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An exposition on possibility of adoptive reuse: Case study of Nahar-e-Ambari, Aurangabad, Maharashtra (India)

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ABSTRACT

This paper attempts to understand an ancient aqueduct system in Aurangabad city, which is a good example of human wisdom. It is a perfect answer to the battle with water scarcity with a sustainable approach. Out of these ancient aqueducts, few are still alive in ancient Aurangabad city. This paper attempts to understand the wisdom, history, technique and present condition of ancient aqueduct system. The paper unfolds that, 400 years old ancient water supply technique has evolved in direct response to local geo-physical conditions which brought prosperity to the region. This water supply system collects underground water from nearby catchments of the city, carrying water through underground aqueducts called "Nahar". Few nahars are still alive and even today people collect water from it. It is essential to learn from traditional wisdom of previous generations through this ancient water supply system for future prosperity.It can become a very powerful tool for improving the future needs.

Keywords :*Nahar-e-Ambari, aqueduct, siphon, gravity, adoptive reuse, Panchakki, water scarcity.*

1. Introduction

The word 'Aqueduct' comes from the Latin words aqua (water) and ducere (to lead) which means "carrier of water". Aqueduct is a structure that transports large quantity of water from a source to end point for use or distribution. Some aqueducts are tunnels dug through rocks, and others are canals in the earth. In an aqueduct, the outlet is so much lower than the water source that gravity alone carries the water to its destination. The topography of the land influences the design of the aqueduct; usually part of the structure is on the high elevated land and part of it remains below non-pressure or Grade aqueducts and pressure aqueducts are two types of aqueducts. One carries the flow in a conduit that is not full and therefore not under pressure; on the other hand, the conduit is full and the water is under pressure. In a non-pressure aqueduct, water moves downhill under the force of gravity.

1.1 Preview of world aqueducts

There are quite a few examples of roman aqueducts which are still in use today. The famous Trevi-fountain in Rome is still fed by aqueduct water from the same sources of the ancient Aqua Virgo; however, the Aqua Vergine Nuova is now a pressurized aqueduct. In Frejus (France) ancient water supply system follows the same course to a great extent as the ancient precedents but its water is now used only for irrigation. The antique Proserpina dam, the start of one of the aqueducts of Roman (Merida Spain) is still supplying the local farmers in the area with water. There are lots of other examples. In many cases only the same water source is still in use or the subtraction got a new lease of life in supporting younger instances of ancient aqueducts.

1.2 Water battle

The interplay of water and architecture has always fascinated the world. Water always is the basic elements of life. Everyone acknowledges that all ancient civilizations could have existed due to great water resources. Even today, many towns and growing cities are dependent of any nearby water source or import the water from far away. In fact importing water from far away from the city is an expensive and unsustainable affair. Due to growing urbanization many ancient local water resources in many regions left ignored. In the era of global warming the scarcity of drinking water in many parts of the world is certainly creating acute problem as depicted from Fig. 1.[1]

Fig. 1. Struggle for water

The war for water is seen everywhere which is resulting into events like Tapiwater war, etc. The crucial problem of potable water is mainly arising in the state of Gujarat, Madhya Pradesh, Rajasthanand Maharashtra. All efforts taken by Central and State government are failed and since past few years people are facing acute shortage of potable water. Aurangabad is an ancient town established before 400 years ago as Khirki by Malik Amber. For increasing beauty of city and fulfilling the requirement of water, Malik Amber developed "Nahar-a-Ambari" in 1618 A.D. for the 2 lakhs of population of Aurangabad in those days. As the population increased several other nahars (aqueducts), namely Nahar-e-Panchakki, Nahar-e-Thatte, Nahar-e-Shahnoor Hamvi, Nahar-e-Kiradpura(Palsi) were constructed based upon the Ambari aqua-technology which supplied drinking water for the growing population of the city.[1]

Due to the careless development of the city, growing population and uncontrolled urbanization historical nahars are in danger and many of them are broken. Citizens and administration are neglecting this ancient free of cost and sustainable technique of water collection. Instead of relying on it, new unsustainable and expensive systems are evolved.

2. Review of ancient aqueduct system in Aurangabad:

Nahar water system provided clean water for the people of Aurangabad and its suburbs. The first aqueduct in Aurangabad was designed in 1618 A.D. by Malik Amber in order to address the shortage of water caused by the lack of reservoirs and natural water reserves in the area. The reason for the construction of the aqueduct was the discovery of a subterranean water supply in the mountainous valleys towards the north of Aurangabad. But ,it was difficult to construct aqueducts with supporting pillars due to surrounding rocky landscape. This constraint resulted into digging of tunnels in the rock. Few are aqueducts canals in the earth. The consequent construction of the waterway provided a stable water supply for the city of Aurangabad receiving enough fresh water to prevent the shortages that had previously occurred. The aqueduct was named Khair-E-Jari. The construction of such aqueducts continued from 1612 until 1803 with two more aqueducts constructed by engineers such as Malik Amber, Shah Mehmood of Panchakki and Shah Ali Nahri. [2]

2.1 History of Malik Amber:

Malik Amber (1549–13 May 1626) was an Ethiopian born in Harar, sold as a child by his parents due to poverty. He was eventually brought to India and remain slave to the people that bought him. Nevertheless in time he created an independent army that had up to 1500 men. This army resided in the Deccan region and was hired by many local kings. Malik Amber, being the Prime Minister of Murtaza Nizam Shah II, made Kharki village as his capital and the men of his Army raised their dwellings around it. Nahar-e-Ambaria miracle in the field of aqua technology was perfectly designed by Malik Amber in 1618 A.D. to supply drinking water to his newly built capital town. [3]

2.2 Planning Designing and Construction of Nahar system (Water Tunnel):

The old system of water supply was dependent on the canals. At the origin, only huge land fields can be observed. Origin of these canals is either in the lap of mountain or in the vicinity of river. Under the principle of gravitational power these canals were dug in the porous levels of land and they flow in the natural way. Geographically the town is surrounded by the mountains from all sides. Hence, most of the canals start from the mountainous field and end in the town as shown in Fig. 2. The design of canal is simple and without any complication[4]. Each canal is divided into two parts. First is conduit (large pipe or waterway) and the second part is a net of masonry pipes on which they erected rectangular or round pillars. Sometimes they are higher in a size and sometimes smaller. The cross sectional area of these conduits is based on the old engineering hydraulic & design system is an engineering marvel. The technique of Nahar-e-Ambari later copied in other aqueduct systems such as Nahar-e-Panchakki, Nahar-e-Chavni, Nahar-e-Khokadpura, Nahar-e-Shahanoor Hamvi, Nahar-e-Begampura, etc.]

The city has fourteen principal aqueducts out of which five aqueducts are still alive.[1]

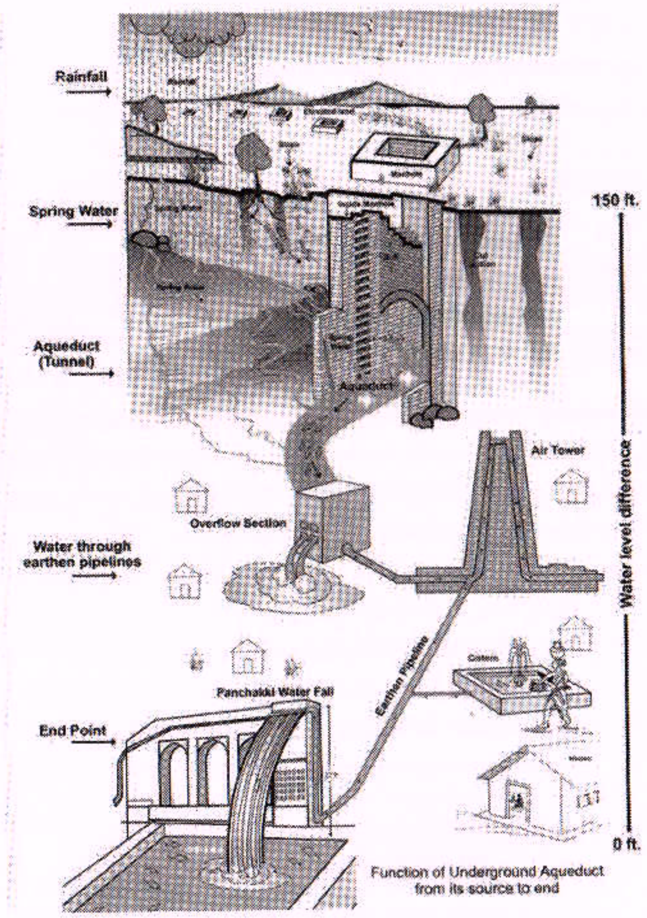

Fig. 2. Schematic sketch of ancient aqueduct from source to end point[1]

One of the famous landmarks of Aurangabad, the work on the Nahar-e-Ambari began in 1618 under the instructions of slave king Malik Amber. The network of aqueducts and cisterns was built to meet the needs of the ancient two lakh population of the city. Most of the Nahar-e-Ambari aqueducts pass through the city, including Fazilpura, and are still active in filling water in many cisterns located at strategic locations as predicted from Fig. 3. About 691 cisterns are connected to the aqueducts.[5]

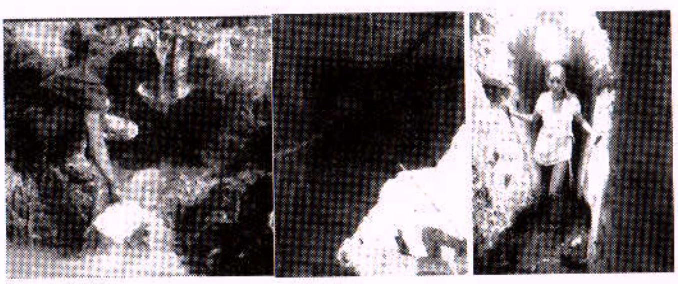

Fig. 3. Manholes of live Water tunnel (Nahar)

Like Nahar-e-Ambari two more aqueducts are still seen alive and people living nearby the man holes are using water even in summer as the nahar tunnels carry water in summer season Fig 3(b) shows that many electric motors are being used to pump the water from manholes. In Fig. 3(c) clear water running from tunnel can be seen which is observed in a survey carried by authors in summer season dated 27th April 2017 at Nahar-e-Panchakki and Nahar-e-Begampura. Locations of three live nahars are shown in the map of Aurangabad as shown in Fig. 4.

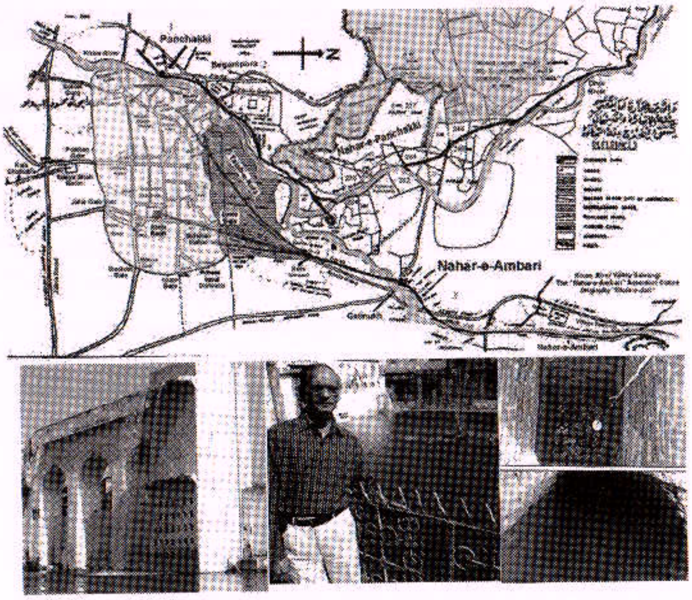

Fig. 4. Map of Aurangabad showing locations of live nahars with photos

2.2.1 Nahar-e-Ambari:

Nahar-e-Ambari is the original and first nahar designed by Malik Amber. Gomukh is the distribution point of collected water from source. Further it gets divided into three branches; Pipalkatta, Aamnahar and Khasnahar.[1]

2.2.2 Nahar-e-Panchakki: The Panchakki water fall and watermill are famous for its magnificent beauty in India and also in the world. The whole world appreciated its unique and mysterious structure of aqueduct, water fall and water mill. Water gushes out from the tower in the form of a solid shied of clean water across the big reservoir above the cascade of panchakki. An arrangement has been made at the top of the cascade to turn the heavy pressure of this water through pipe to operate flour mill.[1] The water of Panchakki was given to power house to generate electricity. Also, the garden around panchakki was also irrigated. The aqua technology of panchakki is totally copied from nahar-e-Ambari after one hundred eighteen years.The panchakki aqueduct is nothing but a rock-cut-canal under the earth running from the northern hills to the Panchakki water fall.[1]

2.2.3.Nahar-e-Begampura:

The famous ThatteHoud inBegampura receives water from this Nahar-e-Begampura [1] In total fourteen nahars were built till 1803.[1]

The most important and original among the fourteen is the underground water tunnel which was constructed by Malik Amber and known as Nahar-e-Ambari. It is the biggest and first aqueduct built amongst all other aqueducts in Aurangabad city. The Nahar-e-Ambari had capacity to provide ample water to palaces like temple, mosques, well, gardens, etc. Nahar was designed to fulfill the water demand of people for further three centuries. The output of the water in 24 hours was measured about 175536 gallons.[1]

3. Technical Study of Nahar-e-Ambari:

It is a simple technique of gravitation. At a distance of 12840 feet away from the town, a well was dug at the bottom of elevated hills, connecting to underground tunnel with gradual slope towards the city. The sub terrain water current gushed into the well and then connecting to tunnels as shown in Fig. 5. On the both the sides of tunnel walls were raised in brick and lime masonry leaving thousands small cavities for sub terrain spring water to fall inside the tunnel as shown in cross section of canal in Fig. 5. The walls were covered in archway and many man holes were provided for maintenance. Tunnels of 3 ft wide and 8 ft high were made up of brick and lime. The bottom of tunnel has been provided gradual slope towards the city. Thousands of sub terrain water currents gushed water into the tunnel and move fast towards the city.

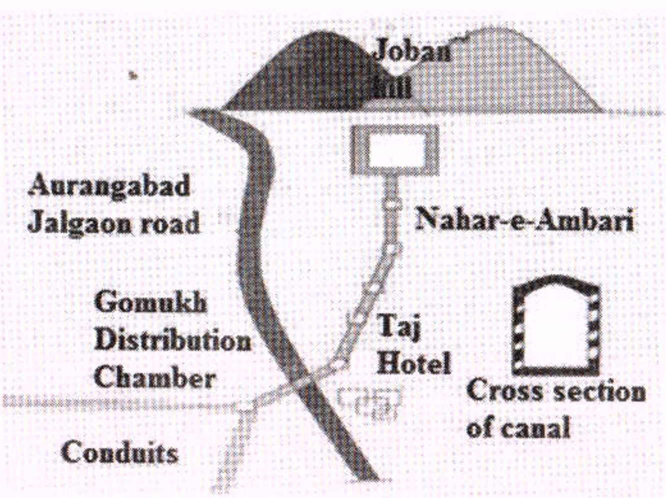

Fig. 5. Schematic flow of rain water collected at Joban hill foot, travelling throughNahar-e-Ambari till Gomukh[6]

There was a difference of height of 70 feet between source points and end point. The possible problems in those days were taken care in this technology. At some places earthen pipelines were built and siphon system was used and overflow was also given way with a proper manner as seen in Fig. 6. The overflow section reduces water pressure and does not allow damage to earthen pipeline.

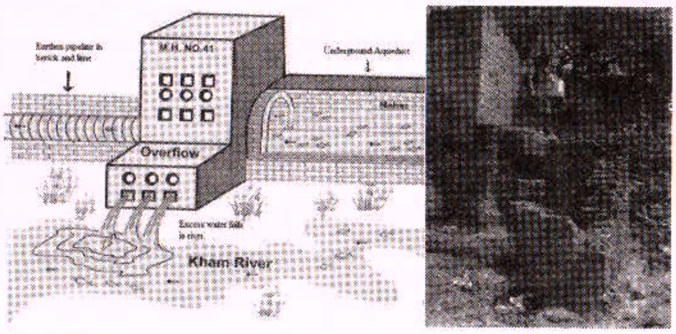

Fig. 6. Overflow of tunnel with Photos by Author

3.1 Travelling of water from start to end:

This underground aqueduct starts its way from the foot of the Joban hills which is towards the north of Aurangabad and flows downword, from north side of the town. The rock is cut deep, 40 feet below the surface of the ground, in the beginning and its vertical side walls are raised in brick masonry and closed at the top in an archway as shown in Fig. 7. This is continued throughout the canal.

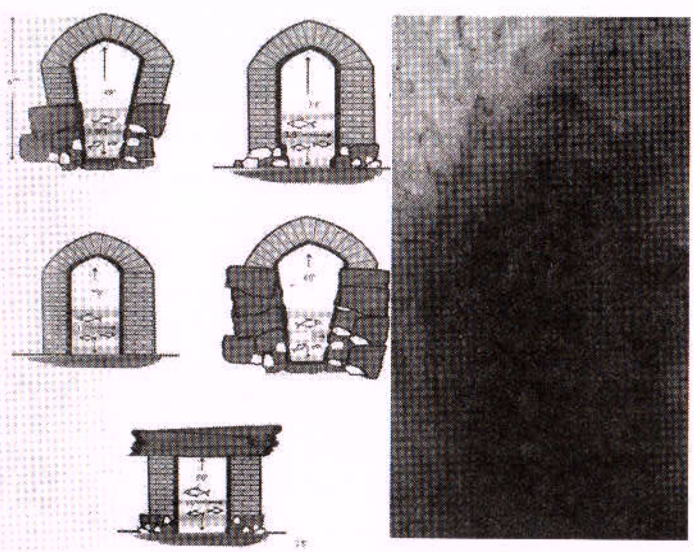

Fig. 7. Various cross sections of aqueducts[1] with photo taken in survey made by Authors

The Nahar-e-Ambari is 12840 feet (about 3914 m) in length from its source point to Gomukh where it is terminated into several cisterns. There are 100 manholes constructed over the aqueduct for cleaning and maintenance purpose. The supply section of Nahar-e-Ambari underground aqueduct tapped into hillside measured 12,840 feet length having average width of 3 ft. and height of 7 ft. Brick walls raised on both the sides of the aqueduct are completely covered in archways to avoid the sub terrain water entry from soil inside the tunnels. Thousands of small cavities specially left in the brick walls to allow sub terrain water. Solid rock bottom has been provided with gradual slopes from the source situated at the hillside at 2031 ft. height above sea level, to carry water to its destination i.e., Gomukh erected at the lower height at 1954 ft. S.L.[1]

3.2 Gomukh:

Ambari aqueduct was mostly passed by the side of a small stream known as Kham River by which a quantum of water input is raised. Basin shaped catchment area at hillside at source point is enough to keep constant supply of water to the town. Gomukh, a seen in Fig. 8,

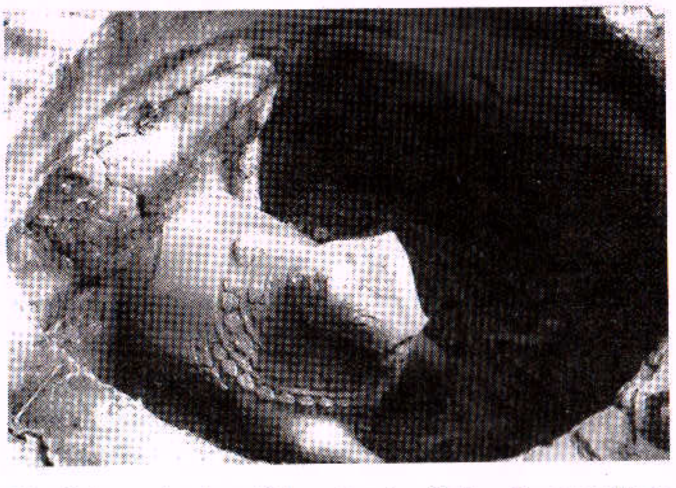

Fig.8. The end point of the nahar i.e. Gaimukh opposite to Hotel Taj, further terminates into distribution web of earthen pipelines.[6]

is a terminal point of aqueduct, from onward an earthen pipelines of section measuring 12" diameter embodied in 1.5'x1.5' in lime mortar nutshell as shown in Fig. 9. Network of earthen pipelines ranging from 2", 6", 8" diameters connected to more than seven hundred cistern spread all over the town. People used to take water from cisterns and take it to their houses for drinking and other purposes.

The nahar travels zigzag along the right bank of the Kham River. From the end point i.e., Gomukh, earthen pipe lines were used throughout the town to supply water in different areas. The Gomukh is a distribution center to supply water at every corner of town through earthen pipe

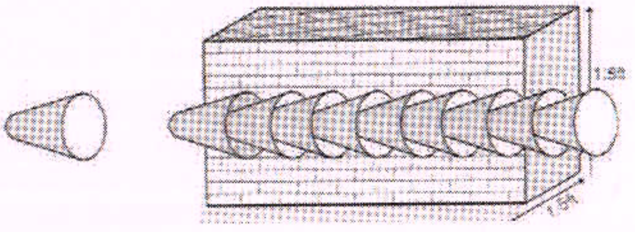

Fig. 9. Earthen pipeline embedded into lime mortar nutshell[1]

lines. The water distribution chart shows complete network of supply of water through near about 691 cisterns.

3.3 Principle of Gravitational force:

Gravitational forces allow water to flow fast towards the town as there is level difference of 77 ft. in between source and end-points. There are one hundred vertical manholes constructed at every 200 ft. average length distance over this aqueduct, so as to reach into bottom of the aqueduct from the surface of ground for cleaning and repairs purposes.[1]

The rain that falls on the hills and at the hill foot flows down through small rivers and rivulets. Some water percolates down in to the soil making its way deeper, until it is checked by impervious lava rock through which it cannot percolate further. The underground water then flows on the slopes over the surface of the impervious lava rock and flows down due to gravitational force.[1]

3.4 Siphon System and overflow:

A high skilled siphon system was applied in between manhole no. 65 and 66 while crossing the bed of the Kham River. A pipline of 12" was used at this point. The construction of tunnel to cross theriver, that too in the bottom of the river, was not at all possible to prevent from the water force of river. Therefore, earthen pipelines was installed using highly intelligent engineering siphon skill to carry water of aqueduct from one edge of the river to another edge to cross below the river water. [2]. The pipelines were embedded in 2 feet 3 inches in height and 3 feet wide having 380 feet length.Considering the aqua pressure developing inside the pipeline, especially in rainy season, a highly skilled overflow structure is designed. Fig. 9 shows the technical functioning of siphon system.

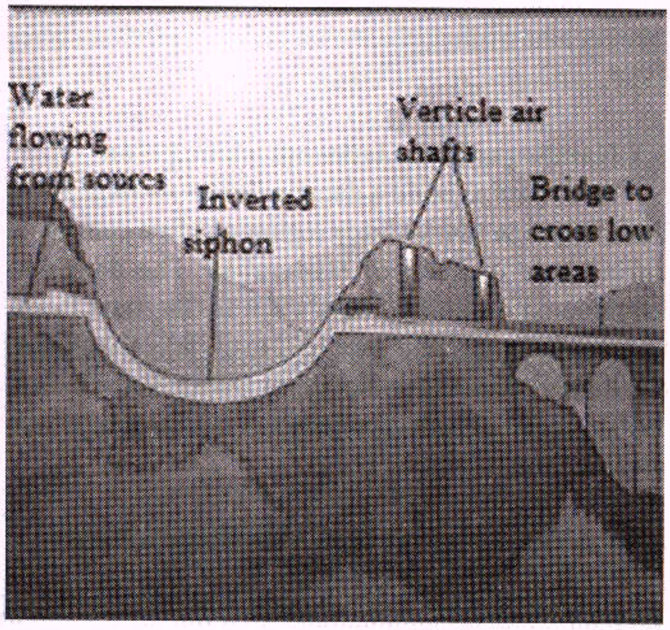

Fig.9. An example of Siphon system Similar technique was used in Nahar-e-Ambari to cross Kham River

3.5 The output of water for public use:

The huge water supply through the tunnel later on terminated all corners of the city through earthen pipelines measuring 8 inches to 12 inches as shown in Fig. 10.

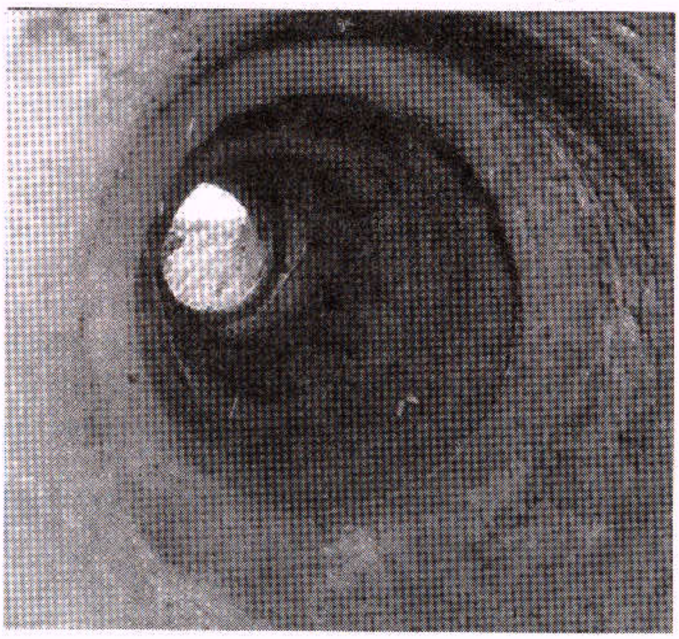

Fig.10. Earthen pipe from inside[6]

At the end point of these earthen pipelines many small cisterns were constructed with fountains in the center to supply the water. The people were collecting water from these cisterns. Near about 691cisterns were built in the city connected with these pipelines to supply drinking water. The air towers as shown in Fig. 11 were specially constructed at many places over the earthen pipelines to provide ventilation.[1]

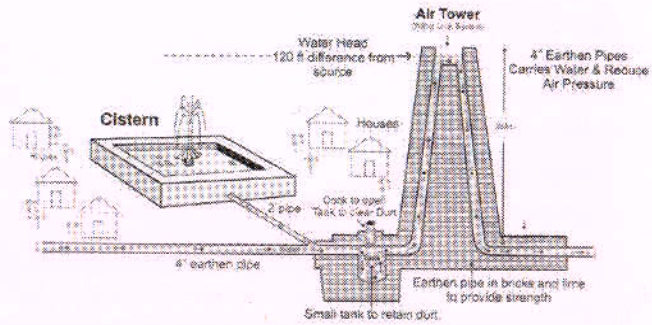

Fig.11. Detail of air tower [1]

3.6 Silent Features of Ambari Aqueducts[7]:
The water carrying system based on simple principle of gravity has following features:

1. Non polluted Fresh Drinking Water
2. Built in Local Bricks and Lime
3. Public utility
4. No Need of Electricity, Motor Pump or Diesel.
5. No Need of Filtration Plant.
6. No Maintenance or Repair Cost.
7. Man power required is less.
8. No Loss of Water.
9. Useful at "Rain-Shadow" Areas.
10. Other usage of surface land are possible
11. Possible to Construct in Modern Era.

4. Sustainable approach with socio economic and cultural value:

Adoptive reuse of structures has a major role to play in the sustainable development. When adaptive reuse involves historic structures, environmental benefits are more significant, as these structures offer so much to the environment, landscape, identity and amenity to the communities to which they belong. One of the main environmental benefits of reusing structures is the retention of the original structure's "embodied energy". By reusing buildings, their embodied energy is retained, making the project much more environmentally sustainable than entirely new construction.[8] When done well, adaptive reuse can restore and maintain the heritage significance of a building and help to ensure its survival rather than falling into disrepair through neglect or being rendered unrecognizable. Heritage structures that are sympathetically recycled can continue to be used and appreciated.[8]

It is essential to emphasis the value and potential of cultural heritage wisely used as a resource by sustainable development and quality of life in a constantly evolving society. The heritage structures built in the past that have high historical, architectural, spiritual, social, political and economic values. The expansion of heritage and its conservation from earlier curatorial roots to more creative and productive means has been an important development. The contribution of urban heritage in cities is not just aesthetical and environmental values but also of economic production. [9]

Another important dimension of Heritage in India is its living character where the past is very much part of present lives of people; an evolving cultural resource in which continuity and change are deeply embedded. It is the "humble" and "humane" aspect of heritage which is Non-material.

5. Water Management of Auranagabad city:

Malik Amber the founder of Khirki (Aurangabad) town discovered subterranean water table of elevated mountains around Khirki. He practically manipulated and procured a stable perennial water supply to solve the acute problem of drinking water for newly built town.[10]

5.1 Malik Amber Era (16th Century):

Nahar system constructed by Malik Amber in 1618 A.D. provided clean water for two lacks of population of Aurangabad which was founded as Khirki by Malik Amber.

5.2 Mughal Era (17th Century & 18th Century):

In order to facilitate the Military Activities, Aurangzeb expanded the system. The Aurangzeb Gazetter of 1884 recorded 12 courses of Nahar, four of which are still alive.[10]

5.3. Nizam Era (19th Century):

The construction of the first modern water supply system began in 1932 at the request of Nizam and was completed in 1933. A setting of tank with a capacity of 4.64 Gallons was installed near the Gomukh service reservoir and the distributary system was expanded. Due to the rapidly increasing population another water supply system was constructed. The Harsool river and Kham river were tapped, a filtration system was installed to purify the water and the distributary system was enlarged.[10]

5.4. Harsool Lake (since 1955):

In 1933, a dam was constructed on Harsool River to create Harsool Lake. Due to increased population, this lake became main water source of Aurangabd city since 1955.

5.5. NathSagar Dam, Jaikwadi (since 1976):

A plan to build a dam on Godavari river in the drought-prone Marathwada region was first conceived during rule of State of Hyderabad. The dam was inaugurated on 24 February 1976 by the then Prime minister Indira Gandhi.Since 1976 to till date, Aurangabad city started surviving on Nathsagar Dam which is built in 1976 by acquiring agricultural lands from local farmers who became Dam Affected. [11]

6. Neglected Facts about current water source:

Jaykwadi is 54 km away from Aurangabad. The sea level of Jaikwadi is 465m and sea level of Aurangabad is 513m. So it is essential to carry water from Jaikwadi to Aurangabad with the help of electricity, which is not a sustainable approach. The amount of pending electricity bill is reached above 300 crores.[11] At the same time, pipeline gets damaged frequently due to all time pressure on it. This pressure creates centripetal force on inner walls of pipes as pressure is in opposite direction to gravity resulting into frequent damage of pipelines. It causes cutting of water supply to the city for many days sometimes. Today, almost 90 million liters of water shortage is there in city. [11]

On the other hand, siltation has taken a heavy toll on the project. It is estimated that approximately 30% of the dam is filled with silt, reducing its life as well as storage capacity. Survey findings show that from 2003 to 2012, there was a loss of 31% (that is 8.08 thousand million cubic (TMC) feet) in dead storage and 14% (that is 10.73 TMC) in live storage capacity of the dam due to silt.[11]

7. Present and Future Water Demand of Aurangabad:

Aurangabad is the fastest growing city. It is calculated that it can grow three times in next 20 years. After considering present and future water requirement Aurangabad Municipal Corporation calculates following figures.

Today population of Aurangabad is 15 lacs and its water demand is 140 million liters per day. In 2031, population will be 25 lacs which will demand 375 million

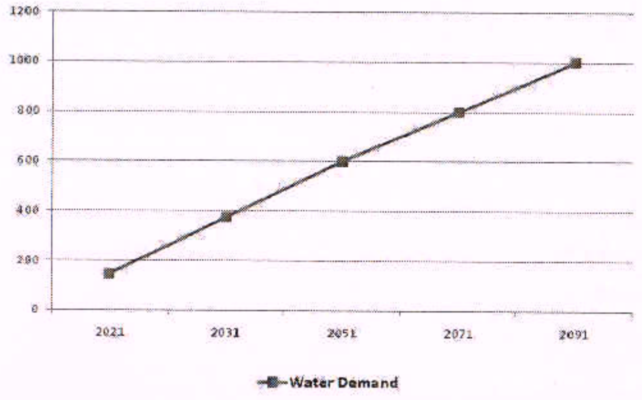

Fig.12. Graph showing increase in water demand [11]

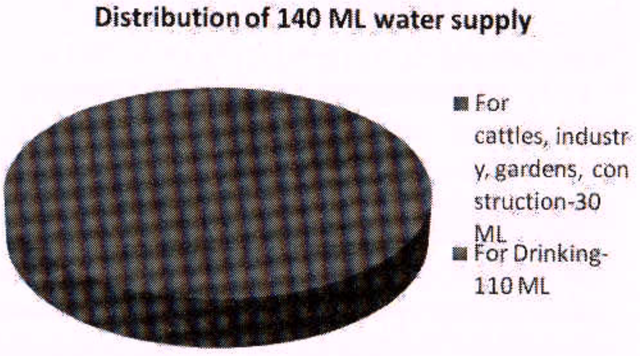

Fig.14. Distribution of 140 ML water supply [11]

liters of water per day. In 2051, water required will be 600 million liters per day.[11] Till 2091, it will be 1000 million litres. New water supply systems will be introduced till the time, but question is of water availability in such a huge quantity. Today 140 million liters of water is brought into the citythrough 700 m diameter pipelines (old) and1200 and 1400 m diameter pipelines (new). Out of which 110 million liters water is used for drinking and 30 million liters of water is used for cattle, gardens, industries, construction, etc.[11] 135 liters of water per day percapita is the target and only 100 liters per day per capita is being supplied. It proves currentwater management is insufficient and unsustainable. Also the average rainfall of Aurangabad fluctuates between 500 to 1000 mm and this is insufficient.[11]

8. Current Scenario ofNaharSystem:

The civic body did not take the appropriate action against illegal construction and encroachment. Following are news published in local news papers whenever nahrs are disturbed by public while various construction activities.

1. On November 8, 2016 the Nahar was broken at Fatehpura area during drainage work by a contractor appointed by AMC.
2. On November 19, 2016 a 9mm diameter earthen pipeline was broken at two places near Dr. Bilgi Hospital in Shrey Nagar. One more damage near Mr. Ghuge's house was found in same pipeline opposite to Bilgi Hospital.
3. On November 20, 2016a part of Nahar was damaged at Quile Ark.

The survey carried out by Authors of this paper proves that nahars are still carrying water upto two feet level inside the tunnel. This survey was carried out on 27th of April 2017 in harsh summer days when water scarcity is experienced everywhere.

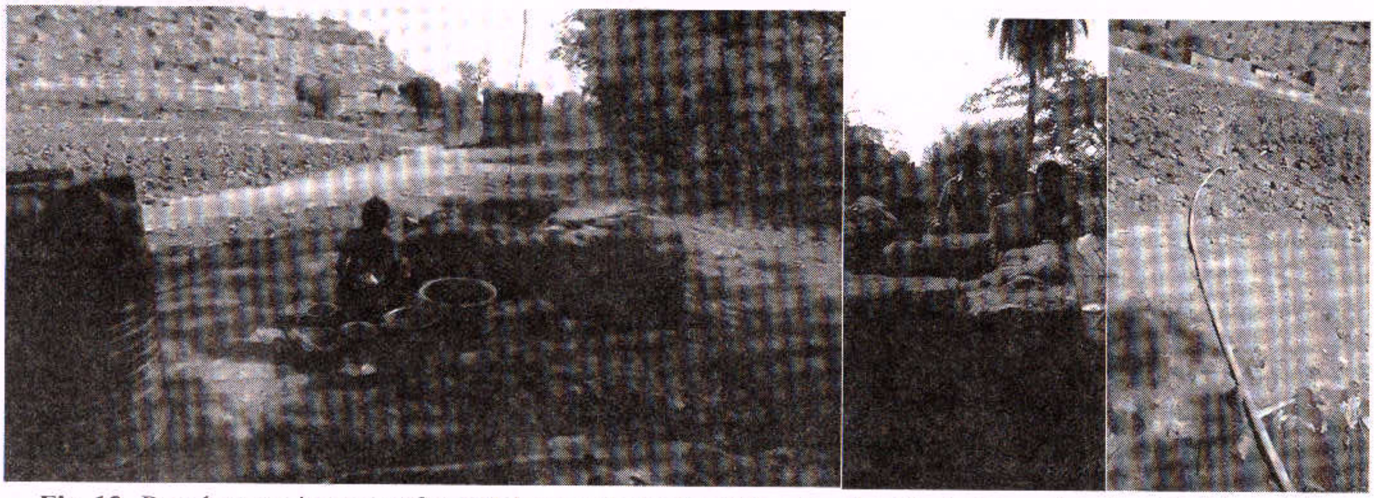

Fig. 13. People are using water from Nahar manholes for daily activities like bathing, cleaning, feed for cattles

9. Conclusion:

This paper concludes that an adoptive reuse of nahar-e-Ambari can enable people to incorporate modern scientific approaches in their traditional knowledge networks.It requires preparatory research, training andappropriate support.

1. Nahar can be used as educational resources for students, technicians, professionals, resources well as well as general public. At the same time it can attract tourists to recur the cost of repair and maintenance.

2. Aurangabad city requires 140 ML of water per day which is brought from Jaykwadi in unsustainable and expensive technique. Out of 140 ML; 30 ML water is used for cattle, industry, garden, construction, etc. Even if some part of this 30 ML of water is produced by rejuvenating or replicating Nahar system, it can be a great relief.Nahar-e-Ambari alone produced 175536 Gallons, i.e., 667036 liters (0.66 ML) of water in 24 hours. It means one nahar can reduce a load of 2.22% of 30ML water demand for other than drinking purpose. Even if five nahars which are still working are properly maintained, they can produce 3.3 ML of water, i.e. 11% of load can be reduced on current 30 ML water which is used for other than drinking.

3. At the same time, it can generate the employment to local people through tourism and restoration of Nahar system. The natural benefits of city can be used efficiently as the aqueduct contains a fully gravitational flow, flawless network of the chambers, properly spaced outlets, air-towers and manholes for the maintenance purpose. Hence the system could cater the city without involving electricity and other traditional resources. Thus socio-economic, socio-cultural, socio-political as well as material and nonmaterial aspects can be fulfilled. It can decrease the load on current water supply system and can become a supplementary, free of cost, sustainable source, by rejuvenating or replicating.

4. Geographic condition like Aurangabad is favorable at 30% land areas in India and 20% of land area of the world for the construction similar to Ambari technique, which are bound to save millions of foreign exchange and fuel.

5. Apart from getting potable water and water for other public utilities, the beautification purpose of Aurangabad city can be fulfilled by making available the basic source for Flora and Fauna.

6. Conservation of heritage forAdoptive reuse of existing structure is the smartest intervention for a city to proceed towards the Smart City. It can help to reduce carbon footprint by retaining the "embodied energy" of existing structure which is of a great heritage value also. Aurangabad is becoming a Smart city which can be achieved in a smart way by rejuvenating or replicating the 400 years old live aqueduct.It will definitely add a feather into the crown of historical Aurangabad city of world heritage value.

10. References:

[1]. Shaikh, R., 400 hundred years underground living aqueduct, Aurangabad:DSR Publications, 2010.

[2]. Mane, Pratik V. January 2017, "Engineering Aspects of Nahar-E-Ambari and Its Necessity in Aurangabad (Maharashtra)", International Journal of Science, Engineering Research and emerging Technology, Vol. 1(1).

[3]. Sayeeduddin S, Er. Shaikh, Zahoor Khalid. Nov.-Dec. 2014,"Aqueducts in Historical CityofAurangabad-A study", An International Peer Reviewed Journal Of Multidisciplinary Research Vol. 1(1).

[4]. Sadgir, P. A. andKahalekar U. J. June 2007,"Dying Wisdom of Medieval Water Management of Aurangabad City", National Seminar on Water & Culture, Hampi, Bellary Dist.

[5]. Times of India, Nov. 8, 2016, "Historic Nahar reduced to rubble at Fazalpura".

[6]. Bhalge, P. "Nahar-e-Ambari Engineering Aspects", Presentation at INTACH Chapter Aurangabad.

[7]. www.aqueductdsr.com.

[8]. Chapter 11, Handbook of conservation of heritage buildings CPWD-2013.

[9]. Chapter 14, Handbook of conservation of heritage buildings CPWD-2013.

[10]. Wikipedia.org/wiki/nahar water system.

[11]. Diwan, V. "Panpasara",Pune:Saket Publications, 2017. (chapter 23, pp. 160-161).

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