

Evaluation of Drainage Conditions along Selected Roadways in Amman

Zain M. Al-Houri, and Abbas S. Al-Omari

Abstract—Roadways in Amman city face many problems consequent upon poor drainage systems. Evaluation tools are necessary to identify those roads needing improvement in their drainage system, and those needing regular maintenance. This work aims at evaluating drainage conditions in selected roadways in Amman city with the intent of identifying the problems encountered in their drainage systems. Three sites in the vicinity of Amman city have been selected and then inspected via several field visits to determine the state of their existing drainage systems and define the major problems encountered in these systems. The evaluation tool used in this study is based on visual inspection supported by photographs that depicted the defined problems. Following the field assessment, the drainage system in each road was rated as excellent, fair, good, or poor. The study reveals that more than 60% of the roadways in the selected sites were in poor drainage conditions, which lead to tremendous environmental problems. This assessment serves as a guide for local decision makers to help plan for the maintenance of Amman city roadways drainage systems, and propose ways of managing the associated problems.

Keywords—Amman Stormwater, Drainage systems, Environmental problems, Roadways drainage.

I. INTRODUCTION

AMMAN is a fast growing city in terms of infrastructural development that involves construction and concretization of the city land surfaces. This urbanization is leading to increased generated stormwater volumes. The removal of stormwater from street and highway pavement, and median areas requires a well designed stormwater collection system. A typical urban stormwater system consists of streets constructed with curbs, gutters, inlets, and roadside ditches; underground storm sewers; and open outfall channels such as stream and rivers receiving runoff [1]. These systems must be properly designed, built and maintained to properly collect water, avoid disruption of the roads transportation function, maintain safe travel conditions, and sustain infrastructure [2], [3]. Poor design can direct water back onto the road or keep it from draining away. Too much water remaining in the surface, base, and subgrade combined with traffic action will cause potholes, cracks and pavement failure [4]. Even on roads built with all the proper drainage elements, neglecting periodic maintenance is likely to result in flooding, washouts, and potholes. Regular annual evaluation of drainage systems is an important part of maintaining and managing roadways [4]. Many streets in Amman lack appropriate drainage systems that can drain the increasing stormwater volumes due to the

rapid urbanization of the city causing flooding of the streets, paralyzing traffic mobility, and damaging private and public property. In addition, poor drainage systems result in the loss of large volumes of stormwater runoff via evaporation during intense storm events therefore increasing water losses in a water-scarce country like Jordan.

Numerous studies have investigated the state of drainage systems in different counties in the world [4], [5], [6]. However the state of the drainage systems in Amman roadways has been neglected and no research has investigated the status of these drainage systems. This study aims at conducting visual assessment of the existing drainage systems in selected roadways in Amman city with the intent of defining the specific problems encountered in these drainage systems. The study is preliminary but is a step forward to raise the awareness of local officials for the importance of evaluating the drainage systems in Amman roadways to plan for periodic maintenance and improvement programs. In addition such an assessment is a necessary component of any water management program in a water scarce country like Jordan.

II. DESCRIPTION OF THE STUDY AREA

Three sites in the vicinity of Amman, Jordan were chosen for inspecting their drainage systems (Figure 1). Each site includes a number of main streets and secondary streets as given in Table I. The streets within each selected site differ in their physical characteristics, traffic flow, surrounding land use and drainage systems. The selection of the study area takes into consideration the vitality of the streets as well as their accessibility for field visits.

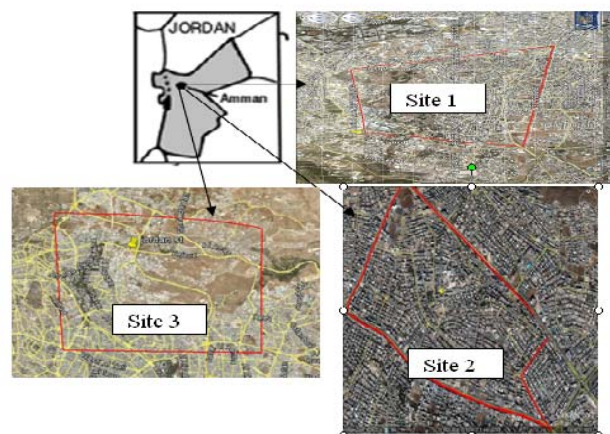


Fig. 1 Location of Amman, Jordan, and the satellite images of the three sites as obtained from Google Earth; Site 1- Tla' Ali , Site 2- Khalda, and Site 3- Al-Jubiha

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TABLE I
DESCRIPTION OF THE SELECTED SITES

Site #	District Name	# of Major Streets	# of Minor Streets
1	Tlaa Al-Ali	3	13
2	Khalda	1	13
3	Al-Jubiha	2	24

III. METHODOLOGY

To achieve the objective of this research, several field visits have been conducted for the selected sites to visually observe the operating conditions of the existing roadways drainage systems. The inspection process was accompanied by representative photographs to aid in the evaluation process. The field visits have been conducted during normal weather conditions as well as during the intense rain events, as Amman is known for its heavy winters and intense rainfall events compared to other cities in Jordan.

The existing drainage systems in the selected sites were rated based on the rating system developed by Walker et al. [4]. This rating system consists of four rating categories: excellent, good, fair, and poor. The ratings are based on the general condition, typical defects, and the recommended improvements as illustrated in Table II.

TABLE II
RATING SYSTEM FOR ROADWAY DRAINAGE (SOURCE [4])

Rating	Condition	Improvement
Excellent	Wide adequate ditches or like-new curb, gutter and storm sewer system. All culverts clean and sound. Overall, pavement and shoulder have adequate crown, ditching or storm sewer on the majority of the section.	No improvement necessary
Good	May need localized cleaning of ditches, storm sewer and culverts, minor repairs to curbs, inlets and culverts. No drainage-related pavement damage. Minimal crown on pavement. Some areas need shoulder slope improvement. Ditching improvement or cleaning needed on up to 50% of ditches. Pavement distress from localized flooding or ponding indicates improvements are needed in some storm sewer, inlets or ditching. Some culverts need cleaning or minor repairs.	Minor or localized repairs
Fair	No pavement crown, Shoulders create secondary ditch. Frequent ponding. Significant ditching improvements needed on more 50% of the roadway. Frequent localized flooding or erosion with pavement distress or failure. Significant improvement in storm sewer, curb or inlets and/or major culvert replacement or improvement needed.	Several improvements necessary
Poor		Major improvement in drainage required

It is worth mentioning that the evaluation process performed in this work is based on visual inspection and on common sense and is intended to be easy to apply to encourage the local officials to conduct such inspection periodically to assess, rate and improve the drainage conditions on the roads.

IV. RESULT AND DISCUSSION

Based on the field inspection conducted during the period of this research, inventories of the drainage systems in the streets of each site and their conditions are prepared. Tables III through V present these inventories for sites 1, 2 and 3, respectively.

TABLE III
DRAINAGE SYSTEM RATING AT SITE 1

Street Name	Type	Drainage Components	Rate
Wasfi Al-Tall	Major	Storm Sewer Inlet	Fair
Jeryes Haddadeen	Minor	Storm Sewer Inlet	Poor
Sobhi Al Kotob	Minor	Storm Sewer Inlet	Poor
Mousa Al Saket	Minor	Storm Sewer Inlet	Poor
Abdalla Al Azab	Minor	Storm Sewer Inlet	Poor
Ghazi Arabeyyat	Minor	Storm Sewer Inlet	Poor
Al Madina Al Monawwara	Major	Storm Sewer Inlet	Poor
Ali Al Azdi	Minor	Storm Sewer Inlet	Poor
Queen Rania Al Abdallah	Major	Storm Sewer Inlet	Poor
Mohammad Al Najdawi	Minor	None	Poor
Abed Al Lateef Abou Kawra	Minor	None	Poor
Hafzi Malhees	Minor	None	Poor
Al Hidaya	Minor	Storm Sewer Inlet	Poor
Saasaa Ben Najeya	Minor	Storm Sewer Inlet	Poor
Al Sahafa	Minor	None	Poor
Mohammad Al Mefleh Al Kuda	Minor	Storm Sewer Inlet	Poor
Mohammad Al Mefleh Al Kuda	Minor	Storm Sewer Inlet	Poor

The drainage systems for the selected sites are rated based on the rating system described in the previous section. It was found that more than 60% of the drainage systems in the selected sites were rated as poor, and only less than 5% were rated as good (Figure 2).

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TABLE V
DRINAGE SYSTEM RATING AT SITE 3

Street Name	Type	Drainage Components	Rate
Al Urdoun street	Major	None Culvert +Concrete Lined	Poor
Yajouz	Major	ditch	Good
Khaleel el sakeet	Minor	Storm sewer inlets	Poor
Akef al Fayez	Minor	Storm sewer inlets	Poor
Ahmad el tarawneh	Minor	Storm sewer inlets	Poor
Sammd	Minor	None	Poor
Abdallah ebn abo baker	Minor	None	Poor
Ebn sodh el telawe	Minor	Storm sewer inlets	Fair
Taleb el safdeee	Minor	Storm sewer inlets	Fair
Jlaad	Minor	None	Poor
Mahammed ebn el hanifa	Minor	None	Poor
Um el fadel	Minor	Storm sewer inlets	Fair
Abu khoosah	Minor	None	Poor
Zenab el assadeh	Minor	Storm sewer inlets	Fair
El awzaaee	Minor	Storm sewer inlets	Fair
Kamel mahammad oadeh	Minor	None	Poor
Rabee el harethe	Minor	None	Poor
Ibrahim el karake	Minor	None	Poor
Alayka	Minor	None	Poor
Alafrah	Minor	Storm sewer inlets	Fair
Alfaaleat	Minor	None	Poor
Al rudwan	Minor	None	Poor
Kossen	Minor	None	Poor
Khaolah bent saad	Minor	Storm sewer inlets	Fair
Uby ebn kaab	Minor	None	Poor
Abd el Raheem	Minor	Storm sewer inlets	Fair

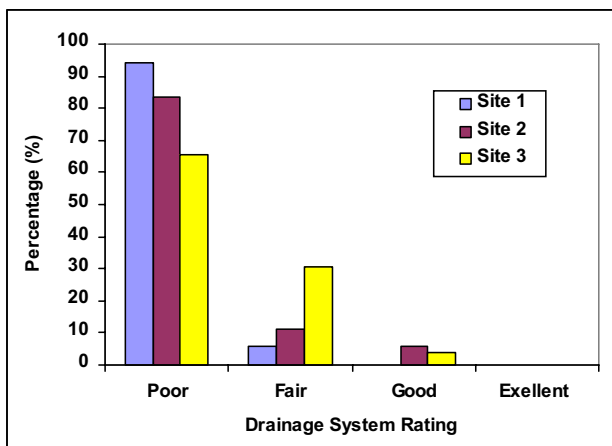


Fig. 2 The percentage of roadway based on rating of the available drainage systems in each site

From the inspection process, the study reveals that the poor drainage is caused by a number of problems. These problems are depicted in Figures 3-5 for the three selected sites respectively. These figures are only examples of the observed problems in the streets drainage systems as it is not possible to show all the observed problems in this paper. Among the observed problems are the followings:

- Poor crowns,
- Lack of curbs and gutters,
- Lack of positive gradient,
- The disposal of waste and impermeable materials (clogging) of storm water inlets,
- Poor outlet conditions,
- Insufficient number of storm inlets or capacity, and
- Poor monitoring and maintenance of the sites

The poor drainage systems caused tremendous environmental problems. Among these problems are ponding, failed pavement and increased road accidents in many streets during the intense rainfall events. In addition, the poor drainage systems in Amman streets added adversely to the problem of scarce water resources since most of the stormwater on roadways evaporates while only a small percentage reaches a defined outlet or replenishes scarce groundwater via infiltration.

In summary, this preliminary work points out to the need for a necessary improvement, repair or reconstruction of the drainage systems in these roadways.

TABLE IV
DRINAGE SYSTEM RATING AT SITE 2

Street Name	Type	Drainage Components	Rate
Wasfi El Tall	Major	Storm Sewer inlet + Culverts	Fair
Sliman Abd Al Kader			
Al Sukkar	Minor	None	Poor
Habeeb Al Fahari	Minor	None	Poor
Taki Al Deen Al			
Sabki	Minor	None	Poor
Mohammad al Zuhari	Minor	None	Poor
Mohammad Ali Al			
Sukkar	Minor	Storm Sewer inlet	Poor
Sliman Abu Hdaib	Minor	None	Poor
Ayman Abu Amer	Minor	None	Poor
Saleh Abu Hdaib	Minor	None	Poor
Ameer Ben Sinan	Minor	None	Poor
Kotb Al Deen Al			
Safawi	Minor	None	Poor
Issa Al Sobae'I	Minor	None	Poor
Mansour Ben Omayer	Minor	None	Poor
Maani Al Shorafat	Minor	None	Poor
Khalda Circle	Circle	Storm Sewer inlets	Fair
Khalda Bridge	Bridge	Storm Sewer inlets	Poor
Waha Circle	Circle	Storm Sewer inlets	Fair
Waha Tunnel	Tunnel	Storm Sewer inlet	Poor



Fig. 3 (a) Example Problems of the roadway drainage systems in Site 1



Fig. 3 (b) Example Problems of the roadway drainage systems in Site 1



Fig. 4 Example Problems of the roadway drainage systems in Site 2

V. CONCLUSION AND RECOMMENDATION

The value of proper drainage systems design and maintenance for roads cannot be over-emphasized. In this study, an evaluation of the conditions of the current drainage systems is conducted by visual inspection and simple common sense rating. Based on the field inspection, it was found that more than 60% of the roadways in the selected sites within Amman city face problems during the intense rainfall events due to the poor conditions of the exiting drainage systems. These poor drainage systems are causing tremendous environmental problems. Hence, there is a need from local officials to prepare and implement a plan to improve, repair or reconstruct the drainage systems in these roadways.

Although, the evaluation conducted in this study is simple and preliminary, it points out to the importance of conducting regular inspection of the existing drainage systems as an important part of maintaining and managing these roadways.



Fig. 5 Example Problems of the roadway drainage systems in Site 3

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REFERENCES

- [1] P. W. Bedient, W. C. Huber, B. E. Vieux, (2008), "Hydrology and Floodplain Analysis" Prentice Hall, Inc. Upper Saddle River, NJ.
- [2] L. W. Mays (2004), "Hydraulic Design Handbook" McGraw Hill, New York (www.digital engineering library.com).
- [3] B.R. Urbonas, L.A. Roesner (1993), "Hydrologic Design of Urban Drainage and Flood Control", handbook of Hydrology edited by D.R. Maidment, McGraw Hill, New York.
- [4] D. Walker, L. Entine, and S. Kummer (2000), "Drainage Manual: Local Road Assessment and Improvement", Transportation Information system, University of Wisconsin, Madison, 16 pp.
- [5] R. A. Offiong, J. E. Atu, G. N. Njar, and U. A. Amuyou (2008), "Problems and Prospects of Poor Drainage Systems and Urban

Sustainability in Calbar, Nigeria", Global Journal of Social Sciences, Vol. 7, No. 2 : 121-127.

- [6] A. Matintupa, and S. Tuisku. (2010), "Roadex Project Report Summary of Drainage Analysis in Ireland, Roads N56 and N59". Rep. N.p., 2012. Web.