Degradation of sewage pipe caused Sinkhole: A real case study in a main Road

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ABSTRACT

Sudden collapse in the form of large hole was observed in one of the main roads of Tripoli. As soon as the failure announced the local council members and police were immediately performed safely traffic and movements of people and cars. The incident presented discussion between people involved in the project and citizens created number of questions concerning to the reason of the collapse. Failure analysis is one of my interest, this lead me to carry out failure analysis study to determine the causes. The investigation results revealed that the pipe interior surface suffering from severe degradation. The original wall thickness was reduced catastrophically. Damages in pipe wall allowed fluid leaks, cavities in soil and collapse of pavement layers. The condition underneath the road resulted in this big sinkhole.

Keywords: failure, leaks, cavities, soil, collapse.

1 Introduction

The incident indicated in Google map images in Figure 1. This cement pipe of TRIPOLI sewage network installed for more than 25 years ago. The road collapsed in circular large hole (sinkhole) with approximately dimensions of 4 meters diameter and 3 meters depth. General photographs were taken to show the damage and its location. The traffic direction is from left to right lane as indicated in Figure 2. Deep excavation was carried out toward the buried pipe. Visual observation confirmed that the replacement of the collapsed pipe was the only solution to overcome the problem and stop leak and further road collapse. Residential homes, Universities and government buildings in the area are directly connected to this pipe. This can state the heavy load by fluids on this pipe which tells of possible more damage can happen in other locations. The time required for the treatment of this collapse not specified because the damage was not anticipated. The reform process took a few days; precautions to protect the residents living in the region were considered. The project team decided to port the maintenance process to install a new GRP.
2. FAILURE ANALYSIS PROCEDURE

Detailed photographs illustrated in Figure 3 were taken after digging operation. These images were taken after the damaged pipe removed out; it shows the pipe lane holes at the bottom level of the manhole. Samples from the broken cement pipe were collected and then documented in group of photographs as displayed in Figure 4. Degradation features on the internal pipe surface is shown in Figure 5.
3. FAILURE MECHANISMS

3.1 Role of external parameters in the failure scenario

There are sources may influence the buried structures performance. The external stress can be caused by human error or loads by cars and heavy trucks. When look at the schematic shown in Figure 6 one can inspire the possible failure mechanism of a buried structure into the following stages; (i) Buckling of pavement permits the external liquids to penetrate the road layers and causes wet soil. (ii) Heavy rain provides high quantity of water drains through the manhole to the buried pipe. (iii) Liquid increases interior load on pipe and may induce turbulent fluid mode.
3.2 Role of fluid and internal pipe condition in the failure scenario

Sewage systems contain contaminants like biological organisms, acids, sand or rocks. Each of these elements can impact the structure in many ways. Lack of information concerning to this case study allowed us to go to the most possible cause behind this incident.

3.3 Role of bacterial in interior pipe surface degradation

Sulfate-reducing bacteria (SRB) are responsible for production of the gas sulfide and are a major factor in microbial concrete degradation. Figure 7 shows the chemical process for hydrogen sulfide departure from the waste fluid to the air space above the liquid, where sulfur oxidizing bacteria (SRB) oxidize sulfide to sulfuric acid.

- Sulfate reducing bacteria that increase in sewage while reducing sulfur compounds to produce hydrogen sulfide increase.
- Sulfur compounds such as sulfate, $\text{SO}_4^{2-}$, is reduced to $\text{H}_2\text{S}$ by sulfur reducing bacteria in an environment depleted of oxygen, in the flowing wastewater or biofilm.
- $\text{H}_2\text{S}$ in the liquid depart as a gas into the air space, where reduced sulfur is oxidized by sulfur oxidizing bacteria (SRB) to produce sulfuric acid $\text{H}_2\text{SO}_4$ in the sewage pipe.
- Bacteria eat the cement and the concrete. When the wall of a concrete pipe becomes corroded, the pipe gets thinner and can finally collapse.

Pipe cement material is dissolved by acid reaction at condensate area and use bacteria into food phase for its life cycle. This can reduce the cement pipe thickness. Cement pipe degradation features are shown in Figures 5-8.

3.4. Final stage of collapse mechanism

The pipe collapsed, and the soil entered the pipe, and pushed forward to distances beyond the location of damage. Pipe leakage allowed the fluid to wash the soil out to the pipe and create cavities around the buried structure. The soil movements caused cavities and left gaps between soil and pavement. The cavity formation mechanism is illustrated in the schematic in Figure 9. It’s not clear yet how long this process took in forming this sinkhole or the road collapse.
4. REPAIRING OPERATION

The ruptured pipe was removed, and the installation of new pipes started. The damage repair operation took a few days because the collapse was not anticipated. The glass reinforced plastics (GRP) pipe was installed. GRP has high resistance to most of chemical substances.

5. CONCLUSION AND RECOMMENDATIONS

For conclusion of this problem as presented. In the first, the drains and pipes are difficult to assess their condition as they are underground and the only solution to stop leak was replacement. The pipe internal surface degradation was due to the effect of acids produced by biological and hydrogen sulfide gas and the chemical analysis confirmed the presence of SRB bacteria. The soil washed out by liquid leaks from the pipe formed cavities or voids resulted in road layers collapse, reduce in water level enhances the phenomena of voids formation. The same problem is possible to happen in other parts of the city.

These recommendations are important to be considered particularly for the new projects of the infrastructure. In the first, plans to inspect pipes regularly, or replace or apply linings on defected structures in the system are required and mapping out plans to carry wide survey of buried pipe network is important issue to reduce risk of any sorts of similar failure. Monitor the road condition is one of indicators can be used to tells what is below; pavement cracks, holes and other significant damages and awareness by road conditions must be treated immediately. Maintenance control is required to guarantee a well functioning sewage system and finally, concrete or cement pipes that are subject to sulphuric acid attacks may require more frequent inspections.
REFERENCES
