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Risk minimization in isolated subsurface structures through ventilation induced by natural forces

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ABSTRACT

The subsurface infrastructure contains solitary structures and complex networks interconnected by piping or duct. These structures meet generally accepted criteria for classification as confined spaces. Fatal incidents continue to occur through mechanisms often not recognized or appreciated until follow-up study. This paper reviews some of the recent fatal incidents that have occurred in order to identify actions needed to minimize the risk posed by hazardous atmospheric conditions in the airspace. Consistent, optimized ventilation in isolated subsurface structures not entered for a long period of time induced by natural forces minimizes development and persistence of hazardous atmospheres. A logical venue through which to pursue these actions is the Prevention through Design (PtD) initiative of the National Institute for Occupational Safety and Health (NIOSH). This paper recommends research to discover and understand the means by which ventilation of these structures induced by natural forces occurs and application of engineering principles to the design and placement of openings in manhole covers and hatches to achieve optimization. These outcomes are believed capable of considerably reducing risk to workers from exposure to the internal atmosphere during preparation for entry and work in these structures, to passersby exposed to emissions through openings in manhole covers and hatches and to everyone from risk of explosion.

1. Introduction

The success of the densely populated, modern urban model depends on the availability of services and utilities. The ground underlying streets and walking areas provides the logical and most available location for installing the infrastructure. The subsurface infrastructure comprises many types of chambers and related components and piping in the electrical, communications, fuel gas, potable water supply, hot water and steam district heating, and sanitary and storm water collection systems.

The subsurface infrastructure is all around us under foot. All that we normally can see are the manhole and access covers of these structures located at grade (Fig. 1). These covers form walking surfaces and surfaces to support vehicles. When the occasional removal of a cover occurs, the size and extent of what lies below becomes visible and often surprises the casual observer. Structures that lie under manhole and access covers range in size from the very small to the very large. The cover provides little feedback to indicate what lies underneath.

2. Subsurface structures

The structures that form the subsurface infrastructure are constructed mostly from cast-in-place or precast concrete, although fibre-reinforced plastics and plastic-lined concrete are increasingly in use. The infrastructure includes vertically-oriented tubular structures of constant dimensions (manholes), horizontally-oriented structures (vaults) and combinations of both shapes.

These structures are built or set onto specially prepared bases of material in order to ensure drainage and to prevent movement during service life. Gaps between walls and native material are backfilled using selected materials to ensure controlled compaction and drainage. In some circumstances, native material removed during excavation also may be used. Backfill also may cover the top of the structure. These structures are found under streets and sidewalks, under parking areas, and under grassed areas.

Typically, access is provided by a cast steel manhole cover or extruded aluminum hatch and sometimes a steel plate or cast concrete (Fig. 2). The manhole cover generally has one or two lifting holes that also serve for ventilation. The aluminum hatch contains latches for

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Fig. 1. The subsurface infrastructure. This street scene in Rio de Janeiro, Brazil illustrates the many types of covers that provide access to subsurface structures. The access cover provides little if any information about what lies underneath.

opening and lacks openings for ventilation. Tightness of the fit depends on the extent of warping of the two pieces of metal. Steel hatch covers and concrete covers fit into a frame or cut-out moulded into the

Fig. 3. Openings in the end wall of an underground electrical vault through which interconnection occurs.

Fig. 2. Access covers on subsurface structures. Access covers include cast steel manhole covers, extruded aluminum hatches, steel plates, and poured concrete hatches.