Sustainable Flood Prevention Using Interconnection of House Pump System

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Abstract. The Unesa Ketintang Campus in Surabaya City is in lowland with an altitude between 3-4 m above sea level. Every rainy season arrives in this area frequent flooding. Puddles that occurred in 2013 with a long pool of ± 4 hours. Efforts have been made in 2014 to tackle flooding by raising paving pairs in open fields and roads and making reservoirs of ± 0.6 ha in the Unesa Ketintang Campus environment, normalizing the channel and installing pump houses to support the process of accelerating the reduction of standing water happen. However, still standing water (2014, 2015, and 2016) with a pool of ± 2 hours. The condition of the campus location which is lower than the condition of the surrounding area causes waterlogging and flooding in the study area. This study proposes a flood mitigation model using interconnection of the pump house system to reduce waterlogging, accelerate the water flowing process, and still optimize the operation and function of existing reservoirs. Water pump interconnected Pump House P1 to P8, namely: Unesa I Water Pump House (P1) functions to drain water from the campus area to reservoir campus, then in Unesa II Water Pump House (P2) serves to drain water from reservoir campus, which is flowed south towards the Wonorejo Primary channel through the Water Pump House (P3) and partially forwarded to the north of the Kalimir Jagir Water Pump House (P4), while eastward to drain water from the Wonorejo Primary channel to the Jemursari Prapen Water Pump House (P5) serves to help drain water from the Wonorejo Primary channel towards Jagir River, the Water Pump House Wonorejo I (P6) has a capacity of 8.9 m³/sec to accelerate the flow of water to the Water Pump House Wonorejo II (P7), Pump House Water Wonorejo II (P7) is used to accelerate the flow towards reservoir Wonorejo, and the reservoir Wonorejo Water Pump House (P8) serves to accelerate the flow of water to reservoir Wonorejo to be forwarded to the sea. Interconnection of the water pump system is able to overcome waterlogging and inundation problems.

Introduction

The location of the Unesa Ketintang campus is in the area of South Surabaya City and is located in a lowland area that has a height of 3-4 m above sea level. Because of its location on the plains, almost every rainy season with high intensity is flooded. The area of water inundation that occurred in 2013 was ± 0.9 ha, the inundation depth ranged from ± 25-35 cm and the inundation time was ± 4 hours.

Efforts were made in 2014 to tackle floods by raising roads, making reservoirs of ± 0.6 ha in the Unesa Ketintang Campus environment, normalizing channels, and installing pump houses to support the process of accelerating the reduction of standing water. However, standing water still occurs (in 2014, 2015 and 2016) it has an area of ± 0.3 ha, the inundation depth ranges from ± 10-25 cm and the inundation time is ± 2 hours.

The condition of campus location which is lower than the condition of the surrounding area causes a puddle of water that cannot flow outside. Overflow water discharge originating from the
primary channel of Wonorejo upstream enters the campus area during high-intensity rainfall. This can cause an increase in the volume of standing water which is often called (Back Water) and the addition of backwater flow from the Wonorejo primary channel due to the occurrence of high tides. Pumphouse stations and detention reservoirs have been used as alternatives in the past to prevent and reduce flooding in urban areas. Several previous studies related to flood mitigation used pumping house interconnections, as follows: (1) Reservoir operating systems are centralized and decentralized[1]; (2) Using a double drainage system simulation model was published: surface flow and pipeline flow as an alternative method for tackling flooding based on the principle of hydraulic flow[2]; (3) Using small reservoirs made at each housing in a housing can be a solution to reduce the volume of flooding so that it allows shelter of rainwater harvesters, and a larger retention reservoir is introduced as a measure of extensive urban drainage storage[3]; (4) Surface drainage design using ways to extend urban drainage capacity so that without the need for private land replacement or complicated rearrangement of underground pipes and drainage network systems can be used as an effective and practical strategy[4]; (5) Using the discharge scheduling model is an effective step to reduce the burden of the impact of the existing water discharge design. The location of the dam building at the right location is very important[5]; (6) Tidal levels, peak floods, and high tidal levels can increase with the completion of the reclamation project[6]; (7) Making a basin is used to reduce the occurrence of losses caused by rainfall during runoff periods when the rainy season is applied to arid and semi-arid regions, runoff that occurs is stored by being accommodated in the basin which can be used to be absorbed into the soil[7]; (8) Water flow simulation model for water maintenance projects using pump house stations, culverts, and scheduling sluice optimization simultaneously can be used for flood control, drainage, and irrigation[8]; (9) Simulation models of storm storms caused by hurricanes can provide a reference for the design of sea dikes and are used for planning disaster control of coastal areas[9]; (10) The new model is used for a combination of SuDS devices and placement in system design[11]; (12) The probability distribution of a bivariate joint estimated based on the risk of being able to catch a flood each year can be assessed by calculating the probability of occurrence of flooding causing annual storm events. The proposed method applies to urban areas with different catching conditions and drainage facilities, and it can provide an efficient way that is used as an alternative to urban flood risk assessment[12]; (13) The results of the approach to SUDS design go beyond the orientation of traditional event-based perspectives to undermine prevention. The method considers stormwater as a resource and seeks optimal use through SUDS design. Several types of urban catches are studied, and the results show that the proposed methodology can be applied both to simulate the behavior of SUDS in the city catchment area or to estimate the optimal volume of water to be reused locally[13]; (14) There are several challenges in the implementation of SUDS caused by the new regulatory framework. Emerging organizational procedures and processes tend to have an impact on SUDS implementation in the future, and highlight the need for further cross-sectoral work to ensure opportunities for cross-sectoral benefits such as those obtained by reducing stormwater flows within the combined sewerage system for water companies, developers property, and environmental protection is not lost[14]; dan (15) Water supply and drainage systems for buildings whose performance has been assessed through development, at Heriot - Watt University, from a series of numerical simulation models. These models accurately predict, using the forms of St. Venant is the exact equation, pressure and regime flow in the system by applying the Method of Characteristics of finite difference techniques. This paper provides three examples of different applications, where each focuses on instilling sustainability in design[15].

This study proposes a flood mitigation model using interconnection of the pump house system to reduce standing water, accelerate the process of water flow, and still optimize the operation and function of existing reservoirs.

**Methods**

The focus of this study is on flood prevention of the Unesa Ketintang campus, Surabaya, East Java, Indonesia. Campus when the rain falls with high intensity there is always a puddle of water and a flood occurs. The campus is located in the Wonorejo Primary channel watershed, the population in this region is ± 232,030 people, a population density of 3,130 residents per Km². The average daily
rainfall in the Wonorejo Primary Watershed is 93.53 mm, the discharge that occurs during high-intensity rainfall is ± 3550 m$^3$. High-intensity rainfall occurs between May and December. Location of the three closest rain stations in the Wonorejo watershed. Based on data from the map of earth's appearance, the location of the Unesa Ketintang Campus has a height of 3-4 m above sea level but based on the conditions in the field several settlement sites have been elevated by backfilling in the Wonorejo Primary Watershed up to ± 30 cm.

Figure 1 The proposed Water Pump Interconnection Scheme in the Wonorejo Primary Watershed

Extreme climate change in the city of Surabaya has occurred since 2008. The frequency of high-intensity rainfall that occurred in 2014, 2015 and 2016 caused flooding in the city of Surabaya. The urbanization of the population that occurs in the Surabaya City area also greatly affects the amount of the existing dirty water discharge and design discharge. The scheme proposed at the time of the flood disaster was overcome using interconnection of the water pump house system in the Surabaya City Area. This new method is needed to overcome flooding problems that often occur every high-intensity rainy season.

Results and Discussion

The results of the analysis of channel capacity using a 10-year return period based on the existing capacity of the channel, design discharge against rainwater discharge, and dirty water discharge indicate that (1) West Tertiary Tertiary Channel with a channel capacity of 1.7647 m$^3$/s, while the design discharge is available amounting to 2.4300 m$^3$/s, so that the channel is unable to accept the design discharge, (2) Karangrejo Secondary Channel with a channel capacity of 11.0987 m$^3$/s, while the existing design discharge is 2.5731 m$^3$/s, so the channel can receive the design debit, (3) New Jetis Secondary Channel with channel capacity of 8.1367 m$^3$/s, while the existing design discharge is 2.5979 m$^3$/s, so that the channel can receive the design debit, and (4) Primary Channels Karangrejo with a channel capacity of 46.9383 m$^3$/s, while the existing design discharge is 39.7855 m$^3$/s, so the channel can receive the design discharge. Furthermore, the results of channel capacity analysis at the Unesa Ketintang Campus for a 10-year return period based on the existing capacity of the channel, design discharge against rainwater discharge, and dirty water discharge indicate that the existing capacity of the channel is 4.0677 m$^3$/s, while the design discharge overloads the channel amounting to 7,5150m$^3$/s, so that the channel is unable to accept the overloaded design discharge.

Stagnant water in the campus location due to the impact of water seepage comes from the surrounding environment or the area rather than the water level elevation in the channels in the Unesa campus drainage sub-system so that the use of pumps cannot be avoided. With a note is the pump
house station held in the campus area, namely the Water Pump House (P1) in the east of Unesa’s central library, Water Pump (P2) in reservoir, and also need to add a new Pump House (P3) which is located near the Faculty of Engineering with pump capacity 1500 m$^3$/hr, 360 m$^3$/hr and 1500 m$^3$/hr, then interconnected with the pump house along the Wonorejo watershed, when on the dike merisi Wonorejo channel is divided into 2 parts, the north to jagir kalimir and bagin east to prapen, part wonorejo channel that flows to Jagir kalimir is pumped using Water Pump (P4) to Jagir River with an overall pumping capacity of 2.25 m$^3$/s, then the eastern part to the wonorejo channel that flows east while in the Jemursari Prapen area will be partially pumped to Jagir River with Water Pump (P5) with Overall Pump Capacity 2.30 m$^3$/s and partially forwarded eastward towards Wonorejo, When water is in Wonorejo area 1 part of the water in the pump uses Pump Water (P6) to the jagir River with Overall Pump Capacity 8.9 m$^3$/s and partially forwarded towards Wonorejo 2, when the water is in Wonorejo 2 part of the water will be pumped using the Water Pump (P7) towards Jagir times and partially forwarded to reservoir Wonorejo, then in reservoir Wonorejo water will be pumped using the Water Pump BozemWonorejo (P8) with a pump capacity of 6.25 m$^3$/s to the Wonorejo Reservoir and the eastern sea of Surabaya.

Conclusions
Flood Management Using Interconnection of Pump House Systems at Unesa I (P1) Water Pump, Unesa II (P2) Water Pump House, Unesa New Plan Water Pump III (P3), Jagir kalimir Water Pump House (P4), Jemursari Prapen Water Pump House (P5), Wonorejo I Water Pump House (P6), Wonorejo II Water Pump House (P7), and Reservoir Wonorejo Water Pump House (P8) capable of reducing stagnant water, accelerate the process of water drainage, and still optimize the function of reservoir at the Unesa Ketintang Campus and Wonorejo Reservoir so as to overcome the problem of waterlogging and urban flooding in the city of Surabaya.

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