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Assessment of Road and Surface Water Drainage Condition in Urban Ethiopia, with Special Reference of Assosa Town

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Abstract:

Drainage facilities on road should adequately be provided for the flow of water away from the surface of the pavement to properly designed channels. On the other hand, inadequate drainage results in serious damage to the road and its structures. The practice of the construction of proper integrated drainage structures did not get due attention in most cities and towns of Ethiopia. For this reason, the main objective of this study was to evaluate road and surface water drainage condition and its integration in Assosa town. To describe and investigate the existing condition, coverage and level of integration between road and storm water drainage infrastructures, exploratory and descriptive types of research methods were used. Field survey and an in depth interview with respondents were methods of primary data collecting. In the study data was analyzed with the help of Microsoft-Excel, Auto CAD 2007, Arc GIS 10.1 and SPSS version 15 software and the analyzed data was presented in tables, charts, graphs and percentages. The result indicated that poor integration between road and urban storm water drainage infrastructures, poor maintenance, illegal sewer connection, absent of drains and lack of good layout plan for the road are among the major causes that resulted in street flooding. Therefore, improvement in the integration of road and urban *storm water drainage facilities; maintenance of drains before the rainy season, awareness creation and construction of additional drainage infrastructures with sufficient dimensions will help in the mitigation of flood disaster in the town.*

Key words: Inadequate Drainage, Storm water, Urban Ethiopia, Urban Flooding

INTRODUCTION

Provision of sufficient storm water drainage is an important factor in the location and design of urban roads. Drainage facilities on road should adequately be provided for the flow of water away from the surface of the pavement to properly designed channels. On the other hand, inadequate drainage will eventually result in serious damage to the road structures. In addition, traffic may be slowed by accumulated water on the pavement and accidents may occur as a result of hydroplaning and loss of visibility from splash and spray. A properly designed and implemented drainage system should effectively intercept all surface and watershed runoff and direct this water into adequately designed channels for eventual discharge into the natural waterways.

According to Mc Robert, J. et al. (2000), drainage is often described as the central and most important aspect of design, construction and maintenance of any road, including unsealed roads. Drainage of unsealed roads can be of even greater importance because lower quality design and construction standards and marginal materials are generally used, which are more permeable to water. Poor drainage will reduce the life of the pavement and have serious environmental impacts if left unchecked. There are many approaches to reducing erosion of exposed surfaces associated with unsealed roads, such as side drains, cut-off contour banks and batter slopes. Any road will readily concentrate runoff, so there is a need to design and construct roads to allow for frequent and safe discharge. As reported by GTZ-IS(2006) that inadequate urban storm water drainage problems represent one of the most common sources of compliant from the citizens in many towns of Ethiopia and this problem is getting worse and worse with the ongoing high rate of urbanization in different parts of the country. Similarly, Dagnachew Adugna Belete (2011) stated that due to inadequate integration between road and urban storm water drainage infrastructure provision, many areas are exposed to flooding problems. In other words, urbanization and modernization in Ethiopia results in higher rainfall intensity and consequently accelerated and concentrated runoff in the urban areas.

In Ethiopia, the pattern of urbanization and modernization has meant increase densification along with urban infrastructure development. This has led to deforestation, use of corrugated roofs and paved surfaces (Dagnachew Adugna Belete, 2011). The combined effect of this results in higher rainfall intensity and consequently accelerated and concentrated runoff in the urban areas.

In Asosa town, because of inadequate drainage, poor maintenance and lack of sufficient road profile, a significant part of the water accumulated on road pavement. The surface water from the carriageway and shoulder should not be drained off, and runoff water from the adjoining land easily enters to the roadway because of poor drainage provision. The existing side drains did not have sufficient capacity and longitudinal slopes to carry away all the surface water collected. This improper drainage system causes the failure of road pavements by increase in moisture content, decrease in strength, mud pumping, formation of waves and corrugations, stripping of bitumen, cutting of edges of pavement and so on. As shown in figure a street flooding affects pavement performance and obstructed traffic flow.

Figure 1: Ponding of water during rain on road surface near to Assosa town Administration Office

In addition, bad smell and environmental pollution, urban land degradation, development of disease causing organisms like malaria and diarrhea were common at the study area. This critical situation was severely aggravated because the drainage system, which conveys storm runoff from the areas to the river were not fully operated and the existing drains blocked with huge amount of garbage, solid waste, silt sand accumulation and vegetation. The main objective of this study is to assess the existing condition of surface water drainage system and its impacts in Asosa town with the set objective of suggesting remedial recommendations.

Urban Drainage and its Importance

Adequate drainage systems are needed in urban areas because of the interaction between human activity and the natural water cycle. This interaction has two main forms: the abstraction of water from the natural cycle to provide a water supply for human life, and the covering of land with impermeable surfaces that divert rainwater away from the local natural system of drainage. These two types of interaction give rise to two types of water that require drainage. The first type, wastewater, is water that has been supplied to support life, maintain a standard of living and satisfy the needs of industry. After use, if not drained properly, it could cause pollution and create health risks. Wastewater contains dissolved material, fine solids and larger solids, originating from water closets, from washing of various sorts, from industry and from other water uses. The second type of water requiring drainage, storm water, is rainwater (or water resulting from any form of precipitation) that has fallen on a built-up area. If storm water were not drained properly, it would cause inconvenience, damage, flooding and further health risks. It contains some pollutants, originating from rain, the air or the catchment surface.

Urban drainage systems handle these two types of water with the aim of minimising the problems caused to human life and the environment. Thus urban drainage has two major interfaces: with the public and with the environment. The public is usually on the transmitting rather than receiving end of services from urban drainage ('flush and forget'), and this may partly explain the lack of public awareness and appreciation of a vital urban service.

Figure 2: Interfaces with the Public and the Environment

PROBLEM STATEMENT

Impermeability increases with the increase of impervious surface in urban areas, this in turn increases the over land flow resulting in flooding and related environmental problems. The pattern of urbanization and modernization in Ethiopia has meant to increase densification along with urban infrastructure development (Dagnachew Adugna Belete, 2011); it has led to deforestation, use of corrugated roofs, and paved surfaces.

In Asosa town due to lack of proper interconnection between road and urban storm water drainage infrastructures, poorly maintenance of existing structures, solid waste damping and absence of drains street flooding is common in the rainy season. This has resulted in negative impacts on road pavement performance and on the overall situation of the town's basic infrastructures like road and drains. It is observed that the flooding of roads resulting in the accumulation of silt and sediments on the road surface which leading to overturning of cars in the rainy season (from mid-May to October)

The occurrence of erosion and street flooding is a common phenomenon which forced vehicles to stop for some hours from their usual activities. Therefore, this study assesses the existing condition of storm water drainage system in Asosa town and its integration with road net-work infrastructure.

RESEARCH OBJECTIVE

General Objective

The overall objective of this study was to evaluate the existing condition of road and storm water drainage system in Assosa town, Benishangul Gumz Regional State and the challenges for its provision.

Specific Objectives

1. To evaluate the existing condition of road and surface water drainage infrastructures
2. To identify areas/sites highly sensitive to flooding
3. To assess the effects of poor road surface drainage on urban road performance
4. To evaluate the road and road surface drainage integration at the study area

SCOPE OF THE STUDY

The study area is Asosa town, the capital city of Benishangul Gumz Regional State, Ethiopia. The study addresses issues related to urban road surface drainage and its integration with road infrastructures in the town. The specific objectives of it includes: existing condition of road and drainage structures, their net-work condition, the effects of poor road surface drainage on urban road performance, road & drainage infrastructures integration at the study area and flood prone areas in the study area.

LITERATURE REVIEW

Urban infrastructure is one of the indispensable elements in the process of urbanization and emergence and continuity of an urban growth. It is considered as a driving motor/engine for economic development. It is important in eradicating poverty through various job creation opportunities and by so doing; it enables to speed up economic development and ultimately ensures improved quality of life.

A drainage system includes the pavement and the water handling system. They must be properly designed, built, and maintained. The water handling system includes: road surface, shoulders, drains and culverts; curb, gutter and storm sewer. When a road fails, whether it's concrete, asphalt or gravel, inadequate drainage often is a major factor. Poor design can direct water back onto the road or keep it from draining away. Too much water remaining on the surfaces combine with traffic action causes potholes, edge failures, cracks and pavement failure.

In the recent time, numerous researches clearly demonstrating that poor/inadequate drainage can adversely affect pavement performance. According to Rokade et. al. (2012)

inadequate drainage leads to major cause of pavement distresses due to large amount of costly repairs before reaching their design life. Finally, he found that pavement service life can be increased by 50% if water can be drained without delay.
Similarly, pavement systems incorporating good drainage can be expected to have a design life of two to three times that of undrained pavement sections. For a long time, urban drainage systems have existed as a vital town infrastructure to collect and convey storm water and wastewater away from urban areas (Chocat B., 2007). Despite development over the years, it remains a significant challenge to design an effective functioning drainage system. Cedergreen et. al. (1973) evaluated early field tests that included both drained and undrained pavement sections. Based on these field data, he estimated that a flooded undrained pavement experiences 10 to 70,000 times the damage from a load event compared to a drained pavement. As a conservative single value, he suggested that an undrained pavement experiences 15 times the damage compared to a well-drained pavement.

To achieve proper drainage, drains (or ditches) a long side of road are essential to collect water from road surface and surrounding areas and lead it to an exit point where it can be safely discharged. Forsyth et. al. (1987) on his study presented a number of case studies related to pavement drainage. Finally, he reported that the use of edge drains usually improve the durability of pavements. He concluded that the percentage of cracked slabs in the undrained sections exceeds that in the drained sections by a ratio of 2.4 to 1.

Markow M.J. (1982) developed a predictive model of pavement performance that includes the effect of moisture on pavement materials properties and the quality of the subsurface drainage. In this model, the duration of pavement wetness is first estimated taking climatic conditions as well as drainage into account. Then, assuming the pavement system has a 50% reduction in strength when wet.

MATERIALS AND METHODS

Description of the Study Area

Asosa town is one of the emerging towns of Ethiopia and it is the capital city of Benishangul Gumz Regional State. The geographical location of the town is coordinated at 34032′0″ longitudes and10003′0″ latitudes. It is located at a distance of 662 km South-West of the capital, Addis Ababa along with the main highway road, (Municipality of Asosa city, 2014). The elevation of the study area varies from 1,500m to 2,000m above sea level. The recorded temperature of the town showed that the annual mean temperature of Asosa and its surroundings is nearly 22oC, implying tropical climatic condition. According to the Ethiopian Metrological Agency’s (EMA) report of 2014, the mean annual rainfall of the town is about 992mm with the main rainy season extends from mid-May to October.

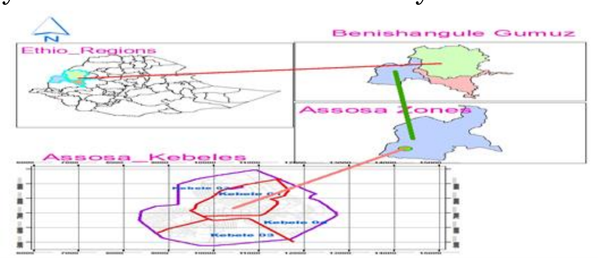


Figure 3: Location Map of the Study Area (GIS Analysis, 2015)

Figure 4: Partial View of the Actual Study Area

Study Design

In this study, descriptive and exploratory types of research methods were employed. The descriptive type was used to describe the existing condition and coverage of roads and urban storm water drainage facilities. Whereas, the exploratory type was particularly used to explore the existing condition by making some required physical measurements, and compare with standards.

Data Type and Sources

To achieve the stated objective of this study, quantitative as well as qualitative data types were employed. Of the total data about 90% of the research data was collected from primary sources of field observations and measurements. Whereas the rest 10% was collected from secondary data sources in order to reinforce the primary data sources.

Methods of Data Collection

In the current study, we used two data collecting methods, namely interview and observational survey. An in depth interview was carried out with respondents to collect primary data related to flooding hazards. The data collection activity was conducted by data collectors in the presence and by closely supervision of the researchers. The Field observation method is the major data collection tool for this study. Pictures of different scenario as it relates to different drainage issues were taken to show the true state of things in the study area. The field survey was done in detail using base map, checklists, Satellite image and surveying instruments. The size of the actual urban storm drains and roads were measured and checked for their required dimensions.

Data Analysis and Presentation

Each and every road and drainage infrastructures of the study area were fully surveyed from June to October 2015. The data collected were checked and analyzed using Soft wares like Auto CAD, 2007, Arc GIS 10.1, and Statistical Package for Social Science (SPSS) version 15 software in addition to the usual Microsoft-excel. The analyzed data was presented in tables, charts and percentages. In addition, photographs that describe the existing conditions and problems were also incorporated.

RESULT AND DISCUSSION

Existing Condition of Road Network

Water has a number of unhelpful characteristics which impact on road performance. The road surface, cross-section slope, longitudinal gradient and shoulders were investigated and different types of damages were observed at the study area. These are depressions, potholes, cracking, over flooding, pavement erosion, silt & sediment accumulation, washing and deformations of the road pavements. Figure 5 shows the severely deteriorated road surface.

Figure 5: a) Ponding of water on potholes b) Surface Runoff on road pavement

It is essential that adequate drainage systems provisions are made for road surface to ensure that a road pavement performs satisfactorily. Thus a drainage system which includes the pavement and the water handling system must be properly designed, built, and maintained. Table 1 shows the existing coverage and condition of road surface at the study area.

Table 1: Detail Length and Condition of Road

S/No	*Road surface Type*	**Total Road** *Length(m)*	*%*	**Road** *Condition*	*Length (m)*	*% of Network*
1	**Asphalt Covered**	**21,936.03**	**32.2**	***Good***	**18,593.36**	**27.1**
				Fair	**1410.58**	**2.1**
				Poor	**1932.09**	**2.8**
2	**Cobble Stone**	**3,535.22**	**5.2**	***Good***	**3,535.22**	**5.2**
				Fair	---	--
				Poor	---	--
3	**Local Earth**	**42,694**	**62.6**	***Good***	**10,707**	**15.7**
				Fair	**882**	**1.30**
				Poor	**28,105**	**41.2**
	Total	***68,165***	***100***		***68,165***	***100***

Source: Asosa City Administration office & field survey data, January to February, 2016

As depicted in table 1, 2.8% of the paved road and 41.2% unpaved road are in poor condition requiring rehabilitation and reconstruction while 2.1% of paved road and 1.3% of unpaved road are in fair condition that requires resurfacing to prevent further decline to poor conditions. The conditions of unpaved roads at the study area are severe. As the maintenance costs of unpaved roads is high and at the same time they have the propensity to reduce the economic life of automobiles riding them, unpaved roads are generally deficient for effective movement and thus, require new development and rehabilitation to improve and aid mobility. The summery of road surface types and condition is presented in table 2.

Table 2: Roads Surface types and Condition at the Study Area

S/No	**Road Type**	**Size(m)**	**Road Condition** *Good(m)*	*Fair(m)*	*Poor(m)*	**% from Total**
1	Highway	6316	6316	---	---	9.3
2	Arterial	12,272	10777	736.5	758.17	18.0
3	Collector	6885	5056	674.08	1155.11	10.1
4	Earth Road	42690	12740	882	28105	62.6
	Total	***68,165***	***37,280***	***2465.96***	***30,018***	***100***

Source: Own field survey data, January to February, 2016

In this study, existing, coverage and hierarchy of roads was fully surveyed using base map, satellite image of the town and checklists. Based on the study, four categories of road types were observed. These are highway (9.3%), arterial (18.2%), collector streets (9.2%) and local earth road (63.3%). And also, considering the surfacing material, four types of road were identified in the study area. These are asphalt covered 21.94km (32.6%), cobble stone covered 2.87km (4.3%) and local earth road 42.33km (63.1%).

Longitudinal Profile of Asphalt Road

Drainage is a basic consideration in the establishment of road geometry and vertical alignments should ensure that: a) outfall levels are achievable; and b) sub grade drainage can discharge above the design flood level of any outfall watercourses. These considerations may influence the minimum height of embankments above watercourses. They could also influence the depth of cuttings as it is essential that sag curves located in cuttings do not result in low spots which cannot be drained. Drainage can then be affected over the edge of the carriageway to channels, combined surface water and ground water drains or some other form of linear drainage collector. Figure 6 shows longitudinal profile of a collector road. This road is Asphalt paved type, which starts from the junction in front of Ethiopia Hotel towards Benishangul Gumz Region Police Commission office, having a total length of about 900m.

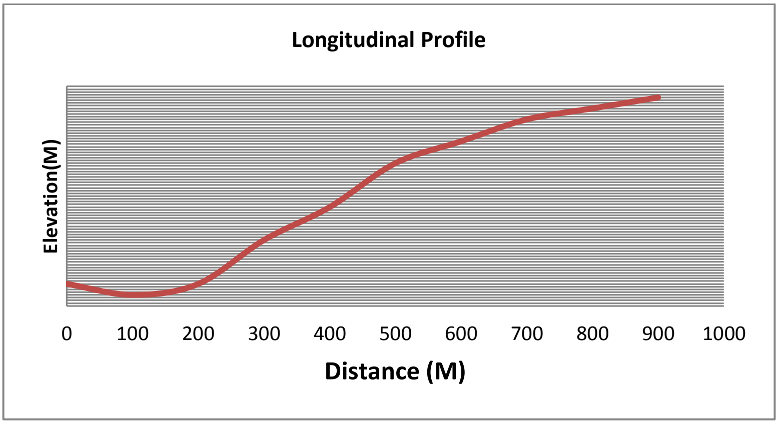


Figure 6: Longitudinal Profile of Asphalt road (Ethiopia hotel to Police Commission)

As we can see from the above figure, the overall distribution of longitudinal and cross sectional slope between the stations is not uniform. As a result of this, the safely disposal of storm water from the road surface towards the side drains is not sufficient.

The profile of Asphalt road segment from Equatorial Hotel to Asosa Prison was also determined as a case study from the field measurement data. This road is categorized as collector road, and used as an entrance for Asosa bus station.

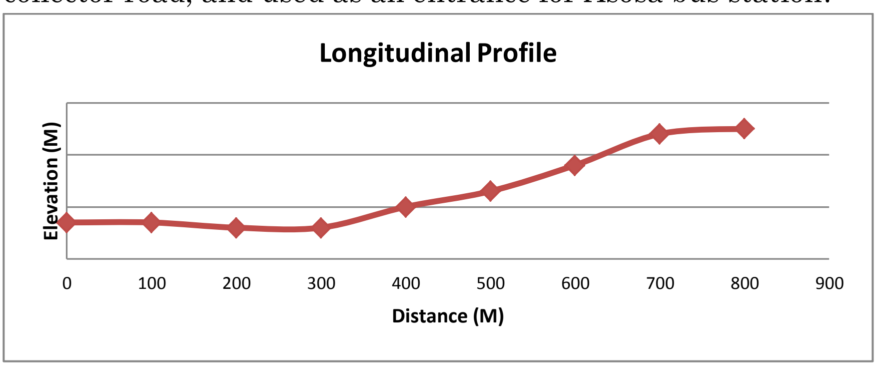


Figure 7: Asosa Bus Station Asphalt Road Profile

This road is a highly deteriorated road because of highly traffic volume compared with the other road types in the town. The longitudinal and cross section profile of the asphalt road shown in the figure in not uniform that shows a high fluctuation, which cannot provide good disposal of storm water from the surface of the road to the side drains.

Existing Condition of Storm Water Drainage

Urban drainage is an important feature in determining the ability of the road pavement to withstand the effects of traffic and environment. The presence of excess water or moisture within the roadway will adversely affect the engineering properties of the materials with which it was constructed. The overall condition and coverage of urban drainage systems of Asosa town is presented in table 3.

Table 3: Length and Condition of Urban Drainage systems by Shape

S/No	Drainage Shape	Made from	*Total Length*	*Condition*	*Length (m)*	% from total
1	Trapezoidal	Masonry	*4566.68*	*Good*	4566.68	12.4
				Fair	---	
				Poor	---	
2	Rectangular	Masonry	*11574.07*	*Good*	5776.6	31.4
				Fair	1069.7	
				Poor	4727.77	
3	Circular	Concrete	*18078*	*Good*	9,169.74	49.03
				Fair	404.73	
				Poor	8503.93	
4	Rectangular	Natural Earth	*2656*	*Poor*	2656	7.17
	Total		36,874.75		36,874.75	***100***

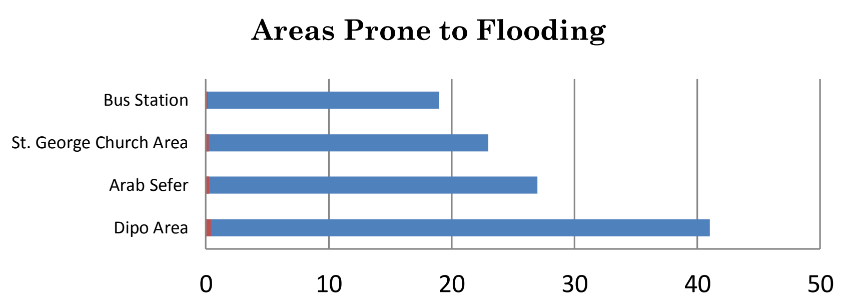
Source: Own field survey data, January to February, 2016

Considering table 3 and from researchers' field survey, 12.4% of the drains are trapezoidal, which are open & closed to the environment, 31.4% of the drains are rectangular, which are closed & open to the environment, and 49% of the drains are circular/pipe, which are also closed/buried types. Most of the rectangular and trapezoidal drains are open and are not environmental friendly, which implies that these may encourage residents to connect and dump their sewerage system and solid waste sources, resulting in unpleasant smells and unaesthetic to the environment.

As indicated in table 2 and 3, the total length of road and urban storm water drainage infrastructure in the town is 68.2 km and 36.9km respectively. In which 54.1% of the road is with drainage and the rest 45.9% is without drainage facility. Based on the analysis of study, the total road network coverage at the study area up to 2015 is 0.661km2.

Street Flooding at the Study Area

In Asosa town, the integration between drainage system and road is not satisfactory in general. Most of the road networks are not integrated with surface drainage infrastructures, the existing drains are not maintained properly, the budget allocated is not sufficient and the dimension of the drains are not sufficient to discharge the flood away from the surface of the road pavement. Even though, there are many sites prone to flooding in Asosa town, the major flood prone areas that needs due consideration were identified through interview with city officials and town residents along with field observations. Based on the study performed, the major flood prone sites are presented in figure 6.



	Dipo Area	Arab Sefer	St. George Church Area	Bus Station
Frequency	41	27	23	19
Percentage	37.3%	24.5%	20.9%	17.3%

Figure 8: Major Flood Prone Areas

In terms of flood sensitivity, figure 8 indicates that 37.3% of respondents indicate that Dipo Area (most part of kebele 03) is highly flood sensitive area that needs due attention by the concerned bodies and followed by Arab Area (24.5%) and St. George Church area (20.9%). Figure 9 shows the major flood sensitive areas in Asosa town.

Figure 9: Major Flood Sensitive Areas at the study area

Discussion with the communities and interviews of professionals, the main causes of street flooding are identified and the result is in line with the field observation. Generally, five major causes of flooding are listed by the officials and town residents, namely: inadequate drains, poor maintenance, illegal sewer connection, absence of drains in some areas of the town and poor layout of road profile. The result is summarized and presented in Figure 10.

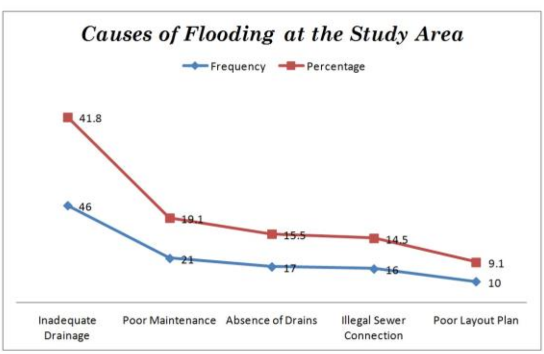


Figure10: the Major Causes of Flooding at the study area

Figure 10 reveals that 41.8% of the respondents claim that inadequate drainage is the main cause of street flooding followed by poor maintenance (19.1%) resulted in blockage of drains. As we can refer from the above table, the town administration should give immediate attention to construct additional storm water drainage infrastructure at the highly victim areas, maintain the existing drains before the rainy season and to change the habit of the town residents who dump their solid waste into the drains and destroy the proper functioning of the structure. In addition, some corrective measures should be taken as per the actual design parameters with a full consideration of the quantity of runoff generated, longitudinal and cross-sectional slope of the road in the respective catchment area to protect over flows of water on the surface of the road.

Effects of Poor Surface Water Drainage on Road Performance

Poor drainage conditions on road pavement are of adverse effects and causes failures in different ways. Proper and well maintained drainage systems provided to road pavements will increase their life span. On the other hand, improper and not well maintained drainage systems causes' failure of road pavements at its early age thereby drastically reducing their service lifespan. Most of the roads in Asosa town having inadequate drainage systems, deterioration often begins with the origin of cracks or pot holes on the road pavements either at the edges or along the drive way (Figure 11) which differs by their shapes, configuration, and amplitude of loading, movement of traffic and rate of deformation.

Edge Failure

Severely failed side drains

Flooded road

Potholes on Road Pavement

Figure 11: Effects of poor drainage on road surface

The bad condition of the side drain and its structures remains the same at the study area throughout the year causing the runoff water to flow on the surface of the road and formation of potholes (Figure11) and unable to run off through the path far from the failed drain. The road edges suffered from detachment of asphalt layer due to continuous contact of water leading to stripping of asphalt from aggregates resulting in severe pavement distresses of cracking, potholes, patches and failure of edges. In addition to these, bad smell and environmental pollution, urban land degradation, development of disease causing organisms were some of the findings as a result of inadequate integration between road and urban drainage infrastructures. Whatever the infrastructures like roads, drains and their structures, culverts are well built they need adequate maintenance for sustainability. One of the main problems of drainage development in Asosa town is maintenance. From the investigations conducted, the roads and drains structures are rarely maintained and whenever maintenance is attempted it is done haphazardly.

It is also observed that most of the side drains are full of sediment and garbage at many places which obstruct the normal flow of water in the channel. Some drains are also covered with grasses and shrubs and thus not giving the desired function for which it was constructed. Figures 13 presents proof of this reduction in service lifespan and it is evident in the deterioration of drainages and subsequent road pavement conditions which are visibly noticed in the form of edge failures of road pavements, pot holes on road pavements, stripping of bitumen off the surface of road pavements and blockage of drainage channels such as culverts and underground drainage networks. Also these poor maintenance culture results in gullies and gratings being blocked with dirt weed, silt sand accumulation over time and in the growth of vegetation inside and around the side drains which has resulted into total failure of the side drains structures.

Fully Blocked Drains


Failed manhole *Eroded pavement surface*


Drains covered by Grass *inadequate sizes*

Figure 12: Showing the Result of Poor Maintenance

Drainage and Road Network Integration at the Study Area

The provision of road and urban storm water drainage infrastructures are essential particularly in an urban center for safe and easy reachability from one area to another, emergency services, fire brigade services, latrine sucking trucks, and to protect flood damage on infrastructure and utility as a result of pavement. As it was observed during the field investigation, proper integration were made along the existing asphalt road and the newly constructed cobble stone road (table 5) but the outlets of the drainage system are poorly defined and overflow of water during rain time, thereby resulting damages to road surface material and flooding in the area. Table 5 presents the survey results.

Table 5: Road and Storm Water Drainage Integration at the Study Area

The Integration of	With Rectangular	With Trapezoidal	With Circular Drains	Total	% from total
Asphalt Road	8,038.85(21.8%)	4,566.68(12.4%)	18,078(49%)	30,683.53	83.2
Cobble Stone	3535.22(9.6%)	---	---	3535.22	9.6
Earth Road	2,656 (7.2%)	---	---	2,656	7.2
Total	***14,230.07***	***4,566.68***	***18,078***	**36,874.75**	**100**

Source: Own Field Survey data, January to February, 2016

Considering table 5, the integration of all roads with rectangular, trapezoidal and circular drains is 21.8%, 12.4%, and 49% respectively. The entire stone surfaced road is integrated with a one way rectangular drainage.

From tables 1 and 5, the total length of road network coverage and surface water drainage infrastructure of the town are 68.2km and 36.9km respectively. From these, the spatial integration between all roads and urban storm water drainage network is found to be 54.1%. This implies that, for every kilometer of the road there is 541metres of drainage line. The rest 45.9% of the road i.e. 459 meters of the road per kilometer is without urban storm drainage facility. Besides, the road density for the total area was analyzed and found to be very small at the study area. The implication of this is that: street flooding keeps continuing, maintenance cost of road and drainage infrastructure will be increased per year.

On the other hand, a significant part of the existing drainage channels are partially (in some areas fully) filled with solid waste of different varieties. And in most of the junctions or inlets, there is no silt trap mechanism and because of this any material from the surrounding areas are transported by surface runoff into the storm drains which reduces its effective carrying capacity.

Street Flooding because of drains blockage

Waste materials in side drains *failed side drains*

Figure 13: Showing Impacts of Poor Drainage

CONCLUSION AND RECOMMENDATION

Conclusion

The impact of poor drainage condition at urban area is very adverse. It causes pavement distresses and deterioration which affect the safety and riding quality on the pavement, it also affects the life and properties of the people. Contrary to the general assumption that heavy rainfall is the major cause of urban flooding which mostly results into destruction of human lives and properties, the study shows that: inadequate drainage system, illegal sewer connection, solid waste dumping, and poor layout of road profile are the major factors responsible for street flood in Asosa town. In addition, the researchers conclude that the actual dimensions of the existing drainage facilities are incapable for the safely discharging of the flood.

Recommendations

In view of the findings, the study suggests that

1.Outlying residential areas of the town have no access to paved roads and storm water drainage facilities. The expansion of these infrastructures were stopped somewhere far from their vicinity. Therefore, it essential to expand paved roads and storm water drainage facility in the area

2.Existing urban storm water drainage infrastructure condition in the town is not satisfactory. Hence, practical measures should be taken to reduce and manage flooding hazard (like, clearing of drains, maintenance of drains before the rainy season begins and providing additional drains)

3.Improvement on the integration of solid waste management system to prevent over flowing of flood as a result of blockage of drains.

4.Regular annual evaluation of drainage systems is an important part of maintaining and managing road. Before making any pavement surface improvements, make drainage improvements. It is most economical and effective to plan and upgrade drainage as part of road surface improvements.

5.Considering the slope of the area and runoff condition, it is recommended that provide drainage system starting from in front of Bamboo Paradise Hotel and Ethiopian Red Cross Asosa Branch to Prison of Asosa, and also starting from Asosa St. George Church along with Tena Area to the natural channel or St. Michael Church, construction of large drainages could effectively reduce the surface run-off during a strong rainfall event.

6.A paradigm shift of the behavioral pattern of the urban community (with respect to indiscriminate dumping of refuse, building without leaving appropriate setbacks, etc) is very crucial to the mitigation of flooding in the study area.

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