Available online at www.sciencedirect.com

ScienceDirect

International Journal of Pavement Research and Technology 10 (2017) 333–342

www.elsevier.com/locate/IJPRT

Field and laboratory investigations on pavement backfilling material for micro-trenching in cold regions

Leila Hashemian [a], Mohammad Rezaei [b], Alireza Bayat [c,*]

[a] University of Alberta, 7-389 Donadeo Innovation Centre for Engineering, 9211 116th Street, Edmonton, Alberta T6G 1H9, Canada
[b] University of Alberta, Department of Civil & Environmental Engineering, 9211 116th Street, Edmonton, Alberta T6G 1H9, Canada
[c] University of Alberta, 7-243 Donadeo Innovation Centre for Engineering, 9211 116th Street, Edmonton, Alberta T6G 1H9, Canada

Received 28 October 2016; received in revised form 9 February 2017; accepted 30 March 2017
Available online 13 April 2017

Abstract

Micro-trenching is an innovative utility installation method that involves creating a narrow trench to place cable or conduit in the road pavement. Compared to other installation methods, micro-trenching provides minimal disturbance to the community and surrounding environment. Despite the advantages of micro-trenching, it is not widely accepted by municipalities because of its potential to damage the existing pavement. Quality of backfilling is an important factor in long-term sustainability of the micro-trench, particularly in cold regions. This paper investigates the performance of two typical micro-trench backfilling methods in cold climates by studying a pilot project in a parking lot in Edmonton, Alberta, followed by a laboratory evaluation of the material used. For this purpose, the installations were monitored through ground-penetrating radar, optical time-domain reflectometer, and visual observations for three years. The monitoring results revealed that conduit had significant vertical movement inside the trench; several premature failures were also observed in the backfilling material. Laboratory investigation showed that the backfilling material did not meet the criteria for use in cold climates, and micro-trench performance could be enhanced using alternative materials.

Keywords: Micro-trench; Pavement backfilling material; Fiber optic installation; Ground-penetrating radar

1. Introduction

1.1. Background and previous studies

One of the major challenges urban municipalities face is cutting the existing road pavement to install utility lines such as waste water sewers, water mains, electrical cables, and conduits. Once a cut is made, it should be backfield with new, appropriate material, thereby resulting in a patched surface on the pavement. Using backfilling materials that are not suitable for the site conditions and not properly installed will lead to premature pavement failures, which can significantly reduce the pavement life [1].

In the telecommunication industry, the number of Internet users has grown considerably over the last 20 years. It was estimated that in 2011, approximately 90 percent of Canada's population had access to the Internet, and by the year 2025, the market is expected to be saturated [2]. The Internet has become a ubiquitous source of both information and entertainment, resulting in a major surge in bandwidth requirements. Since the data transmission capacity of fiber optic (FO) cables is higher than that of the existing copper telecommunication infrastructure [3], providing FO networks has become essential to appease users' growing Internet demands. Providing FO access to

* Corresponding author.
E-mail addresses: hashemia@ualberta.ca (L. Hashemian), rezaei@ualberta.ca (M. Rezaei), abayat@ualberta.ca (A. Bayat).
Peer review under responsibility of Chinese Society of Pavement Engineering.

http://dx.doi.org/10.1016/j.ijprt.2017.03.010
1996-6814/© 2017 Chinese Society of Pavement Engineering. Production and hosting by Elsevier B.V.

homes, also known as fiber-to-the-home (FTTH) and business (FTTB), can be challenging due to the possible disruption of existing utilities, increased surface restoration costs, temporary interruption of services (traffic, waste collection, etc.), and possible environmental disturbances such as contaminant spills, pollutant emissions, and noise [4]. FO installations in cold regions also present specific challenges, such as exposure to frost penetration (potential frost heave) and installation in frozen soils.

Micro-trenching (MT) is a promising method for FTTH connection. The last 200 m of fiber deployment can be particularly difficult to deliver with obstacles both above and below ground to navigate, and these difficulties increase installation time and cost. Providers have found that typical savings of 75% less time and 50% less construction costs may be realized when employing MT procedures [5]. Due to its advantages, MT is growing in popularity as a means of quickly, efficiently, and cost-effectively connecting properties or base stations to the main fiber network, and many installers are now switching to MT.

The MT process starts by cutting a narrow trench. Depending on the size of the conduit used, the trench is narrower than 25 mm wide and up to 120–300 mm deep [6]. Then, the cable or conduit is placed inside the trench, and the process finishes with surface reinstatement. Despite all the advantages, this method is not being widely practiced by Internet service providers (ISPs) around the world because municipalities are reluctant to accept the risks associated with MT, including potential pavement damage, lack of stability of the buried conduit in shallow depths in freeze–thaw climatic regions, and possible damages to the FO cable as a result of road rehabilitation.

Quality of backfilling plays an important role in the performance of MT. It secures the cable in the trench bottom and provides a mechanical protection to the cable against traffic loads. Several studies have been conducted on using different granular, concrete, and bituminous material for backfilling purposes, as well as using recyclable waste materials as an environmentally friendly alternative to the natural resources [7–11]. Due to the tiny dimensions of the trench in micro-trenching, the backfilling material should be flowable enough to penetrate and completely fill the whole trench depth. The other essential requirements for backfilling materials used for flexible pavements include the following: being, flexible so as to allow movement with the existing pavement material; bonding to the existing material; sealing the trench against water ingress; resisting permanent deformation; hardening rapidly to allow the road to be re-opened to traffic quickly; and being simple to apply by multi-skilled installer teams [12].

While a wide variety of re-instatement materials are available, each product should be evaluated for the project location and requirements. Cold climates may require a more robust bonding-type material so water will not penetrate the trench, a phenomenon that could lead to frost heave expansion and push the reinstatement material out of the trench. As the requirement for backfilling micro-trenches has evolved, various materials have been tried with varying degrees of success, including cement and fly-ash based grouts [13], epoxy resins [14], hot mix asphalts (HMAs), sand and hot applied bitumen, and cold mix asphalts (CMAs).

HMA can be a suitable option to backfill the cuts in flexible pavement. However, with micro-trenches, the use of HMA has two major challenges: (1) the volumes of reinstatement products are too small, which makes the use of these materials impractical; (2) the high temperature of HMA during the compaction may damage the conduits and, consequently, the FO cables [5]. Using rigid materials such as cement grouts and epoxy resins may not be suitable for MT backfilling in a flexible road because the rigidity of the material may lead to stress development on the interface between the existing cut asphalt and the reinstatement product, which results in cracking and water penetration in the trench [6]. CMA can be a suitable alternative as it is easy to handle, workable, and less sensitive to temperature variation during compaction. However, it must also be acceptably durable and compacted appropriately to achieve its long-term performance goals.

To study the feasibility and productivity of MT, some pilot studies have been conducted in different countries. For example, in 2011 in Lower Hutt, New Zealand, micro-trenches were cut on the sidewalks in two different pavement types, including road asphalt surface and concrete surface. The trenches' dimensions were 8-cm wide and 43-cm deep and 5.5-cm wide and 23-cm deep for the asphalt and concrete surfaces, respectively. To backfill the trench in the asphalt pavement, a self-compactable and quick-setting mortar was used. The backfilled trench with hardened mortar was milled out on top to create a 2.5–3 cm × 40 cm ditch, which was backfilled with hot mix asphalt (HMA) [15]. According to the reports, the additional milling process produced heavy dust, sound pollution, and prolonged traffic detours, and it might have compromised the structural integrity of the pavement. MTs in the sidewalks were backfilled using concrete mixture; however, the quality of backfilling was not satisfactory for the local authority [14]. Another pilot study was carried out in George Town, Cayman Islands, with a total length of 5.18 km with two MT dimensions of 1.9-cm wide × 30.5-cm deep and 2.4-cm wide × 30.5-cm deep. Beach sand was applied to fill the bottom 10 cm of the trench followed by a compacted CMA on top [16].

MT has been used in Australia [17], Ireland, Germany, France, Norway, Portugal, Israel, Malaysia, and Iran [18]. However, no performance evaluations or monitoring results have been reported for these projects.

1.2. Objectives and scope

The main objective of this research is to investigate the performance of MT in cold regions. Two pilot installations were performed in a parking lot in Edmonton, Alberta, in 2013 and 2014 using typical MT methods and backfilling