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Rainwater Infiltration Box to Prevent Flood Disaster

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ABSTRACT: Flood disaster is a natural disaster that ranks the third cause of economic loss worldwide. As a tropical country that has a rainy season, every year some parts of Indonesia are prone for being affected by floods. The causative factors include high rainfall and poor surface water management, making rainwater directly converted into surface water (run-off). Efforts to reduce run-off water include making biopores infiltration wells from paralon pipe material with a diameter of 10 centimeters, but because of the small volume, the biopores cannot functioned properly, so it is necessary to build infiltration wells with a larger capacity. The purpose of this research is to make a model of infiltration wells that have a larger volume than stainless steel.
This study used a pre-experimental design and is a development research of biopores infiltration wells. The stages in this research include design validation and absorption function testing.
The results of the study were the design of a box-shaped absorption container with a height of 120 cm. 100 cm wide and 100 cm long, made of 304 stainless steel, with an inlet and outlet holes for rainwater, a bottom absorption area, and has a lid that is easy to open for cleaning. In the function test, it was obtained the ability to accommodate rainwater of 1.2 cubic meters and the ability to absorb water of 0.9 liters per second on the soil of the test location, so that this infiltration box is estimated to be able to accommodate rainfall of 120 mm a day.
The conclusion is that this rainwater absorption container is able to accommodate rainwater while absorbing water so that it can be an alternative technology for preventing flood.

KEYWORDS: Design, Flood, Infiltration well, Stainless steel.

INTRODUCTION

Indonesia is a tropical country located on the equator, so it has a dry season and a rainy season. These two seasons are very influential on human activities, so everyone who is and lives in the territory of Indonesia must know them so that their activities can run well. This is because during the rainy season, usually floods often occur in some urban and rural areas. Flood disasters often result in loss of property and life. The impact of losses due to flooding includes damage to buildings, loss and damage to valuables, to the cessation of activities such as not being able to go to school and work, as well as impacts on the environment such as damage and death of plants and animals (Kazmierczak, 2011). As a natural disaster, although flooding cannot be prevented, it can be controlled and the impact of losses can be reduced (Fajar, 2020).

Rain occurs due to the deposition of water vapor. In the rainy season, rainfall in Indonesia reaches 2000-3000 mm/year and can result in inundation of land that is usually dry or inundated. In addition to rainfall, the impermeable nature of the soil due to development makes flooding easy to occur (Findayani, 2015). This flood can be caused by heavy rain or shipments from other areas. According to Sudirman, flooding in a city near the coast such as Jakarta could be caused by factor 1). Contour 2) Type of soil, 3) land covered by buildings, 4) slope, 5) rainfall, 6) sea level rise, 7). tides 8) Land subsidence (Sudirman, 2019).
Jakarta as the nation's capital is not spared from flooding and is difficult to avoid (Harsoyo, 2013). In
2015 there was a very severe flood and caused up to fifteen trillion lives and material losses (BNPD DKI, 2017). Based on rainfall data in Jakarta in the range of 150 mm/day (Jakarta.bps.co.id 2021). Jakarta as a coastal city often experiences flooding due to factors such as reduced infiltration soil, soil type, land surface contours, land slope, high tides, rising sea levels, high rainfall, and land subsidence, the delivery of water from the surrounding area (Sudirman, 2019). According to Elisa Sutanudjaya from the Rujak Center (Pudjianto, 2017), the cause of flooding is the large number of inundations caused by inadequate surface water management (run-off). Surface water is a puddle of water that causes flooding (Atap, 2021). Fakhrudin from LIPI said the flood disaster in Jakarta was caused by high rainfall and the water immediately turned into surface water (run off) (Fakhrudin, 2015). So to prevent flooding in Jakarta is an effort to reduce surface water, through surface water management such as through biopori and infiltration wells.

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The amount of surface water is closely related to rainfall and the ability of the soil to absorb rainwater, and this water will experience evaporation and seepage below the surface so that it becomes underground water. Because the rainfall factor cannot be controlled, efforts are made to increase the ability of the soil to absorb water through dredging sediments, making infiltration wells and biopores (Menlhk, 2020).

Biopori is one of the DKI Jakarta Provincial Government's efforts to reduce flooding by increasing groundwater absorption. The government has carried out Biopori since 2013 using a 10 cm diameter paralon pipe with many small holes around it. However, the biopores that have been made have not been able to cope with flooding, so the DKI Jakarta Provincial Government has developed an infiltration well made of concrete with a diameter of 100 cm and a depth of 2.7 meters. Although it is effective in retaining water, based on the analysis, infiltration wells made of concrete are difficult to dredge, have rigid properties, and make road users uncomfortable. Considering that most areas of Jakarta are residential areas, it is necessary to look for a model of infiltration well that matches the sketch of the house, the material is strong but not rigid, and is corrosion resistant and durable. One type of material that meets the above criteria is type 304 stainless steel which is stainless steel metal, has strong properties against pressure, is acid resistant and is easy to connect (Wang, 2019).

Therefore, in this study, a stainless steel infiltration well model was made with considerations that it is easy to shape like a house sketch, strong but not rigid, acid-resistant and easy to maintain. (Alwan, 2019). Meanwhile, the use of infiltration wells made of stainless steel 304 which has anti-rust properties, is strong and easy to manufacture is still limited in research.

LITERATURE REVIEW

The study of infiltration wells includes the shape or model, size, material of manufacture, research on the application of infiltration wells.

The shape and size of the infiltration well from the literature obtained are form Belladona. Belladona was studied at Village Makmur, Bengkulu to reduce water indunation and was proposed the design of infiltration well with a diameter of 1 meter and a depth of 2.2 meters. the capacity of this well is close to the number of infiltration wells currently being worked on by the local government of DKI.(Belladona, 2017). One thing that is interesting from the researcher's proposal is to use infiltration wells with the above capacity for 2 houses. Prasetia researchers analyzed the design of ideal infiltration wells in residential areas to encourage the development of urban drainage systems that consider the environment and groundwater reserves for ecosystem balance. The proposed design is round or tubular with a diameter of 1.25 m. and a depth of 2 meters and a capacity of 2,400 liters or 2 times the capacity made by researchers. (Prasetia, 2014).

A comparative study of pavling block models made of concrete, infiltration ditches, infiltration ditches, and infiltration wells) has been studied by Yoo, by looking at the effect of reducing flood runoff. The SEEP/W model was used to estimate the amount of infiltration of each facility, and the effect of reducing flood runoff was quantified by decreasing the number of curves (CN). The results of this study are that:

(1) infiltration wells and infiltration ditches are found to be the most efficient and economical; (2) infiltration can be successfully simulated by the SEEP/W model, the results of which can also be effectively quantified by decreasing CN; (3) the effect of the intervention of the nearest infiltration facility was found to be not so significant (Yoo, 2016). So that there are many efforts to overcome flooding by using the infiltration well model.

A study that tried to overcome urban flooding was carried out by Champiano, where the infiltration model was to use a ditch on the side of the road. The results of the study prove the benefits of the trench model for reducing surface water runoff in urban areas, although it is not clear at what rate the infiltration rate is. (Campiano, 2011).

The model of using concrete paving blocks, permeable brick pavement systems (PBPs) has been tested for the effectiveness of infiltration to control runoff in downtown Shijiazhuang, China. The results show that rainfall is the main factor affecting the control of permeable pavement runoff, and its effectiveness decreases with increasing rainfall (Chen, 2021).Chen's research, supported by research from Song, proves that the use of permeable brick pavement systems (PBPs) is one of the most widely used low-impact development (LID) measures to reduce the volume of runoff and pollution caused by urbanization and tested with the Horton Model with optimal infiltration yield (Song, 2021)

The function of infiltration wells has been investigated for its usefulness by Duppa, by using a qualitative method, it is known that the rainwater that falls, seeps into the ground, through two stages, namely infiltration and percolation. Infiltration is the process

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of water infiltration into the soil layer, and on its way (percolation) some of it diverges to the side to become seepage water, and partly to underground water (ground water). It is also known that the use of infiltration wells will reduce surface water discharge which causes flooding which in turn will produce groundwater reserves (Duppa, 2017). Fahrurazie's research resulted in the fact that influencing the absorption rate of infiltration wells is The results for the dimensional infiltration system are obtained for H = well depth, R = well radius, n = number of wells depicted in the graph. (Fahrurazie, 2017). Antomo's research in Jogya, resulted in an ideal infiltration well capacity, namely. The depth of infiltration wells ranges from 0.3 m to 1.99 m. Buis concrete is recommended as a construction material for infiltration (Antomo, 2017).

Research on materials for making absorption wells with materials other than concrete was carried out by pratikto and sari where in this research it was concluded that Buis concrete without cement and without sand would be a good and economical solution, but this study did not explain how its strength and effect on absorption (Pratikto, 2015) .

MATERIALS AND METHODS

A. Research Materials

The materials used in this research are:

1. Stainless steel plate (SS) 304 2 mm thick, 4x 8 feet in doff finishing.
2. Stainless steel 304 elbow size 3x3x 2 mm.

B. The tools used in this research are:

1. Argon welding machine, Rhino brand TIG 200 inverter
2. Argon welding wire
3. Tunsten Argon
4. Grinding machine : Ryu brand 4 inchi
5. Cutting grinding wheel
6. Sandpaper Toho brand no 80
7. Water hose to drained water for absorption function test
8. Measured meter
9. Permanent marker for markers the SS plate measurement
10. Argon gas tube.

C. Research Implementation

The first stage in the implementation of this research is

1. Measure and mark the SS plate and SS elbow according to the dimensions on the design.
2. Cut the stainless steel plate according to the design using a hand grinding machine
3. Connect the SS elbows to form the base frame using argon welding on the appropriate sides 4. After the frame is formed, the SS plate is installed on the appropriate side using argon welding.
5. The side that has been joined is then sanded to remove sharp and pointed weld residues.
6. Make influent and exfluent holes each with a diameter of 4 inches for the installation of paralon pipes where water enters and leaves.
7. Excavation of the soil to make a hole in the container for which the function test will be carried out is 145 cm deep, 100 cm wide and 100 cm long. Length a depth of 145 centimeters, intended to make room for red brick or concrete paving blocks as a foothold for the container on the ground, so it doesn't sink easily. It is known that the height of this box container is 120 centimeters. So the remaining 25 centimeters. This difference is used as part of the slope of the paralon pipe from the influent, so that it flows easily.
8. Flowing water from the Shimizu 250 BIT brand jet pump with a flow rate of 50 liters per minute, for 25 minutes until it reaches the volume of the container through the influent hole and then counted until the water runs out.

D. Analysis of results is carried out after implementation is complete.

The data obtained include container construction, volume capacity and absorption rate

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RESULTS AND DISCUSSIONS

The resulting data provides the following analysis:

On the reason for choosing the shape and model of the container container is the city of Jakarta has green open space of 10% of the total area of Jakarta. Green open space is a place for water absorption and the remaining 90% is a watertight area, most of which are residents' houses. Therefore, making rainwater infiltration wells must be adapted to the design of the house and the existing land function, for example for a house with a yard or land space in the shape of a rectangular box, the appropriate infiltration well is rectangular. Meanwhile, for houses with trapezoidal land, the trapezoidal infiltration box will be maximized in capacity than the circular shape. Based on the basic concept of infiltration wells model by Belladona (Beladona, 2018), the design of the infiltration container is obtained which follows the principle of having a rectangular storage room with the bottom as the catchment area, with two holes for influent and exfluent with a diameter of 4 inches and solid walls at the top and bottom around side. The final result of this process can be seen in figure.3. The container model is considered more effective than the trench model, especially the roads in Indonesia are relatively narrow. (Cahmpisano et all, 2011)

Analysis related to the shape of the frame of the container box container is the need for a special frame shape that is adapted to the utility when it is used, this is because an observations of land use in residential homes, the average use of vacant land in the yard which is suitable for planting this box container is usually used to place various kinds of accessories and household appliances, ranging from plant pots, motorbike parking lots and car garages, with Thus the rainwater storage container in addition to having the capacity must also be strong to withstand the load. With these considerations, the design that the researcher uses for the cover frame is to use duplicates, with angled stainless steel material measuring 3x4 cm with a thickness of 3 mm, between the looted frames 25 cm and interconnected with other frames. This model is equivalent to 8 cm stainless steel, which is capable of withstanding loads such as motorcycles and cars (Figure 1). Models container made from stainless steel were believed to be stronger than bamboo, or polymer powder from Pratikto (Pratikto, 2017).

Figure 1. Upper frame design that functions as a removable cover as well as load-bearing.

Analysis on the shape of the frame at the bottom which is a function of absorption and the resistance of the container to pressure due to the weight of the container, obtained, that at the bottom of the box which has an absorption function, the researchers made a frame design made of angled stainless steel measuring 3x4 cm with a thickness of 3 mm. The frame surrounds all corners and the

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middle of the wall on each side, with the aim of being able to withstand heavy external loads such as from the container, as well as the load placed on it, but not reducing the capacity of the container.

Especially for the bottom, a pair of frames is provided on each side, which will serve as a support for the container with barrier objects such as red brick or concrete paving or light/heavy bricks. This barrier has a function as an insulator between the stainless steel frame and the ground, so the container will be more durable. The second function is that this barrier material will expand the footing and pressure space, so that it will slow down the sinking process which usually occurs in surface objects placed in soil excavations. (Figure 2)

Figure 2. The bottom frame of the rainwater storage box with a flat position and double frame, a foothold for the barrier like a brick, as a barrier so that the container does not quickly sink

Figure 3. Infiltration well box made of stainless steel

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From the final result of the rainwater collection box, the sides are made without hooks for transportation. This is intended so that it does not become an obstacle such as snagging when planting the container into the ground. Instead, the function of the hook that is usually on the outside is replaced by installing the hook on the inside of the container. These hooks are attached to the cover retaining frame as shown in Figure 1. Thus, during installation, the rainwater catcher must be removed from the cover and then lowered using a rope. After being placed on top of the red bricks, the empty space on the four outer sides of the container walls is filled with the remaining excavated soil.

The effluent pipe and the influent pipe are 10 cm or 4 inches in diameter, connected by a paralon pipe of the same size. The holes for the effluent and influent in this model are made on the same side to avoid difficulties when connecting the rainwater pipe which generally comes from the house gutters to the influent hole.

In the intact form as seen on the walls, there are clear spots from the sandpaper. The sanding process is carried out on areas where there are remnants of welding and cutting results which, according to researchers, are quite sharp and are at risk of accidental heating and cleaning. When sanding, use Toho sandpaper with number 80, because the rest of the weld joint from argon welding is very hard. (figure 3)

The advantages of the rainwater storage container according to the researchers are that the lid model can be opened easily using a lever, has a lighter weight but is not easy to crack and break and is safer during maintenance. Likewise, the interior is quite spacious so it's easy to clean.

In this study, the other reason, material stainless steel (SS) 304 was used, because this type has good anti-corrosion, non-magnetic and easy-to-weld properties (Fawaid, 2012). Consideration of the use of SS 304 because the nature of rainwater in Jakarta based on analysis of rainwater samples at the BMKG station in the Kemayoran 2 area has a pH of 4.78 or high acidity (BMKG, 2021) and soil characteristics in Jakarta. is sandy loam (DKI Jakarta Sanitation Department, 2012).) where clay has the characteristic of being able to hold water up to a certain level of saturation, meaning that if acid rain water is absorbed it can affect the acidity of the soil.(Song,2021;Chen 2016 ; Yoo, 2021)

The function test was carried out on vacant land (google coordinates -6.294006358412967, 106.880143897501), through the stages of excavating the soil the size of a container, so that the depth of the top side is 25 cm from the soil surface. The calculation of the infiltration capability is carried out after the water filling stops until the water in the container runs out. Based on the stop watch calculation, it takes 22 minutes for the water in the container to run out. Thus, this container has a function and working mechanism similar to an infiltration well, namely to temporarily store and help absorb water (Menlhk.go.id, 2021).

This infiltration tank capacity analysis is sufficient for the category of replacement infiltration wells in residential areas, because with a volume of 1200 liters or 50% of the infiltration wells developed by the DKI Jakarta Provincial Water Resources Agency (SDA), this infiltration capacity is estimated to be able to accommodate rainwater with rainfall of 150 mm/day for a land area of 100 square meters, which means it has a higher capacity than Jakarta's average rainfall of 34 mm/day (Jakarta.bps.co.id, 2021). This volume is also in accordance with the results of Belladona's research in Bengkulu which claims a capacity of 2000 liters is sufficient to overcome standing water for two residential houses (Belladona, 2017; Prasetia, 2014). The advantages of this stainless steel infiltration container compared to the DKI Jakarta Provincial Government concrete buis is that it is not easy to crack and is easy to open for cleaning, and can adjust the size to the empty space of the house yard. This capacity research is also supported by similar studies (Antomo, 2015; Duppa, 2017). When compared with the runoff model from the ditch (Champisano, 2016) or the concrete pavement model (Chen, 2021; Soong, 2021), this model is as effective as the infiltration well model.

The analysis of the structure of the container from this study is that the walls of the container have the first weakness in materials that are considered thin, namely 2 mm, the thinness of this material will be at risk of causing an uneven surface, if this box container at the top is used to put heavy objects such as cars, pots or motorbikes. As a suggestion, the material used should have a thickness of 3 mm, making it easier to weld and more rigid. This stiffness is important so that the container is able to withstand heavy loads from above and from the side, so that the top of this container can be used for household purposes. The next weakness is in terms of weight, a container that reaches 185 kg will affect the installation process, because it requires a minimum of 4 people to transport it and requires special tools in the form of a simple pulley to lower it into the dug hole.

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CONCLUSION

The rainwater catchment tank made of stainless steel 304 is rectangular in shape, can be opened for cleaning, and is elastic but strong so it is recommended for use in a household environment. This rainwater storage box also has the function of absorbing water up to 0.9 liters per second, so that this container is expected to reduce water runoff as a factor causing flooding, and this stainless steel container can be an alternative technology as an alternative material for making infiltration wells for flood prevention.

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