Revitalizing and Preparing Drainage Operation and Maintenance to Anticipate Climate Change in Semarang Heritage City

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Abstract: Semarang urban coastal areas are experiencing tidal flood. In addition, land subsidence of 5 to 10 centimetres per year is taking place. The climate change phenomenon provokes land areas that are lower than sea water level from time to time. This makes the situation with respect to flooding increasingly risky. Semarang Old City (heritage) as part of principal Semarang area is suffering also from regular flooding and pollution that hamper the revitalisation of the old city. These areas used to be productive lands, but flooding make the existing public infrastructure does no longer function, and residential areas have changed into unhealthy slums. To overcome these problems, the Government of Semarang chooses a polder drainage system to address the flooding in Semarang. In the framework of the cooperation between Indonesia and the Netherlands, these activities consist of research and workshops on Urban Heritage. The scope consists basically of five components: experiences with urban drainage and flood protection in Semarang with a focus on Semarang Old City, field visit to relevant places with respect to urban drainage and flood protection of Semarang Old City, lectures on the relevant aspects of urban drainage and flood protection, exercises to get an insight in the processes that can take place under normal and extreme conditions, formulation of a preliminary plan to improve the situation with respect to urban drainage and flood protection of Semarang Old City. In this paper, the various relevant points are described, such as scenarios analysis as well as the findings and recommendations for improvement of the urban drainage system and flood protection of Semarang Heritage City.

Key words: Drainage, heritage city, revitalization, operation and maintenance.

1. Introduction

Semarang Old City is suffering from regular flooding and various other persisting problems-traffic congestion, pollution, lack of safety and security, budget deficits and limited investments-that hamper the revitalisation of the old city. In addition, primarily due to extraction of deep groundwater, land subsidence is taking place, which is estimated in the range of 5 to 10 centimetres per year [1]. This makes the situation with respect to flooding increasingly risky.

In the framework of the cooperation between Indonesia and the Netherlands, several joint activities have already been developed with a focus on the

cultural heritage of the old city and to contribute to improvement of the situation. One of these activities consists of workshops on Urban Heritage. So far, four of these workshops have been held over the years.

While regular flooding and pollution are among the persisting problems, it was considered to be important that a separate workshop would be organised with a focus on these problems and on how to find solutions to improve the situation in such a way that there are good chances for revitalisation of the important Old City. At the beginning of this workshop, a presentation of the outcomes of the workshops on *Urban Heritage* as far as relevant for urban drainage and flood protection were presented.

The workshop programme consisted of lectures, a field visit, exercises and the formulation of a preliminary

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Fig. 1 Google Earth map of Semarang Old City.

plan on improvement of the drainage system and flood protection in Semarang Old City (Kota Lama). The Google Earth map of Semarang Old City is shown in Fig. 1.

2. Methods

The Drainage System Plan in Semarang Old City consists basically of five components [2]:

- experiences with urban drainage and flood protection in Semarang with a focus on Semarang Old City;
- field visit to relevant places with respect to urban drainage and flood protection of Semarang Old City;
- lectures on the relevant aspects of urban drainage and flood protection;
- exercises to get an insight in the processes that can take place under normal and extreme conditions;
- formulation of a preliminary plan to improve the situation with respect to urban drainage and flood protection of Semarang Old City.

During the workshop it has been analysed and

discussed what the participants observed with respect to the urban drainage system and flood protection of Semarang Old City and what recommendations could be given with respect to the improvement options.

The presentations of the lectures and exercises as well as relevant data that were available during the workshop have been submitted to the participants. In the next paragraph the result, the findings and recommendations will be presented.

3. Results and Discussion

3.1 Urban Drainage and Flood Protection of Semarang City

Semarang Old City is a flood prone lowland area. In such areas, flooding can be caused by different phenomena [3]. A distinction can be made in:

- severe rains: *short duration, unpredictable, local influence*;
- river floods: *short-long duration, relatively good predictable*;
- sea floods: *short duration, tidal influence, wave*

In the case of Semarang river floods, there will be a relatively short duration, while the length of the rivers is relatively short and the rainfall in the river basin can be intense. As a consequence the time for flood forecasting is also relatively short. Although there are some storage provisions in the upstream sections of the rivers, it looks like that they are not storing much water during extreme events (Fig. 2).

- In the mouth of Semarang River, a big pumping station with a reported capacity of 30 m³/s has been built (the Japanese pumping station) (Fig. 4). There are also discharge sluices aside of this pumping station. However, it was reported that these are normally closed and that they only will be opened in

Fig. 2 Existing drainage system of Semarang. In red colour the West and East Banjir canals [4].

Fig. 3 Sketch location of Semarang River, Baru River, Asin River and its infrastructures [5].

Fig. 4 Newly built pumping station at the mouth of Semarang River.

very extreme cases. This implies that there is no tidal influence anymore in Semarang River and that all the excess water from the area that is served by this pumping station is being pumped out to the sea.

- It has been reported that a large amount of sediment is coming down through the East and West flood canals and that the resulting sedimentation is hampering the functioning of especially the East flood Canal;

- In addition, it has been mentioned that substantial urbanisation is taking place in upstream sections of the river basins. This results in increased flows in the East and West Flood canals during extreme events, among others resulting in overflow of their banks in downstream sections. This overflow water can flow overland into Semarang Old City.

It has been mentioned that flooding from the sea only occurs during spring tide periods and that there is not really a danger of storm surges, or tsunamis. However, while the new pumping station (Fig. 4) is there, no tidal flooding has to be expected anymore through Semarang River. On the other hand, the Banger River is still in open connection with the sea and tidal flooding can occur through this river. The flood water can then still flow overland to Semarang Old City. This may also be the case along some other sections of the coastline. In the coastline, it needs to

respect water flow through porous soil [4].

As far as the urban drainage of the low part of Semarang is concerned, the systems are in principle the same as in Semarang Old City. However, in most of the surrounding areas drainage is still achieved by gravity, and no pumping has been introduced yet in addition to the big pumping station.

Flood protection for the lower part of Semarang, including Semarang Old City, is provided by the walls along the East Flood Canal and the West Flood Canal (Figs. 5 and 6). It would have to be investigated whether in addition water can flow from higher parts of Semarang directly to overland or through small urban drains to the lower parts.

3.2 Urban Drainage System and Flood Protection of Semarang Old City

As far as the urban drainage system of Semarang Old City is concerned, the excess water flows through open (Fig. 7) or covered drains. Where these drains cross roads there are generally culverts. The impression is that the bottoms of these drains are located at a certain depth below the roads. While several of the roads have been raised over time in many cases the floor levels of the houses are substantially below the level of the adjacent roads. Due to this flooding of the houses occurs at an early stage, the drains along the roads don't provide sufficient drainage for the houses.

There is a pond near the railway station where water can be stored (Fig. 8). This storage plays an important role in the storage of excess water that is needed during wet periods.

Discharge of water from Semarang Old City takes place to Semarang River in two ways:

- Through an outlet structure that is provided with vertical gates (Fig. 9);
- Through two pumping stations, one aside of the pond near the railway station (Fig. 10) and the other near the split in Semarang River (Fig. 11). It is not clear if these pumping stations pump the water separately to

Fig. 5 Wall along the East Flood Canal.

Fig. 6 The downstream section protecting Banger Polder and mouth of the West Flood Canal.

Fig. 7 Open drain in Semarang Old City.

Fig. 8 Storage pond near the railway station.

Fig. 9 Outlet structure of Semarang Old City to Semarang River provided with two vertical gates that would have to be closed during high water levels at Semarang River.

Fig. 10 Pumping station beside of the pond near the railway station.

Fig. 11 Pumping station near the split in Semarang River.

Semarang River, or that the pumping station near the storage pond pumps water to the pumping station near the split in Semarang River and that all the water is

pumped by this pumping station to Semarang River.

3.3 Scenario Analysis

Those scenarios can actually be used as the reference of implementation phases to reduce inundation in Kota Lama [5]. There are seven scenarios to solve inundation issues in Semarang Old City:

- Cleaning the canal and retention basin;
- Full pump capacity;
- Full gate opening operation at every outlet;
- Flap gate operation at every outlet;
- Close the connection with Banger drainage sub system;
- Proposed new pump capacity;
- Full developed polder system.

Then, according to the observation the clean canal curve shows that Kota Lama starts to inundate when the boundary condition is at +0.18 m MSL. For fulfilling the flexibility criteria, the vertical gates can be operated if the water level in boundary condition is -0.05 m MSL. So, it can be divided into two cases, namely normal case and critical case. Normal case is applied when the gate operation can be used as an outlet regulator and the water level on the boundary condition is less than -0.05 m MSL [2]. The condition when only pump can be operated due to the high water level at boundary condition (more than -0.05 m MSL) can be categorized as critical case [6].

According to the scoring evaluation the seven scenarios, fully developed Kota Lama Polder System, is the most appropriate scenario for critical case. As consequences, Baru River pump as the pump for outside Kota Lama Polder should be increased its capacity and new ring dike has to be constructed. The area within the Kota Lama Polder needs to be installed some flap gates to restrict the water from outside entering the polder system. The existing Tawang pump as the polder's pump still can be utilized because the capacity is still sufficient [5]. The diagram of implementation phases for Kota Lama is presented in Fig. 12.

Fig. 12 Implementation Phases for Kota Lama [5].

3.4 Findings and Recommendations of the Workshop on Drainage System Plan in Semarang Old City

During the workshop, it has been analysed and discussed what the participants observed with respect to the urban drainage system and flood protection of Semarang Old City and what recommendations could be given with respect to the improvement options.

The following comments, suggestions and recommendations have been formulated:

- The high speed of land subsidence (5-10 cm per year) has a very negative impact on Semarang Old City. This subsidence is primarily due to the extraction of groundwater from the sandy aquifer under the thick clay and/or peat layers. As long as this will not be stopped this subsidence will still go on for a long time and will have much more impact on the area than sea level rise. It is therefore of importance that the groundwater extraction will be reduced as much as possible and that water supply can be provided from surface water, for example by creating more storage facilities upstream. Such storages can also be used to reduce peak flows and to make better use of the available water resources. There is already a plan for the overall improvement of the drainage and flood protection systems of Semarang, including new provisions for storage in the upstream parts of

the rivers. The status of this plan would have to be verified;

- At several places sedimentation and deposition of solid waste can be observed in the urban drains of Semarang Old City. In addition at several places damage to the banks and sidewalls can be observed. These issues will hamper the functioning of the drainage system during wet periods due to reduction in the cross section and/or by blocking of culverts or even of the canals themselves during extreme rainfall. This will cause unnecessary flooding.

First improvement step would therefore be:

- to make a good inventory of the condition of the urban drainage system;
- if it is not yet available to make a good description of the components of the system in such a way that it easily can be updated when changes occur;
- to clean the urban drains at least before the start of the wet season and may be locally at some additional moments when problems are being observed.

Such activities require the full commitment of the municipal authorities and of the other stakeholders in the area. It also requires consultation of the stakeholders to determine who will do what and when it will be done. For the first two of the listed items, it can be considered to involve students as a type of practical work or as an object of study. For the third

item, involvement of jobless people can be considered as is already being done with good results in other cities of Indonesia;

- in addition, it is recommended to make an inventory of the drainage bases compared to the level of the streets and the floor levels of the adjacent or influenced houses. In those cases, where the drainage base is insufficient for either the street or the house the best way of reconstruction can most probably be determined at an ad hoc basis. For this inventory also involvement of students can be considered;

- the outlet structure as shown in Fig. 9 is relatively new and the conditions in Semarang River are new as well since the construction of the big pumping station. It is therefore recommended that the discharge through this structure is being recorded during wet periods and that in addition the water levels in Semarang River are being recorded. In this way, information can be obtained to enable determination of the capacity of this structure during wet periods. If it has not been

established yet, it will also be important to formulate an operation rule under what conditions the gates will be closed. This operation rule would in fact have to be made fully public, preferable on a similar type of plate as is shown in Fig. 8a.

- It is unclear about how the two pumping stations as shown in Fig. 9 are exactly operated and if their actual capacity is still equal to the design capacity. This would have to be analysed. Based on the information on the blue board (Fig. 10a) along the pond one may conclude that the total pumping capacity is 3,000 litres per second. On the other hand, 16 years of rainfall data are available for two nearby stations. Based on these data, it can provisionally be concluded that a shower of 220 millimetres per day has only occurred one time in 16 years [7]. When the pumping stations would be operated at the design capacity, it would have taken a little more than two days to remove all that water and flooding would only have occurred during the first day (Fig. 13b).

(a)

(b)

Fig. 13 Bleu board (a) showing the characteristic data with respect to the pumping stations and graph (b) showing rainfall of 220 mm and resulting storage and pumping.

Fig. 14 Map showing the polders in Central Semarang.

- The blocking of Semarang River upstream of Semarang Old City and the construction of the big pumping station at the mouth of the river have resulted in a substantial improvement of the discharge conditions of the influenced part of Semarang. It is very important that the impacts of these changes are carefully analysed. In principle this can be done in a similar way as described above for Semarang Old City;

- in order to analyse whether still tidal flooding ('rob') in Semarang Old City can occur it would have to be verified whether water can pass the ring road between Semarang Old City and the sea in such a way that this floodwater can flow into the area of Semarang Old City;

- as far as river flooding is concerned, it is also worthwhile to analyse whether overland flow from upstream between the West and East Flood canals can flow into Semarang Old City. With respect to this, there is a map showing the polders in Central Semarang (Fig. 14). The status of this map has to be verified. From this map, it can be derived that overflow in principle can occur from the river upstream of the areas

1, 9, 10 and 8. It will have to be checked whether this indeed can occur.

4. Concluding Remarks

When the measures and activities as prescribed above would have been implemented, there is a good change that effective and adequate systems for urban drainage and flood protection of Semarang Old City will be in place. However, the experiences in practice and the ongoing subsidence may imply that in time additional measures will be needed. It is therefore important that the annual maintenance will be carefully implemented, that the operation of the outlet structure and the pumping stations will be carefully recorded and analysed and that the changes in surface levels due to the subsidence will be monitored. Additional measures would have to be based on the results of these observations.

The author sincerely hopes that the workshop, as well as this report may contribute to an improvement of the urban drainage system and flood protection of the important Semarang Old City in such a way that it can be revitalised.

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