GIS based current analysis and efficiency improvement of building water supply network

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Abstract. This paper will discuss about the current examination and efficiency improvement measures of the building water supply network specifically terrace looping and its impact identification based on GIS mapping. The efficiency improvement is in terms of supplying unit rate of water by keeping desired parameters e.g. velocity, pressure at constant rate another the other aspect of efficiency improvement is to cater more taps based on current network by improving it. GIS, as a tool to be utilized to identify and analyze the impact of efficiency improvement to a vicinity covering specific number of buildings. The GIS tool found helpful in terms of identifying the impact assessment on building water distribution network.

1. Introduction
Water being the precious commodity of 21st century, it is important to maximize utilization of water. Through the scientific research process following experimentation will be carried out to achieve efficiency improvement by field modelling and experimentation on plumbing fixture and water supply network. Geometrical modifications to be made in existing plumbing fittings and fixtures. Currently the fixtures like European WC consumes 6 litres of water in single flush and urinals consume 3.8 litres of water per flush. The consumption through various fittings & fixtures needs to be reduced to match the water scares scenario in India. To achieve water reduction in fixtures & fittings extensive study to be catered in various establishments e.g. residences, offices, malls, metro stations, etc. Design of fittings & fixtures such as water closet, wash hand basin, urinals, shower, bib tap, health faucets, flush valve, etc. should be optimized through various calculations and practical. Which shall in-turn help in reduction of water consumption.

Conducting field experiments to identify optimized way of designing terrace water distribution network through various calculations. Thereby it can be assessing with a set of results showing ‘terrace water distribution network’ of a building which will be ideal for uniformly distributing water throughout the water distribution network length. The flow in the pipe to be kept laminar as much as possible. Thereby increasing the efficiency of distribution networks which shall result in implementing uniformity in water distribution. In accordance with the terrace water distribution network we have to ensure compatibility of down take piping system. The system can either be telescopic of parallel pipes or combination of both. The compatibility needs to be identified with various calculations, hydraulic modelling and field experiments.

Geographical information system mapping (GIS) is to be used to identify the density of the buildings per unit area to identify the number of buildings with their approximate sizes. This is because practically finding size of building would be time-consuming task which increases the duration of research.
2. Literature Review
The analysis of different journal papers suggested different areas of building plumbing. One of the papers written by Salehi, M., Abouali, et. Al. [1] focuses on quality of drinking water used in residential apartment complying to green building norms. Various factors influencing the consumption of water in residential building were studied by Talita Flores Dias et. al. [3]. The factors were then used to identify the consumption pattern from southern Brazil area of user through multiple regression analysis. This model can be used to improve the supply in urban infrastructure. Life cycle cost (LCC) analysis is also very important from current research perspective as it it important know the LCC of enhanced fixtures, the paper by I. M. Chethana S. et. al. [5] has done the life cycle costing for green building services. While enhancing the flow for fixtures / fittings, the hygiene perspective also needs to be taken into account which is evaluated in the paper published by Stephen Kwasi Adzimah, et. al. [18]. Terrace area identification by GIS is utilised by Steven Jige Quan, et. al. [23] for evaluating the building energy model by solar. To enable the user to decide the building retrofitting based on carbon footprinting, GIS is used by Rene Buffat, et. al. to prepare the options of retrofitting. In this paper also building area mapping by GIS is adopted.

Overall, GIS is a vital tool now-a-days to reduce on certain aspects like manpower, time-duration, cost for the current analysis conducted in this paper.

3. Methodology
The objective of study is to analyse the result of improvising the water supply network inside the building. According to object the methodology adopted is based on GIS based software, identify the building foot-prints. Later, field experimentation for efficiency improvement of water supply network of a building along with its fixtures water consumption enhancement to be conducted. These results will later be implied on a particular vicinity to identify the nett savings through improvements.

However, for current paper theoretical and mathematical variation will be analysed about before and after efficiency improvement and its techno-commercial comparative will be drafted to review the monitory benefit. Certain assumptions will be made to demarcate the boundary condition for the research work.

3.1. Pipe Size Enhancement
Based on the reputed manufacturer’s catalogue the internal diameter of 16 mm (refer figure 1) for most of CP (chrome plated) fittings e.g. bib taps, health faucet, etc. however the pipe size provided is 15 mm as per codal requirement (refer below table).

| Sr. No. | Type of fixture                | Minimum Pipe Size |
|--------|-------------------------------|-------------------|
|        |                               | Private | mm   |
| 1      | Bathtub                       | 4       | 15   |
| 2      | Ablution faucet/Bidet         | 1       | 15   |
| 3      | Clothes washer                | 4       | 15   |
| 4      | Dishwasher                    | 1.5     | 15   |
| 5      | Drinking fountain             | -       | 15   |
| 6      | Hose bib                      | 2.5     | 15   |
| 7      | wash basin (with metered faucet) | 1   | 15   |
| 8      | wash basin (with standard faucet) | 1.5 | 15   |
| 9      | Service sink                  | 1.5     | 15   |
| 10     | Kitchen sink                  | 2       | 15   |
| 11     | Surgical sink                 | -       | 15   |
Figure 1. CP Bib Tap.

Hence, based on demand if the pipe size diameter can be reduced to 10mm along with the reduction in diameter of CP fitting. Accordingly, there will be considerable amount of saving happen in terms of revenue and precious material. On other note, with same size diameter of pipe, more fixtures can be feed with water.

3.1.1. Terrace Looping of Water Supply Distribution Network
The pipe distribution ring main at terrace is called as ‘terrace looping’. The terrace looping pipe size is depending upon the number ‘fixture units’ to be catered multiplied by the diversity factor. The fixture unit is defined by codes e.g. table 1 shows the fixtures units defined by ‘National Building Code of India, edition 2016. The terrace loop pipe starts at overhead tank and ends till the shaft entrance. Since ages this terrace looping concept is in place and there is no modification is sought in terms of journal paper or from practical aspect. This area of building plumbing needs to be focused along with enhancement of flow through fixtures/fittings.
3.1.2. Downtake water supply pipe

The downward pipe which start from terrace looping is also called as ‘downtake pipe’ and has several terminations at each apartment placed vertically below each other. There are different ways the downtake pipe is designed e.g. telescopic, multiple down pipes for group of floors, etc. This downtake pipe plays the vital role to connect the terrace loop to individual fixtures / fittings.

![Figure 2. Building Terrace Loop.](image)

However, the key focus area will be terrace looping and individual fixture / fitting.

3.2. Fixture and Fittings Enhancement

The flow through fixtures is key area need to be focused to reduce the water consumption. The perennial solution to be worked out for reducing the flow through fixture/fittings. One of the easiest solutions would be reducing the internal diameter through which the flow is passing from the fixture. However, by reducing the internal diameter through which the flow is passing it required to be ascertained that the utility is not impacted. In some cases, even though the utility impacted the desired effect should be achieved. Example, even though the flow through shower is reduced from 10 lit/min the user should not have any adverse effect of reducing the flow through shower. Following table – Table 2, indicates The maximum Flow Rate Through Fixtures and Fittings [22].
Table 2. The maximum Flow Rate Through Fixtures and Fittings [22]

| Plumbing Fixture / Fitting       | Maximum Flow Rate |
|---------------------------------|-------------------|
| Water Closets                   | 6 litre/flush     |
| Urinals                         | 3.8 litre/flush   |
| Lavatory, metered faucet (Public)| 1 litre/minute    |
| Lavatory, faucet (Private)      | 8 litre/minute    |
| Sink, Faucet                    | 8 litre/minute    |
| Bidet, hand held spray          | 8 litre/minute    |
| Shower Head                     | 10 litre/minute   |

3.3. GIS Based Impact Identification

Every building, in the vicinity of Mumbai, has a standard terrace looping at terrace. Here, Mumbai is considered as territory for reference. Usually the length of the terrace looping of water distribution system is nearly equal to the periphery of the parapet wall. Hence, based on GIS software the periphery of the building is computed. Figures shown in following figure 4 shows GIS Image for Study Vicinity at Large.

3.3.1. Case study for Terrace Loop

The below image – Image 6 shows GIS Image for Matunga Local Vicinity from GIS software named ‘Mapit GIS’ which shows the red demarcated area with perimeter of 108.91m. In this particular vicinity. There are 10 identical building also numbered in the ‘Figure 6, GIS Image for Matunga Local Vicinity (from Mapit GIS)’. Now, the area demarcated is of the building constructed from the ‘Figure 6’.
Figure 5. GIS Image for Matunga Local Vicinity.

Figure 6. GIS Image for Matunga Local Vicinity (from Mapit GIS).
Hence, there will be the terrace looping water supply piping of approximately 108.91m. accordingly, for 10 numbers of buildings the length of water supply piping would be 1089.1m.

3.3.2. Terrace Loop Water Supply Pipe Size Calculations

Assumed data:
- Number of Fixture / Fittings to be catered by terrace looping water supply are 100 FU.
- Length of terrace looping water supply is 108.91m.
- Velocity range in pipe considered is 1 m/s to 1.2 m/s.
- Water temperature is 20°C.
- Material of pipe is plastic.
- Assumed reduction in fixture unit due to usage of enhanced fixtures / fittings is 10% i.e. 90 FU

Design:

i. As per complete loading unit
Probable simultaneous demand derived from NBC-2016 (Part 9, Table 3) = 166.5 litres/min for 100 FU Pipe size based on Hazen William’s equation = 62.1 rounded to 65mm commercially available size for 100 FU.

ii. As per 10% water saving unit
Probable simultaneous demand derived from NBC-2016 (Part 9, Table 3) = 155.2 litres/min for 90 FU Pipe size based on Hazen William’s equation = 50.04 rounded to 50mm commercially available size for 100 FU.

Hence there is one size pipe diameter reduction due to 10% enhancement of fixture / fitting. Following table i.e. ‘Table 3. Cost Saving Due to reduction of Pipe Diameter of Terrace Looping’ shows the cost saving due to reduced diameter of pipe:

| Pipe Diameter | Unit cost ($/RM) | Total Cost Saving ($) |
|---------------|------------------|-----------------------|
| 65mm pipe dia | 21.81            | 2375.32               |
| 50mm pipe dia | 9.52             | 1036.82               |
| Savings       | 12.29            | 1338.5                |

4. Result and discussion

Based on subsequent author’s literature review and the data analysis and going through the local consultant design procedure along with various manufacturer’s catalogues it has been found that there is potential chances of enhancement of water supply network and fixtures.

GIS tool will be very much useful to identify the number of repetitions which is very important. Because, unless the extent of application is known it is not advisable not advisable to define the area of focus. Also, GIS will help in reducing the efforts of actual ground surveys and omits the human error. Based on above general calculation as there is considerable amount of monitory saving also occurring. The result indicates that GIS based current analysis and efficiency improvement of building water supply network is useful.

5. Conclusion
The analysis catered about building terrace looping shows that there is significant saving in terms of direct cost. Current analysis shows saving of $1338.5 with respect to terrace looping only. There will be significant indirect cost savings shall happen on allied accessories. Also due to GIS mapping the physical involvements of human and human errors will be reduced to great extent. There is significant time saving to arrive at results due to GIS. The Water is becoming scarce resource which should be utilised efficiently. To utilise the water more effectively not only infrastructure network but building level distribution network also needs to be carefully re-invented and re-designed along with various fixtures and fittings. Now-a-days most of the building piping network is made of plastic – PVC. Saving on PVC piping is important from global resources perspective i.e. manufacturing, transportation, stocking, installation – labours, etc. To achieve such improvisations tools like GIS mapping will certainly prove its utility to ascertain the manpower and costing. Further utilization of GIS mapping needs to be explored in this sector of civil engineering.

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