

Design and Construction of Drain Covers to Mitigate Flood in the Cities

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Abstract: *Flood in Ghana is growing from bad to worse. Many Ghanaians for the past years have lost their lives and properties, and other displaced from their homes through flood. The main course attributed to the flood is choke drainage system. Observation shows that the city's roads have been encroached by settlers and food vendors who through all sort of waste into the drainage system through the drain covers. Mud pickup by vehicles are also drop on the roads and washed by rain into the drainage system. Approximately 59 of the drain covers have been stolen. In order to overcome these challenges a drain cover was design and constructed for experiment. The experimental results taken after experimenting on the drain cover shows that flood mitigation is possible as 77% mud was trapped by the drain cover when liquid-solid waste mixture was pass through it. However, recommendation was made to further improve on the drain cover to overcome the passing of heavy vehicles.*

Keywords: Drain Cover, Drains, Liquid and Solid waste, Roads, Waste, Flood, Mud

1. Introduction

Ghana has seen a rapid development in most of its capital cities. The development had attracted many settlers from the nearby towns and even foreigners [11]. But this has been challenging to most cities. Accra for the past years' experience several flood of which the cause has been natural or man-made phenomena. The phenomenon is usually followed by negative effect which mostly are loss of lives, properties and displacement of people. In February 24, 2011, National Disaster Management Organisation (NADMO) recorded that approximately 43,087 victims with 14 deaths were affected due to heavy downpour that wreaked extensive havoc on properties in most parts of Accra and some of its surrounding communities [3]. The 3rd June 2015 heavy downpour also claimed over 152 lives as a GOIL Fuel Station exploded at the Kwame Nkrumah Circle [2].

Tucci (1999), explain that most flood are course by illegal settlements, construction of housing structures within flood plain, reduced capacity of drainage channels, poor maintenance, high rainfall intensities, and low lying areas [2]. However, poor attitude by the people (man-made phenomenon) cannot be over looked. As some residents of the city indiscriminately throw waste any were and on the roads. Food vendors virtually damp and drop both liquid and solid wastes into the drains. According to Songsore (1992), solid waste management has remained one of the difficult problems with the Accra Municipal Assembly (AMA). His argument supports the fact that waste producers (businesses, passengers, drivers, etc.) generate large volumes of wastes that are not dispose off in an acceptable manner [1]. Vehicle that commute human to-and-fro the city also pickup mud from roads that are not asphalt and deposit on the asphalt roads.

Drainage systems are constructed to carry liquid waste from upstream catchment into the main stream. Highway drainage systems removes water from the road surface, preventing ingress of water into the pavement, passing water across the road, either under or over and preventing scour and/or

washout of the pavement, shoulder, batter slopes, water courses and drainage structures [12]. Therefore all waste deposited on the asphalt roads are washed into the drain. The solid wastes that get into the drains choke the drains and impede the flow of liquid wastes and causes flood. Every year AMA spend millions of Ghana Cedis dredging the drainage system. Social groups and assembles also organize community labour to clean the choke drains, but the challenge still proliferate. According to EM-DAT: 2015, Economical loss caused by flood in Ghana is roughly US\$ 108,200,000 [2].

In the quest to mitigate the flood situation in Accra, the research focus on the design and construction of drain covers that will trap solid wastes from going into the drains.

2. Methodology

The primary data were collected using structured data. This was carried out by means of personal observations to look at the existing types of drain covers, material used, and types of refuse disposed into the drains. Consideration was given to some major roads such as Kwame Nkrumah Ave, Kojo Thompson Road, St Barnes Raod, Akasanomah Road, Castle Road, Kinbu Road, Farrer Ave.

Secondary data were collected from appropriate data sources, including books, journals, newspapers, and activities both published and unpublished. This aid in the design to prepare the conceptual designs of various drain covers.

3. Types and Status of Drain Covers

3.1 Types of Drain Covers

Though several drain covers are used to construct drain covers, the most common one found on the Accra-city roads are the U-Type Drain Cover. The U-Type Drain Cover adopt angle steel as the end plate and are not buried in advance before construction. One of the prevailing characteristic of

the U-Type Drain Cover is it large open area that facilitates the flow of water, easy to install and with high safety factor. The drain covers are located at the ingress of the drainage system at the shoulder of the roads to remove water from the road surface (Muhammad, 2014).

The drain covers located on the city roads are in rectangular or square shape and covered between 5 cm to 85 cm from the shoulder of the road. The cross sectional area of the drain covers ranges between 850 to 4225 cm².

3.2. Status of Drain Covers

Observation indicates that the roads (Figure 1) selected are among the busiest roads in the city aiding in the transportation of humans and goods. All the roads contain a substantial number of drain covers with only Farrer Ave as provision of walk-way was not included. Lack of walk-ways has exposed the drainage system to all kinds of waste that are deposited on the road to be washed into it.



Figure 1: Kojo Thompson Road.

Table 1 shows that out of the seven roads, three (Kinbu Road, Kojo Thompson Road and Kwame Nkrumah Ave) were the most populated road as activities of traders, food vender and settlers have spring all over.

Table 1: Status of Drain Covers on the Accra-City Roads

Road	Quantity	Percentage (%)	Good	%	Poor	%
Kojo Thompson Road	279	35	276	38	3	4
Kwame Nkrumah Ave	214	27	199	28	15	19
St. Barnes Road	179	22	155	21	24	31
Akasanomah Road	45	6	41	6	4	5
Castle Road	40	5	34	5	6	8
Kinbu Central Road	42	5	16	2	26	33
Farrer Ave	0	0	0	0	0	0
TOTAL	799	100	721	100	78	100

Kojo Thompson (279) and Kwame Nkrumah (214) roads were the roads that recorded high numbers of drain covers, it was Kinbu road which recorded 26 (33%) of its drain covers being in a poor state (see Figure 2). Further observation indicates that 59 covers were lost to theft and sold as scraps [5].

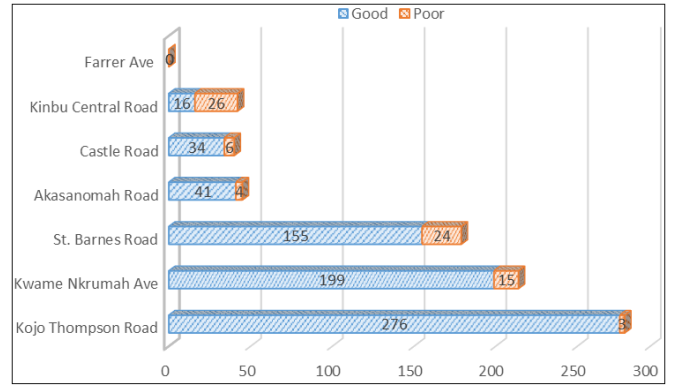


Figure 2: Number of Good and Poor Drain Covers on Accra-City Roads.

4. Conceptual Design of Drain Covers

The three conceptual designs were developed base on the following consideration;

- 1) Food venders throw both liquid (sometimes corrosive) and solid waste into the drainage system through the drain covers.
- 2) Mud drop by vehicles on the roads are washed into the drainage system through the drain cover. Averagely 1.2 kg of mud is located at the shoulder of the roads.
- 3) Unsecure drain covers (approximately 59) are stolen and sold as scraps.
- 4) Many of the drain covers have sagged due to heavy track passing. Though tough materials were selected for the design, the strength was not address in this research.

Design “A”: The design (Figure 3) contain hinges that joins the cover to the cover basin and prevent it from stolen. However, easy opening of drain cover provides easy access to food venders and settlers to through all kinds of wastes into the drains. The lid of the trap basin allows unfiltered waster to run directly into the drains. The slope of the trap basin also impose a challenge of holding the filter in position.

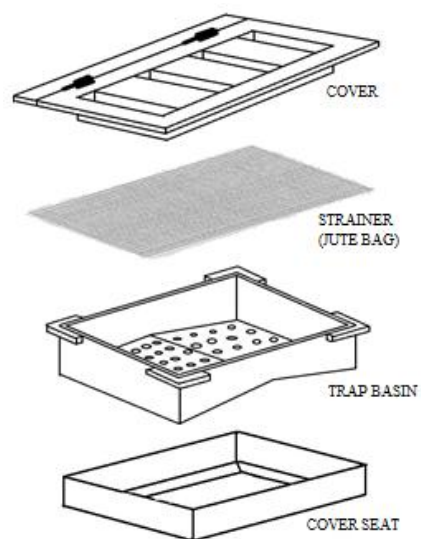


Figure 3: Design “A”.

Design “B”: This design (Figure 4) has the same features as Design “A” with an exception of the trap basin lid that can

sustain more load trapped by the trap basin. The design make it will to hold the filter onto the trap basin.

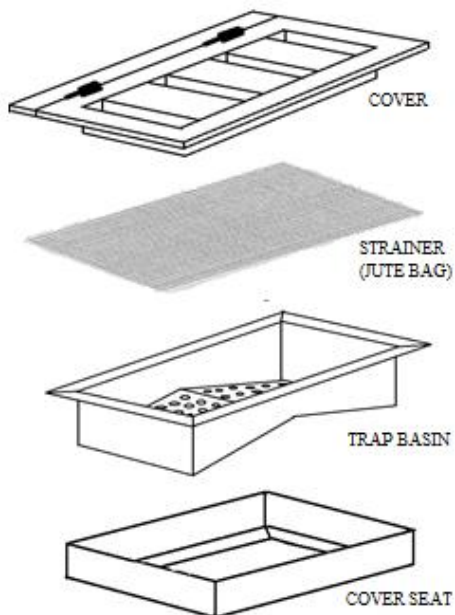


Figure 4: Design “B”.

Design “C”: The locking system introduce into the design (Figure 5) prevent it from being stolen. The design also averts throwing of waste directly into the drains by both food venders and settlers. The trap basin can hold more load and prolong the life of the drain cover. Filter are properly secure on the flat base of the trap basin and that ensures that no unfiltered waste goes into the drains.

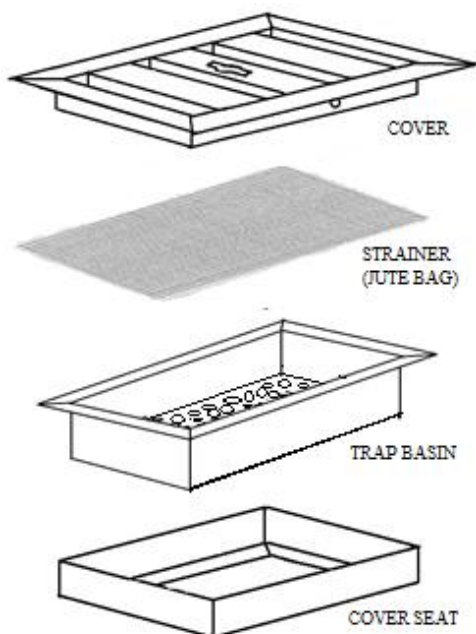


Figure 5: Design “C”.

The best drain cover was selected based on the detailed criteria to determine the highest scoring design as shown at Table 2. Design “C” score the highest marks among its contemporary with 41% making it the best to be constructed. The manufactured drain cover in shown in figure 6.

Criteria	Weight (W)	Design “A”	Design “B”	Design “C”
Anti-rust	10	9	9	8
R×W		90	90	80
Aesthetics	10	8	8	7
R×W		80	80	70
Anti-theft	15	7	7	9
R×W		105	105	135
Simplicity in design	10	5	6	8
R×W		50	60	80
Waste trapping efficiency	20	7	7	9
R×W		140	140	180
Ease of manufacture	15	4	6	8
R×W		60	90	120
Cost of manufacture	20	6	5	8
R×W		120	100	160
Total	100	560	570	795
Percentage		29%	30%	41%

Where:

R = Rated Value

W = Weight

RATING (0-10)

9-10 = Excellent; 7-8 = Very good; 5-6 = Good; 3-4 = Poor; 0-2 = Unsatisfactory



Figure 6: Drain Cover

5. Results and Discussion

5.1. Testing of Drain Cover

Test was conducted on the drain cover to ascertain the effectiveness of trapping solid waste (mud) when liquid-solid mixture waste was pass through.

Apparatus: Weight scale, Bucket, Mud, Drain Cover, Stick for Steering,

Experimental procedure: The experiment was carryout by following the steps below;

- 1) A good amount of solid waste (mud) was poured in the container and mix with water by steering.
- 2) Pour out the water and record the reading of the solid waste (mud).
- 3) Pour a substantial amount of water on the solid waste (mud) and stir to achieve a flood like mixture.
- 4) Pour all the mixture in the drain cover.

- 5) Place the emptied container on the weight scale and record the weight of the readings (tare reading).
- 6) Open the drain cover and carefully lift the trap basin off the cover seat.
- 7) Pour the trapped waste into the container and record the weight.

5.2. Tabulation of Experimental Result

Readings recorded before passing mixture through the drain cover:

Weight of Bucket = 0.42kg

Weight of the solid waste (Mud) = 5.18kg

Net weight of solid waste (Mud) = 4.76kg

Readings recorded after passing mixture through the drain cover:

Weight of Bucket = 0.42kg

Weight of trapped solid waste (Mud) = 4.08kg

Net weight of trapped solid waste (Mud) = 3.66kg

Total waste escaped into the drains

= Net weight of solid waste -- Net weight of trapped solid waste

= 4.76 – 3.6 = 1.10kg

Hence;

Percentage of Solid waste into the drains

$$= \frac{1.10}{4.76} \times 100 = 23.11\%$$

Percentage of Solid waste trapped by the Drain Cover

$$= \frac{3.66}{4.76} \times 100 = 76.89\%$$

The outcome of the experimental results indicate that the filter was able to hold approximately 77% of solid waste (Mud) with the smallest grains passed into the drains. This prove that wastes with smaller particles can be trapped by the drain cover. Adopting the design for use in the cities will help mitigate the flooding situation.

6. Conclusion

The following conclusions were drawn after experimenting with the drain cover.

- The locking system incorporated into the drain cover will secure the cover from theft.
- Solid wastes including mud can be trapped by the trap basin to prevent drainage choke.
- Approximately 77% of the solid waste (mud) was trapped by the filter (Jute bag).
- Low cost of product by effective routine maintenance.

7. Recommendation

- Government to speed-up the covering of all open drains in the cities.

- Regular routine maintenance schedule should be prepared and followed rigorously by the regular authorities.
- Research agency and institutions must collaborate to improve on the performance of the drain cover.

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