses, khans, baths, caravansaries, bridges, etc.). There are many historical bridges in Diyarbakir. In total, 40 old bridges were detected in the field, herein only 14 of them, which are made of limestone, are discussed.

III. GEOLOGICAL STRUCTURES OF CONSTRUCTION MATERIAL

Diyarbakir is located where the Arabian plate meets the Eurasian plate. This situation created a suture zone at the northern of the province with E-W direction. The metamorphic and ophiolitic rocks are intensely encountered along the zone. So the geological structure is too complex. On the other hand, the province is under the impact of the old Karacadag Basalt. Therefore, the complexity is being higher than other Anatolian regions [4-5]. Due to the limitation on the length of the manuscript, the details of the geological structure are not presented in this study. Herein, only the limestone structure is taken under consideration.

Eocene limestone sits on the old cretaceous pelagic limestone at the north of the province from Çüngüş to Silvan (W-E direction). Therefore, at the Eocene Zone the region becomes to a large and very thick carbonate platform. In the eastern part, there are a shallow shelf carbonates and sedimentary reef limestone. On the other hand, at the western part, in deep shelf there are some clay-marl and chalky clay zones with different level of limestone. On these layers, a sedimentary unit composed of Early Miocene neritic limestone, sandstone, and clay-stone is deposited. This layer is overlaid with an old Miocene-Pliocene unit composed of continental tires.

Diyarbakir and surrounded area geologically consist of the Eocene (Euphrates Formation) and Miocene (Hoya Formation) old limestone, because such rocks are easy obtainable [4-5]. The formations are presented in Fig. 1. Therefore at the region, the limestone was easy found and was used in the construction of bridges in the past.

IV. HYDROLOGICAL CHARACTERISTICS OF THE STREAMS THE BRIDGES WERE BUILT ON

The region has semi-arid climate. The annual total rainfall height in Dicle Basin is 814 mm [1]. However, the total annual rainfall of the cities is used for the calculations. The flow coefficient of the Dicle Basin is 0.5373 [1] and the daily maximum rainfall height is 71.6 mm for all the cities [1]. The basin area of the streams which the bridges were built on and other hydrological characteristics of the bridges are presented in Table 1. The altitudes of water surface were determined precisely by using Google Earth. Daily maximum rainfall data were obtained from Halifeoglu et al. [1] for each basin. The daily maximum rainfall of the streams’ basin assumed to be the same of Dicle (Tigris) Basin, because all of them are distributaries of Dicle River. The total annual rainfall height obtained from the meteorological stations for each city. The mean discharges of the streams presented in columns 11th and 12th in m³/s were calculated by using the Equations (1) and (2), respectively. Equation (1) calculates the flow with daily maximum rainfall height whereas Equation (2) calculates the flow with annual rainfall height of the cities.

\[ Q = \frac{A \times 10^6 \times h_D \times 10^{-3} \times c}{86400} \]  
\[ Q = \frac{A \times 10^6 \times h_A \times 10^{-3} \times c}{86400 \times 365} \]  

Where, A, h_D, c, and h_A are the basin area, daily maximum rainfall height of the basins, flow coefficient, and annual rainfall height of the basins, respectively.

The bridges were constructed before Dicle, Kralkizi, Batman, and Devegecidi dams which are established on the Tigris River and its tributaries. The dams make the flows regular. Therefore, the discharge calculated by the first equation which base on the daily maximum flow data can be assumed as project discharge of the bridges (Table 1). Another reason for this consideration is the believing in existence of global climate change (GCC) [6-9], which affects all water resources as well as stream flow conditions.
There is not historical bridge made of limestone in Diyarbakir city center. The bridges examined in this study are located in districts of the province. These are namely Malabadi, Haburman, Gökerni, Hoşan, Cüngüş, Sinek, Roke, Onbaşlar, Hüzeyinaga, Değirmen, Kalezman, Ambar, Hazro, and Perpira. All the bridges except the Hazro Bridge are mapped in the Fig. 2. Hazro Bridge’s coordinates have not been exactly determined yet. The architectural features of the bridges have been presented only on their photos. It is possible to present each bridge in a separate paper with their full details, whereas the main goal of this study is to only introduce 14 of ancient limestone bridges located in Diyarbakir province. Due to the limitation on the length of the manuscript, all of them have been discussed in brief.
A. MALABADI BRIDGE

The bridge was made of limestone and built on the today’s boundary of Diyarbakir and Batman provinces. It is 104 km far from Diyarbakir city centre and located in Çatak Köprü (a village of Silvan), on the Batman Stream (a distributaries of Dicle-Tigris River). A new bridge was built at the upstream of the old bridge. According to the epigraph, the bridge was built by Governor of Artuklu (Hüsamettin Timurtaş) in 1147 [9-11]. With the arch width of 40.86 m this bridge is known as the largest historical bridge still used in the world. The altitude of the water surface is 603 m, rainfall area of the stream is approximately determined as 4500 km$^2$, daily maximum rainfall of the basin, annual total rainfall of the city, and flow coefficient of the basin are 71.6 mm, 722.10 mm, and 0.54, respectively. Based on the hydrological data, the mean discharge of the stream is calculated as 2003.68 m$^3$/s and 55.36 m$^3$/s by equations (1) and (2), respectively. The bridge was recently restored and now in use. The plans, profile, photos of the bridge are presented in the Figs. 3-5 to give information in architectural details.

Fig. 3 The plan of the Malabadi Bridge (technical drawing)
B. HABURMAN BRIDGE

The bridge is located in Haburman which is a village of Çermik (district of Diyarbakır) on the Haburman Stream. It is 83 km far from Diyarbakır city centre. The bridge is called as Çermik Bridge at the region. According to the epigraph of the bridge it was built by Artuklu in 1179. Structurally, the bridge was made of limestone and it is 108.37 m in length, 5.5 m in width and 12.84 m in height from the base [2]. The altitude of water surface is 644 m, rainfall area of the stream is approximately determined as 315 km², daily maximum rainfall of the basin is 71.6 mm, annual total rainfall of the city is 825.68 mm, and flow coefficient of the basin is 0.54, respectively. Based on the hydrological data, the mean discharge of the stream is calculated as 140.26 m³/s and 4.43 m³/s by equations (1) and (2), respectively. The bridge was restored previously and now in use. The architectural features of the bridge are presented in the Figs. 6-8.
C. GÖDERNI BRIDGE

The bridge is located in Taşköprü Village which is 30 km far from Kulp (district of Diyarbakir province) centre. It is on a junction of roads which were connecting Kulp, Silvan, and Hazro in the past. There are not any epigraph shows its construction year. The bridge was made of limestone. The altitude of the water surface is 570 m, rainfall area of the stream is approximately determined as 2639 km², daily maximum rainfall of the basin is 71.6 mm, annual total rainfall of the city is 722.10 mm, and flow coefficient of the basin is 0.54. Based on the hydrological data, the mean discharge of the stream calculated as 1175.05 m³/s and 37.47 m³/s by equations (1) and (2), respectively. The bridge was restored previously and now in use. The architectural details of the bridge are presented in the Figs. 9-11.

D. HOŞAN BRIDGE

The bridge is located in Hoşan Village of Ergani district and on the Hoşan Stream. It is recorded as Kömürtaş Bridge in inventory of 9th Regional Directorate of Highways (General Directorate of Highways of Turkey) [10]. There are not any epigraph shows its construction year. However, based on the type of the arch, the bridge was dated by researchers as second half of the 19th century [11-13]. The bridge was made of limestone. The altitude of the water surface is 570 m, rainfall area of
the stream is approximately determined as 733 km², daily maximum rainfall of the basin is 71.6 mm, annual total rainfall of the city is 800.31 mm, and flow coefficient of the basin is 0.54. Based on the hydrological conditions, the mean discharge of the stream calculated as 44.53 m³/s and 1.36 m³/s by equations (1) and (2), respectively. The bridge has not been restored yet and it should be restored as soon as possible. Figs. 12-14 show the architectural properties of the bridge and its current condition.

Fig. 12 The plan of the Hoşan Bridge (technical drawing)

![Plan of Hoşan Bridge](image)

Fig. 13 The profile of the Hoşan Bridge from upstream (technical drawing)

![Profile of Hoşan Bridge](image)

Fig. 14 Photos for Hoşan Bridge: (a) from upstream (b) from downstream

![Photos of Hoşan Bridge](image)

E. NG Ş BRIDGE

The bridge is located in the Çüngüş city center on the Çüngüş Stream. There are not any epigraph shows its construction year. However according to the archive of the Çüngüş Municipality the bridge was built by Kapikiran Mehmet Ali Pasha together with Ali Bey Mosque in 17th century [2]. The bridge has 18.72 m of the length, 5 m of the width and 15.2 m of the height from the base. The opening of the arch is 10 m [2]. The bridge has been restored with cut stones. The bridge was made of limestone. The altitude of the water surface 966 m, rainfall area of the stream is approximately determined as 8 km², daily maximum rainfall of the basin is 71.6 mm, annual total rainfall of the city is 1150.6 mm, and flow coefficient of the basin is 0.5373. Based on the hydrological conditions the mean discharge of the stream calculated as 3.56 m³/s and 0.16 m³/s by equations (1) and (2), respectively. The bridge was restored previously and now in use. Please see the Figs. 15-16 for the architectural specifications of the bridge.
F. SINEK BRIDGE

The bridge was constructed in Çermik on the Sinek Stream. The bridge was restored but there is not the record about restoration. There are not any epigraph shows its construction year. However based on the construction technique and materials it is similar to Haburman Bridge, therefore İlter, (1978) indicated that it might be constructed in 1179 just as Haburman Bridge [14]. On the other hand, Tunç (1978) pointed out that the bridge is a handiwork of Ottoman [13]. The bridge was made of limestone. The altitude of the water surface is 655 m, rainfall area of the stream is approximately determined as 312 km², daily maximum rainfall of the basin is 71.6 mm, annual total rainfall of the city is 825.68 mm, and flow coefficient of the basin is 0.54. Based on the hydrological conditions the mean discharge of the stream calculated as 138.92 m³/s and 4.39 m³/s by equations (1) and (2) respectively. The technical drawings of the bridge have not been found in the archives or current literature; however Fig. 17 gives a brief knowledge about its architectural features.

G. ROKE (KOKI) BRIDGE

The bridge was made of limestone in Hani District, on the Ambar Stream. It was not restored recently. According to Fig. 18, the restoration is not essentially needed and it is currently in use. The altitude of the water surface is 783 m, rainfall area of the stream is approximately determined as 130 km², daily maximum rainfall of the basin is 71.6 mm, annual total rainfall of the city is 1049.11 mm, and flow coefficient of the basin is 0.54. Based on the hydrological conditions the mean discharge of the stream calculated as 57.88 m³/s and 2.32 m³/s by equations (1) and (2), respectively. The technical drawings of the bridge have not been found in the archives and current literature. Fig. 18 shows the architectural structure of the bridge.
H. ONBAŞILAR BRIDGE

The bridge was made of limestone in Silvan District, on an unnamed small stream which a distributaries of Batman Stream. Based on the current condition of the bridge, it needs to be restored. The altitude of the water surface is 1015 m, rainfall area of the stream is approximately determined as 14 km$^2$, daily maximum rainfall of the basin is 71.6 mm, annual total rainfall of the city is 722.10 mm, and flow coefficient of the basin is 0.54. Based on the hydrological conditions the mean discharge of the stream calculated as 6.23 m$^3$/s and 0.17 m$^3$/s by equations (1) and (2), respectively. The technical drawings of the bridge have not been found in the archive and current literature Fig. 19 gives a little information in its architectural specifications. The main bearing system and the construction material of the bridge are still visible. This means that it is possible to restore the bridge.

I. H SEYİNAĞA BRIDGE

The bridge was made of limestone in Kulp District, on Kulp Stream. Based on the bridge’s current condition, it needs to be restored immediately. The altitude of the water surface is 959 m, rainfall area of the stream is approximately determined as 410 km$^2$, daily maximum rainfall of the basin is 71.6 mm, annual total rainfall of the city is 1159.04 mm, and flow coefficient of the basin is 0.54. Based on the hydrological conditions the mean discharge of the stream calculated as 182.56 m$^3$/s and 8.10 m$^3$/s by equations (1) and (2), respectively. The technical drawings of the bridge have not been found in the archive and current literature. Its architectural properties are simply presented in Fig. 20. It is important to record such a bridge before completely damaged. In the case of reaching the older/oldest drawings/photos and/or technical properties it will be possible to restore it.

J. DEĞIRMEN BRIDGE
The bridge was made of limestone in Ergani District, on Değirmen Stream. Recently it was not restored. It is highly recommended to restore the bridge in the near future. The altitude of the water surface and the rainfall area of the stream could not be determined, because the coordinates of the bridge still could not be obtained. Daily maximum rainfall of the basin is 71.6 mm, annual total rainfall of the city is 800.31 mm, and flow coefficient of the basin is 0.54. The discharge of the stream could not be calculated, because the basin area could not be measured. The technical drawings of the bridge have not been found in the archive and current literature. Fig. 21 shows its architectural properties.

Fig. 21 Değirmen Bridge

K. KALEMDAN BRIDGE

This bridge was made of limestone in Ergani District, on Değirmen Stream. So it is possible to say that this bridge close to the Değirmen Bridge. In some imprecise sources, the Değirmen Bridge is mentioned as Kalemdan 2. Similar to Değirmen Bridge, the altitude of the water surface and the rainfall area of the stream could not be determined, because the coordinates of the bridge still could not be obtained. Daily maximum rainfall of the basin is 71.6 mm, annual total rainfall of the city is 800.31 mm, and flow coefficient of the basin is 0.54. The discharge of the stream could not be calculated, because the basin area could not be measured. The bridge was restored previously and it is currently in use. The technical drawings for the bridge have not been found in the archives or current literature, the photo presented in Fig. 22 gives a little information in its architectural specifications.

Fig. 22 Kalemdan Bridge

L. AMBAR BRIDGE

Any knowledge in the length and width of the Ambar has not been found in the literature. The bridge has not been restored yet. It was made of limestone in Sur District, on Ambar Stream. The altitude of the water surface is 600 m, rainfall area of the stream approximately about 1350 km², daily maximum rainfall of the basin is 71.6 mm, annual total rainfall of the city is 488.17 mm, and flow coefficient of the basin is 0.5373. Based on the hydrological conditions the mean discharge of the stream calculated as 601.10 m³/s and 11.23 m³/s by equations (1) and (2) respectively. The technical drawings of the bridge have not been found in the archive and current literature. As can be seen clearly from Fig. 23, currently another modern bridge was constructed on the remains of the bridge which is about disappearing. Unfortunately this situation make impossible to restore the bridge.

Fig. 23 Ambar Bridge
M. HAZRO BRIDGE

The bridge made of limestone in Hazro District, on Hazro Stream. The bridge was not recently restored and it is currently used in its original form. The altitude of the water surface and the rainfall area of the stream could not be determined, because the coordinates of the bridge still could not be obtained. Daily maximum rainfall of the basin is 71.6 mm, annual total rainfall of the city is 998.89 mm, and flow coefficient of the basin is 0.54. The discharge of the stream could not be calculated, because the basin area could not be measured. The technical drawings of the bridge could not be obtained. Fig. 24 shows the architectural details [14].

N. PERPIRA BRIDGE

Any knowledge in the length and width of the Perpira has not been found in the literature, but it is known as the oldest and the longest bridge located in Diyarbakir province (Fig. 25). The bridge has not been restored yet. It was made of limestone in Silvan District, on Batman Stream. The altitude of the water surface is 558 m, rainfall area of the stream is approximately determined as 4535 km², daily maximum rainfall of the basin is 71.6 mm, annual total rainfall of the city is 722.1 mm, and flow coefficient of the basin is 0.5373. Based on the hydrological conditions the mean discharge of the stream calculated as 2019.27 m³/s and 55.79 m³/s by equations (1) and (2), respectively. The technical drawings of Perpira have not been found in the current literature. As can be clearly seen from Fig. 25, its foundation is about to disappear, therefore it should be restored in the nearest time.

VI. CONCLUSIONS AND RECOMMENDATIONS

This study aims to introduce the ancient bridges which are made of limestone located in Diyarbakir province. Up to date, 40 of old bridges located in Diyarbakir Province have been detected in the field. In the current study, namely Malabadi, Haburman, Goderni, Hoşan, Çüngüş, Sinek, Roke, Onbaşılar, Hüseyınağa, Değirmen, Kalemdan, Ambar, Hazro, and Perpira Bridges, which are certainly defined as limestone bridges, are mapped and examined in detail. Furthermore, the bridges details are tabulate with a brief discussion on their location, construction material, and hydrological, geological, historical, and architectural characteristics. The following conclusions can be extracted from the study:

1. Most of the ancient bridges under study, located in Diyarbakir province, have not previously detected or recorded.
2. All the old bridges were constructed on Dicle (Tigris) River or on its distributaries.
3. The technical drawings of the Roke, Onbaşılar, Hüseyınağa, Değirmen, Kalemdan, Ambar, Hazro, and Perpira Bridges, which are certainly defined as limestone bridges, are mapped and examined in detail. Furthermore, the bridges details are tabulate with a brief discussion on their location, construction material, and hydrological, geological, historical, and architectural characteristics. The following conclusions can be extracted from the study:
   1. Most of the ancient bridges under study, located in Diyarbakir province, have not previously detected or recorded.
   2. All the old bridges were constructed on Dicle (Tigris) River or on its distributaries.
   3. The technical drawings of the Roke, Onbaşılar, Hüseyınağa, Değirmen, Kalemdan, Ambar, Hazro, and Perpira have not been found in the current literature or in the archives. The technical drawings of these bridges (their plans and profiles) shall be produced. This is the objective of the authors for a future study.
   4. Perpira, Ambar, Değirmen, Hüseyınağa, Onbaşılar, and Hoşan bridges have not been restored yet. These bridges, except of the Ambar should be immediately restored according to their original forms.
   5. Perpira is the most important old bridge since it is the oldest and the longest bridge and its foundation is about to disappear.
   6. It is recommended to give priority to the Perpira and Ambar, in terms of producing technical drawings and restoring the bridges to their original condition.
REFERENCES


