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Design of Retarding Basin as an Effort to Reduce Flood

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Abstract: The retarding basin functions as a body of water that is useful for temporarily storing water, namely by giving the opportunity for rainwater to seep into the ground. The concept of the retarding basin is to accommodate the volume of rainwater when the maximum discharge occurs. Medan Johor sub-district is part of 21 sub-districts in Medan City, which is located in the south of the city. Topographically, Medan Johor District has several basin areas that cause the water flow to be concentrated. Another problem is that the drainage channel in the Medan Johor Subdistrict is not functioning properly due to sedimentation from the garbage. When the rainy season arrives, Medan Johor District often experiences flooding. The impact of floods resulted in damage to public facilities and infrastructure, disruption of public services, and the emergence of social impacts in the community. The purpose of this study was to design a retarding basin that serves to hold stagnant water temporarily. The water reservoir will then be channeled to the nearest sewer or river. Based on theoretical studies and analysis based on primary and secondary data, it is necessary to design a retarding basin in the Medan Johor District area to reduce flooding. From the results of the research conducted, it is necessary to design 3 (three) retarding basins in the Medan Johor area.

Keywords: Medan Johor District; Reduce flood; Retarding basin

Introduction

The city of Medan as the capital of North Sumatra Province has experienced quite rapid growth in development of its city. In the era leading up to the 1990s, there was still a lot of agricultural land or vacant land on the outskirts of Medan City. As a result of urban development since the 1990s, agricultural land and vacant land have slowly turned into residential areas and residential areas. The change in the function of the land has made the outskirts, which are the reapan areas, change their functions to become flood-contributing areas (Sari et al., 2018). This impact occurs because the land above the housing/settlement is no longer able to optimally absorb water that falls to the ground surface (Darmawan et al., 2010).

Not much different from the rivers that flow into the city of Medan such as the Percut River, Deli River, Belawan River, Babura River and other small rivers. The impact of population growth, residential growth and environmental degradation, the upstream part of the river suffers continuous damage so that it gets worse over time (Harliani, 2014). Consequently, all of this will contribute and have an influence on the city of Medan, one of which is the flood of shipments. The phenomenon mentioned above makes Medan City a flood-prone area as a result of the overload of rainwater entering the river. When it rains for a short time it can cause flooding and then if it rains for a long period of time it will certainly cause wider flooding as well. The impact of the flood has greatly disrupted people's activities and lives (Awan et al., 2017).

Many methods have been used by researchers to anticipate flooding, one of which is by building retardation ponds (Harmani et al., 2017). Retarding ponds or Retarding basins are storing water during floods and are more dominantly delaying water entering the river (Putri et al., 2020). So that when it rains the river floods can be reduced because it is assisted by retarding basins (M. I. Rizaldi et al., 2020). Retarding basin ponds are divided into 2 types depending on the lining material of the walls and the bottom of the pool, namely natural ponds and artificial ponds. Natural ponds are retention ponds in the form of basins or infiltration ponds that

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have been formed naturally and can be used either in their original condition or in adjustments. Artificial ponds or non-natural ponds are retention ponds that are deliberately designed with a certain shape and capacity at a pre-planned location with a rigid layer material, such as concrete (Andayani et al., 2017). Retarding basins are usually built upriver to collect water before it enters residential areas. The retention pond functions to accommodate excess water and reduce the volume of river runoff water temporarily, to be returned to the river when the flow rate returns to normal (Dirjen, 2010; P.U., 2003). The use of retention ponds has another function as a means of water conservation because it can be a place for water to seep into the ground, so it is one of the recommended methods in flood control efforts (Asmorowati et al., 2021; Nugroho et al., 2019).

Retarding basin is quite effective in tackling floods (Andayani et al., 2017; O. Rizaldi, 2019). The results of Pradhana's research (2022) stated that Retarding Basin or Retention Ponds are a fairly effective alternative to flood control. Similar research results were also stated by Prasetya (2022) that flood control using retarding basins (retention ponds) is considered effective for flood control. This is indicated by a decrease in the water level of 2 meters from the initial elevation of the river (Canubry et al., 2021).

Therefore, it is necessary to do research by designing retarding basin that can reduce flooding. The research location is in the suburbs of Medan, namely in the Medan Johor District which is located in the south of Medan City and is directly adjacent to Deli Serdang Regency. The design of the retarding basin serves as a temporary shelter for rainwater before it is channeled into the river.

The Medan Johor area as a place of research was carried out with the aim of designing a retarding basin and determining the location of the retarding basin.

Method

Topographical Conditions

The topographical conditions of the Medan Johor sub-district can be seen in Figure 1. The elevation of the Medan Johor sub-district is at an altitude of 11-40 m. The highest elevation is on the south side, namely Kwala Bekala Village and Gedung Johor Village. The lowest elevation is found in the Sei Bekala River Basin (a tributary of the Babura) and Sei Babura on the west side, and the Deli River on the east side. In these three rivers, topographic conditions tend to form land surface basins.

Figure 1. Topographical Condition of Medan Johor District

Figure 2. Profile of A-A land surface in Medan Johor District

Figure 3. Land Profile 1-1 Medan Johor District

Figure 2 is the slope profile of the Medan Johor sub-district from the A-A profiles for the west to the east side. It can be seen that the land surface of the Medan Johor sub-district has two main basins, namely the Babura Watershed (DAS) and the Deli DAS. Then between the two there is a basin with a slope of about 1.7% where at that location becomes a gathering place for water during the rainy season. From profile 1-1 (Figure 3) for the south side to the north side, it can be seen that the surface water flow pattern is from the south side to the north with a land slope of about 2.6%.

Water Flow Direction Pattern

The pattern of water flow direction in Medan Johor District is presented in Figure 4. From this picture it can be seen that the water flow pattern in Medan Johor District can be explained as follows: (a) On the west side of Karya Wisata street, the drainage water flow pattern mostly empties into the Babura-river. (b) On the east side of Karya Jaya Street, the pattern of drainage water flow mostly empties into the Deli-river. (c) The area between the Deli River and Babura River, the flow direction pattern tends to the middle of the basin. From the east side of Karya Wisata, the water flows eastward towards the basin area. Then, on the other hand, from the west side of Karya Jaya, the water flows westward to the basin area. Then between the two river basins, the water flow also comes from the south from the Eka Surya area (Deli Serdang Regency boundary) towards the north (Jl. AH Nasution).

From the pattern of flow direction above, it is clear that the central basin area of Medan Johor District is the center of the direction of water flow so that when it rains the capacity of the existing drainage system in this area is no longer sufficient so that inundation and flooding often occur.

Drainage System Analysis

Based on the survey results of the existing drainage conditions in the Medan Johor sub-district, the data were analyzed that the drainage problems that occurred were the result of the following: (a) From the topographical aspect, the presence of a basin in the central area of the Medan Johor sub-district causes the water flow to be concentrated in the basin. The water source comes from the southern border of Deli Serdang Regency, from the west from the Jl. Karya Wisata and from the east from Karya Jaya Street. (b) The discontinuous drainage system causes blockages and obstructions so that water overflows onto the road. (c) Inundation occurred in the area of Eka Warni Street, Eka Rasmi Street, Karya Darma Street in a basin area and entering a residential area. (d) The drainage capacity cannot accommodate the amount of rainwater that occurs.

Hydrological Analysis

The hydrological analysis in this work aims to obtain the amount of discharge (volume) or flow that can be accommodated in the Badera River. The discharge or flow analyzed is flood discharge that can occur within the next 1-100 years (Safii, 2010; Tawakkal et al., 2022) to anticipate overflow flows and provide the potential for inundation in the Medan Johor District.

In the analysis of surface runoff flood discharge, in general, the approach method for rainfall data in the catchment area is analyzed into runoff flow. The data used in analyzing flood discharge are as follow (Sari et al., 2018): (a) The maximum daily rainfall data uses data from the last 10 years. (b) Rainwater catchment area. (c) Land Use.

Analysis of Planned Rainfall

Rainfall data collection that has been tabulated, will then be analyzed for planned rainfall. Analysis of planned rainfall is carried out to obtain runoff discharge (Kamiana, 2011). From the results of the analysis of the position of the rainfall station and the existing data patterns, it can be seen in Figure 4 below. From the rainfall pattern above, it can be seen that the maximum rainfall tends to be in June, July, October, and November.

The data consistency test aims to find out that the rainfall data that has been recorded for 10 years at the rainfall measuring station each month is still in a straight line, which means that the rainfall data is consistent and does not form a distribution that deviates far from the straight line. A typical consistency test analysis is shown in Figure 5.

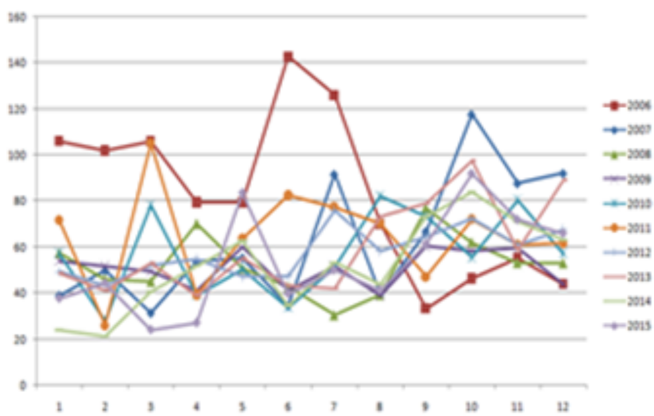

Figure 4. Ten-year rainfall pattern

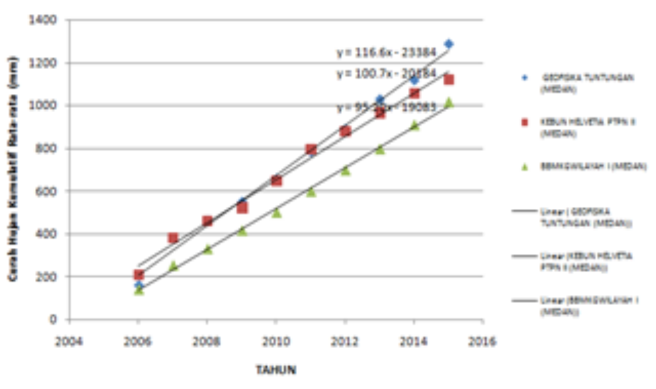

Figure 5. Graph of rainfall data consistency test

Analysis of rainfall with a return period of 2-100 years aims to determine the maximum amount of rainfall that occurs within 1 year so that the return period rainfall becomes the basis for calculating channel flood discharge. The rainfall used in analyzing the return period rainfall is the maximum daily rainfall data for the previous 10 years. Analysis of the return period rainfall was used with Normal distribution, Log Normal, Log Pearson III, and Gumbel. This distribution is a formula that is used statistically with the values of previous observations and analyzes these values in the future (P.U., 2003).

Result and Discussion

There are three potential retarding basin locations and they can be described as follows: (a) To serve the flow of water from the southern side of the Deli Serdang district boundary, it is recommended that a drainage system from the Eka Surya street flow directly to the Baura river. This is to reduce the load on the retarding basin storage volume by reducing the catchment area. (b) Retarding basin 1st was placed in the basin area. In this area, there is also vacant land which is currently green open space. This location is a potential location for 1st pond. This location serves water flow from residential areas between Eka Warni Street and Eka Surya Street, and between Karya Wisata Street and Karya Jaya Street. (c) The next scenario was if the storage volume for the location of 1st basin is not sufficient to meet the flood discharge runoff, the water flow will be continued to the potential location of the retarding basin 2nd with additional runoff from settlements in some areas of Eka Warni Street and Karya Dharma Street. (d) Further to serve the runoff area between Karya Darma Street and Karya Kasih Street then planned the 3rd retarding basin.

Flood Discharge Analysis

Flood discharge analysis is carried out to calculate the runoff discharge that occurs which will be flowed into the retarding basin.

Calculation of Concentration Time

The time it takes for rainwater to fall on the watershed, starting when it hits the surface of the watershed (DAS) to the time that is farthest from the estuary, to the point under consideration is called the concentration time. To analyze the concentration time usually use the Kirpich equation, 1940. Or the Kirpich Formula 1, 1940 as follows (Chow et al., 1988):

$$t_c = \frac{\{0.87x\,L^2\}^{0.385}}{1000xS} \quad (1)$$

calculation of planned flood discharge

Calculation of the planned flood discharge using the Rational method. The length of the farthest drainage flow obtained ± 1400 m. With a concentration-time of 58 minutes (1 hour). Calculation of flood discharge using rainfall data with a return period of 10 years. From each point, first, find the catchment area. The calculation of the catchment area is based on the flow direction pattern from the results of the flow direction survey that has been carried out.

First Pool Needs Analysis

Analysis of flood discharge using the Rational Method where the intensity of rainfall used is a return period of 10 years. The results of the analysis of rainfall intensity, flood discharge, and the results of the calculation of flood discharge analysis in the 1st pool area for a return period of 10 years and a concentration-time of 1 hour, the planned flood discharge for 1st Pool was 5.81 m^3/s.

$Q_{1st\ pool} = 5.81\ m^3/s$

To be able to accommodate water during the concentration-time, which is 1 hour, it takes a number of pond volumes 1 of: $V_{1st\ Plan\ Pool} = 5.81 \times (60 \times 60)$; $V_{1stPlan\ of\ Pond} = 20{,}196\ m^3$. From the existing land potential, there is green open land with a total area of A = 62,229 m^2.

If the planned area of the first pond is 0.75% of the available land area, then plan A is 0.75 x 62,229 m^2 = 46,671 m^2. If the depth of pond 1 is planned to be as deep as H = 1.5 m (considering the groundwater level is quite high). Then the design volume of first pool was:

$V_{available} = 46{,}671 \times 1.5\ m = 70.007\ m^3/s$. So that:

$V_{Available} > V_{Plan}$

$70.007\ m^3 > 20{,}196\ m^3 \rightarrow$ OK

In other words, the first pool can be realized.

Second Pool Needs Analysis

For a return period of 10 years and a concentration-time of 55.9 minutes (± 1 hour), the planned flood discharge for the second pond is 5.12 m^3/s.

$Q_{2^{nd}\ pool} = 5.12\ m^3/s$

To be able to accommodate water during the concentration-time, which is 1 hour, a second pool volume of: $V_{2nd\ Pool\ Plan} = 5.12 \times (60 \times 60)$; $V_{2nd\ Planned} = 18{,}432\ m^3$. From the existing land potential, there is green open land with a total area of A = 33,347 m^2.

If the planned area of the second pool is 0.75% of the available land area, then plan A is 0.75 x 33,347 m^2 = 25,010 m^2. If the depth of the second pond is planned as deep as H = 1.5 m (considering the groundwater level is quite high). Then the design volume of 2nd Pool was:

$V_{available} = 25.1010 \times 1.5\ m = 37.515\ m^3/s$. So that:

$V_{Available} > V_{Plan}$

$37{,}515\ m^3 > 18{,}432\ m^3 \rightarrow$ OK

In other words, the 2nd pool can be realized.

Third Pool Needs Analysis

For a return period of 10 years and a concentration-time of 56.92 minutes (± 1 hour), the design flood discharge for 3rd Pool was 4.26 m^3/s.

$Q^{3rd\ pool} = 4.26\ m3/s$

To be able to accommodate water during the concentration-time, which is 1 hour, it takes a volume of 3rd pools of: $V_{3rd\ Plan\ Pool} = 4.26 \times (60 \times 60)$; $V_{3rd\ Planned\ Pool} = 15{,}336\ m^3$. From the existing land potential, there is green open land with a total area of A = 51,599 m^2.

If the planned area of 3rd pond was 0.75% of the available land area, then plan A is 0.75 x 51,599 m2 = 38,699 m^2. If the depth of 3rd pond was planned to be as deep as H = 1.5 m (considering the groundwater level is quite high). Then the planned volume of 3rd pool was:
$V_{available} = 38{,}699 \times 1.5\ m = 58{,}048\ m^3/s$. So that:
$V_{Available} > V_{Plan}$
$58{,}048\ m^3 > 15{,}336\ m^3$ → OK

Conclusion

The results of the analysis can be concluded, among others: (a) From the topographical aspect, the presence of a basin in the central area of Medan Johor District causes the water flow to be concentrated in the basin. The water source comes from the southern border of Deli Serdang Regency, from the west of Karya Wisata Street, and from the east of Karya Jaya street. (b) The discontinuous drainage system causes blockages and obstructions so that water overflows onto the roads. (c) Inundation occurred in the area of Eka Warni street, Eka Rasmi street, and Karya Darma street in a basin area and entering a residential area. (d) The drainage capacity cannot accommodate the amount of rainwater that occurs. (e) From the results of the hydrological analysis, it was found that in the Medan Johor sub-district the maximum rainfall trend occurred in June, July, October, and November.

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