TREES ARE NOT THE ROOT OF SIDEWALK PROBLEMS

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Abstract. Locations of defective sidewalk blocks in Cincinnati, Ohio, were compared to various soil complexes in the city. Soils with a percentage of repair record greater than the percentage of soil coverage were identified. The Urban-Stonelick soil complex had a low frequency of repair history. The Switzerland-Urban soil complex had a moderate record, while the Rossmoyne-Urban soil complex and the Urban-Martinsville soil complex had high frequencies of repair when compared to the records of other soil series and complexes in the city. Soil surveys categorized the Switzerland-Urban soil complex with moderate limitations for road construction and the remaining soil complexes with severe limitations. The 4 soil series were selected, and associated sidewalks were randomly surveyed to determine sidewalk failure rates. Sidewalks did not fail at higher rates where trees were present. Sidewalks greater than 20 years old failed at a higher overall percentage rate. Sidewalks less than 20 years old on the Switzerland-Urban soil complex and the Urban-Martinsville soil complex appeared more stable and less prone to failure than the Rossmoyne-Urban and Urban-Stonelick soil complexes. Sidewalks less than 5 years old were not affected by trees in any soil. A variety of problems were identified as being involved in the failure of sidewalks. It appears that trees play a minor role in sidewalk service life. Extending service life of sidewalks will require the cooperation of urban foresters, landscape architects, and engineers.

Key Words. Sidewalk–soil interaction; tree–sidewalk interaction; sidewalk failure; sidewalk design.

As society in the United States becomes increasingly litigious, municipalities are more susceptible to lawsuits that are the result of someone tripping over raised sidewalk blocks. In 1997 the City of Cincinnati was involved with 21 suits seeking damages from the city as a result of damaged sidewalks. This is in spite of a sidewalk safety program that spends US$2 million annually to repair sidewalks. Trees are assumed to be major contributors to the problem by City of Cincinnati public works officials. According to current estimates, tree-related infrastructure repairs cost U.S. cities more than $US135 million annually (McPherson and Peper 1995).

Working with the assumption that correcting the tree will solve the problem, biological research has concentrated on identifying trees less likely to cause problems (Wagar and Barker 1983; Dirr 1990), evaluation of root barriers (Wagar 1985; Urban 1995; Gilman 1996), and redirection of tree roots (Wagar 1985; Barker 1991, 1995). Simply blaming trees for sidewalk failure has come into question. Some researchers are now questioning whether other factors, such as soil characteristics, are partially responsible (Sandfort and Runck 1986; Sandfort 1997). Sidewalks also influence factors, such as soil moisture, which have implications for tree growth and sidewalk serviceability and must be further investigated (Wagar and Franklin 1994). Landscape design also is involved in sidewalk serviceability because trees located in lawns are less likely to disrupt sidewalks than trees in tree lawns (Sommer and Cecchettini 1992).

Replacements of trees and sidewalks have been used to deal with the problem in some instances (Dreistadt and Dahlsten 1986; Sandfort et al. 1996). Care was taken to ensure selection of smaller-growing trees as replacements. This approach may be more likely to occur in a business district or where there are overhead utilities.

Davis Sydnor has noted that all trees are essentially surface rooted for one reason or another. Surface roots are noted for both dogwood (*Cornus florida*) and honeylocust (*Gleditsia triacanthos*) as trees exceed approximately 10 in. (25 cm) diameter (data not shown). Small tree species develop surface roots slowly because they require more time to reach the 10-in. diameter. These observations were made primarily in the states of Virginia, North Carolina, and Ohio—areas characterized by soil series at or above field capacity during much of the winter. These low oxygen levels are assumed to force shallow rooting. Perry (1981) found that 95% of a tree's roots are in the top 18 in. (75 cm) of soil. Urban sites are also commonly characterized by compacted soils with low oxygen levels. Thus, it seems unlikely that plant selection would hold much promise for reducing the conflicts between tree roots and sidewalks.

Soils affect not only tree growth and root development, they also have limitations that affect infrastructure items such as sidewalks, roads, and building foundations. In 1880, the Russian scientist Dokuchaev recognized that each soil has definite physical properties and suggested a genetic classification (Foth 1984). The taxonomy system in use today classifies soils based on morphology and physical properties. The taxonomic units are mapped so that soil qualities are easily identified and managed. Cincinnati, Ohio, is built upon 33 different soil series, as mapped in the Hamilton County Soil Survey Report (Lerch et al. 1992). The survey lists physical properties such as slope, strength, water permeability, particle content, and susceptibility to frost action, flooding, and engineering factors for each mapping unit. The soils are then categorized by their respective suitability for uses such as agriculture and building-site development that includes roads and streets. For example, the Rossmoyne-Urban soil complexes have severe limitations for road construction because they have low strength and are susceptible to frost action (Lerch et al. 1992).

Three major categories were identified in the soil survey to determine suitability for road construction. We feel that this is the most appropriate category to compare factors for sidewalk construction. Soils are rated as severe, moderate, or slight based on their limitations for specific use (Soil Survey Staff 1993) as follows:

- **Slight:** Soil properties and site features are generally favorable for the indicated use, and limitations are minor and easy to overcome.
- **Moderate:** Soil properties and site features are not favorable for the indicated use; special design, planning, or maintenance is needed to overcome or minimize the limitations.
- **Severe:** Soil properties or site features are so unfavorable or difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Thirty-three soil types and complexes are found in Cincinnati and of those, 3 are defined as having slight, 7 as moderate, and 23 as severe limitations for road construction such as would exist for sidewalks. Soils with moderate and severe limitations for road construction comprise 92% of the land area of the city.

Time is a factor that has not been given due consideration (McPherson and Peper 1995, 1997). It is difficult to evaluate sidewalk failure unless time is used as a reference. It is not logical for a sidewalk to be expected to last for hundreds of years. The Cincinnati Public Works Department's Engineering Division estimates that the sidewalk design used in Cincinnati has an average service life of 20 to 25 years, so it is not reasonable to blame the failure of a 30-year-old sidewalk on the presence of a tree. The sidewalk has exceeded its design specifications and therefore the installation was a success.

Sidewalk design is another factor that has not been considered in previous studies (McPherson and Peper 1995; Francis et al. 1996). The Cincinnati Park Board conducted a survey of 100 cities in Ohio and Kentucky to identify practices used by other communities in dealing with trees and sidewalks (Gamstetter 1997). Thirty-seven cities responded to the survey and 94% of them replied that they modify sidewalk construction to accommodate trees. Eighty-eight percent of the respondents replied that they consider soil complex and drainage when designing sidewalks. Despite that fact, 100% reported that they use the same construction specification regardless of soil limitations. Clearly, different sidewalk construction techniques are not currently being used in dealing with varying soil conditions

MATERIALS AND METHODS

The Cincinnati Park Board obtained 5,726 city sidewalk repair location records over a 4-year period (1992 through 1995) to investigate whether sidewalk failures and soil complexes are associated. The locations were entered into a relational database and linked to a geographic information system (GIS) (ArcView 3.1) to generate a soil shape file. The maps were at a scale of 1:24,000. The percentage of repairs was calculated by soil complex or type then compared to the percentage of the city represented by that particular soil complex or type. The percentage of repairs for each soil complex or type could then be compared to the percentage of the city covered by that soil complex or type to identify potential problem areas and note them for further study.

In a city such as Cincinnati, most of the soils have been disturbed to various degrees and are called soil complexes. If the complex lists the parent soil type first (such as Rossmoyne-Urban) that soil type is dominant and makes up more than 50% of the complex. If, as in Urban-Martinsville, the complex begins with "urban," the complex is dominated by disturbed soils. As one might expect, older areas of the city were dominated by more disturbed soils. Digging soil pits to further characterize urban soils is not practical in urban sites because of the danger of disrupting utilities—even if costs were not an issue.

After evaluating the results of historical sidewalk repairs, we chose 4 soil complexes for additional study. Each of the 4 soil complexes represented at least 3% of the area within the city limits of Cincinnati and represented differing sidewalk repair histories. Switzerland-Urban and Rossmoyne-Urban soil complexes were selected as among the most common soils in the city, while the Urban-Stonelick and the Urban-Martinsville soil complexes were selected for differing soil characteristics. The Rossmoyne series are fine-silty, mixed, superactive, mesic Aquic Fragiudalfs. The Switzerland series are fine-silty over clayey, mixed, mesic, Oxyaquic Hapludalfs. The Rossmoyne and Switzerland series have fragipans or hardpan layers. The Stonelick series are coarse-loamy, mixed, superactive, calcareous, mesic, Typic Udifluvents. The Martinsville are fine-loamy, mixed, active, mesic Typic Hapludalfs.

At least 300 locations (street addresses) were chosen from areas within each soil series known to have trees. Fifteen specific addresses were then chosen at random from within each area. The sidewalk joint nearest the center of the business, residence, or lot was selected as the starting point for that location. The global position of that site was located using a Trimble GeoExplorer with Omnistar Model OS 7000 for real-time differential correction. Sidewalk width, approximate age, tree lawn width, sidewalk thickness, and the presence or absence of a cinder or gravel base was evaluated for each location.

Sidewalk blocks extending 40 ft (12.1 m) to either side of the center point were evaluated. Each sidewalk block was examined for cracks and whether the block had been raised. Presence or absence of a tree within 6 ft (1.8 m) of a block on either side of the sidewalk was noted for each block. The size, species, and location of each tree were recorded. Sidewalk condemnation criteria provided by the city's Public Works Department were used to determine sidewalk failures. If a block was broken, cracked, or offset more than 3/8 in. (1 cm), the block is considered to have failed. Failed blocks were evaluated to determine if a tree had caused the sidewalk block failure. Slab thickness and the presence or absence of a base material was determined by digging next to the sidewalk to a depth where the base would be.

An average of ten 4-ft (1.2-m) long blocks were sampled in each direction at a location. Blocks averaged 4 ft in length but varied and were as long as 10 ft (3 m) long. If the blocks were 10 ft long, a total of 4 blocks would have constituted the 40-ft (12-m) length. Thus, more than 120 blocks were evaluated for each soil complex. The percentage of blocks in a location that were cracked, raised, or not failed was evaluated separately with and without trees. Thus, the tabular data would not be expected to total 100. For example, let us say that a location had 20 blocks. Ten blocks were in good condition, 7 were cracked, and 3 were raised. Two trees were present. One tree was adjacent to a good block and one was adjacent to a raised block. Then for that cell there would be 50% good blocks, 35% cracked, and 15% raised. Fifty percent of the blocks with a tree in that cell would be raised, and 50% would be adjacent to good blocks.

There were 16 samples per soil complex. A 1-way analysis of variance was used to compare differences among soil complexes.

RESULTS AND DISCUSSION

Repair History Study

Soils with slight limitations for use in road construction did have a better repair history than other soil complexes. Soils with slight limitations covered 3.7% of the city but required only 1.4% of the sidewalk repairs. Soils with slight limitations were not chosen for the survey of soil complexes because of the limited areas available for study.

The Urban-Martinsville soil complex had moderate limitations for road construction. Limitations were for low soil strength and high frost action. Despite the more favorable soils for local road construction, sidewalk repair history was poor. The Urban-Martinsville soil complex covered 4.7% of the city but required 10% of sidewalk repairs.

Although the Rossmoyne-Urban soil complex is the most common in Cincinnati, encompassing 22% of the land area, 30% of sidewalk repairs occurred on this soil complex. Rossmoyne-Urban, like Switzerland-Urban soil complexes, were common in more recently developed areas of the city. The Switzerland-Urban soil complex also presents severe limitations for road construction. Limitations were for low soil strength and high frost action. The Switzerland-Urban soil complex required 7% of sidewalk repairs in 5.5% of the land area for a moderate sidewalk repair record.

The Urban-Stonelick soil complex has severe limitation for road construction but had a good sidewalk repair history. Soil limitations were due to the possibility of flooding. The Urban-Stonelick soil complex covered 3.5% of the city's land area but required only 0.7% of the sidewalk repairs. This soil was originally chosen for its low frequency of repair. These soils were common in older areas developed around the turn of the century. Sidewalks were often quite old. Residents in the areas covered by the Urban-Stonelick soil complex tended to be renters rather than owners. The city had received few complaints regarding sidewalks in this area despite the fact that the sidewalks were in similar condition to those in other soil complexes.

Survey of 4 Soil Complexes

Percentage of blocks failed. Sidewalks are more likely to fail when constructed on soil complexes classified as having moderate or severe limitations (Table 1*). The absolute numbers of blocks falling into the various categories varied and are given in Table 2. The Rossmoyne-Urban soil complex with a 3% to 8% slope had the highest percentage of sidewalk failure in the sidewalk repair history study and the highest or second highest failure rate in the survey of 4 soil complexes (Tables 3, 4, and 5). The Urban-Stonelick soil complex also had high failure rates although they had not been reported to the city. This area was populated with renters who city officials feel are less likely to report sidewalk failures. Switzerland-Urban and the Urban-Martinsville soil complexes had fewer failures in the newer blocks. Switzerland-Urban soil complexes also had the fewest soil limitations (Table 1).

*Tables for this article begin on page 27.

Sidewalks more than 20 years old had a higher average failure percentage than sidewalks less than 20 years old, as could be expected. The sidewalk design used by the City of Cincinnati has an estimated 20- to 25-year service life. If tree roots were involved in the failure after this period of time, the sidewalk design would still be judged to be a success because the sidewalk functioned for longer than the designed time. Failure of a sidewalk after its design life has expired is a success, not a failure, when design time is considered.

The percentage of blocks, in all age categories, that had cracked and had trees adjacent to them was consistently less than the percentage of blocks that cracked without trees nearby (Tables 3, 4, and 5). Due to the variation in the study, the effects were not statistically different but were remarkably consistent—leading to the implication that planting trees protects sidewalks. More accurately, the data remind us that trees are not a major factor in determining sidewalk service life. The same effects were noted among blocks less than 20 years old as well as blocks greater than 20 years old. Locations in this study were chosen at random and not because a raised sidewalk existed next to a tree. This reflects a more accurate picture of sidewalk service life as influenced by trees than has been reported elsewhere.

Trees do not appear to be a major contributor to the failure of sidewalks during the design period. Even in older blocks, failures in blocks adjacent to trees was not higher than in blocks without trees. Table 2 shows that the chance of any single block being adjacent to a tree is less than 10%.

Percentage of blocks raised. In 3 of the 4 sampled soil complexes, sidewalk blocks of all ages were more likely to be raised where there are no trees than where trees are present. Only in the Urban-Martinsville soil complex were blocks raised more often, where there was a tree than where there was not a tree. It is interesting to note there were no raised blocks in the newer sidewalks associated with trees, yet some blocks were raised. Perhaps this reflects that time is required for roots to get large enough to begin to displace sidewalks and that tree roots take longer to disrupt sidewalks than sidewalks were designed to last (20 to 25 years).

The Urban-Martinsville and the Switzerland-Urban soil complexes had fewer raised blocks in blocks less than 20 years old than did the Rossmoyne-Urban and Urban-Stonelick soil complexes. Lower failure rates in these soil complexes suggest that there may be an effect of soil complex on sidewalk failure potential. Perhaps concentrating on blocks less than 20 years old would prove beneficial.

Trees certainly can displace sidewalks, but acknowledging this fact does not lead to the conclusion that trees are the principal reason for sidewalk failure. Science requires that we look at the problem without the bias of starting with a known problem. To gain insight into why sidewalk failures occur, we must instead start with an examination of the population of sidewalks in the city. Only then may we properly evaluate potential causes of sidewalk failure. When this was done in Cincinnati, many factors were identified for further consideration in sidewalk failure studies. For instance, sidewalk failures were similar with and without trees. Tree-related failures did not occur during the first 15 to 20 years. Sidewalk blocks that fail within the first twenty years may encourage root growth beneath the cracked blocks. Approximately 20 years ago, the city changed its sidewalk construction specification and sidewalks are no longer constructed on a compacted gravel or cinder base. Older sidewalks (50 years old and older) were thicker. Citizens in some areas seem to be less willing to ask for service from the city and tend not to report sidewalk failures. In this study, trees growing in lawn panels never damaged sidewalks, but trees growing in the tree lawns were associated with some sidewalk failures. In the final analysis, it appears likely that trees are a minor part of the sidewalk failure problem that plagues our cities.

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Résumé. Des trottoirs endommagés de Cincinnati en Ohio ont été comparés selon les types de sols dans la ville. Les sols avec un pourcentage de réparation plus élevé que leur pourcentage de couverture ont été identifiés. Historiquement, les sols de type Stonelick avaient une bonne fréquence de réparation, ceux de type Switzerland avaient une fréquence modérée et ceux des types Rossmoyne et Martinsville une fréquence faible lorsqu'ils étaient comparés aux données des autres types de sols dans la ville. Les inventaires de sols ont classés les sols Switzerland avec des contraintes modérées pour la construction routière et les autres types de sols avec contraintes sévères. Ces quatre types de sols ont été sélectionnés et leurs trottoirs inspectés de façon aléatoire afin de déterminer le taux de dommages aux trottoirs. Les trottoirs ne se sont pas affaissés de façon importante lorsque des arbres étaient présents. Les trottoirs âgés de plus de 20 ans s'affaissaient en général d'un pourcentage plus élevé. Les trottoirs de moins de 20 ans sur les sols Switzerland et Martinsville apparaissaient plus stables et moins sujets à se briser que ceux sur les sols Rossmoyne et Stonelick. Les trottoirs de moins de cinq ans n'étaient pas affectés par les arbres dans aucun des types de sol. Une variété de problèmes ont été identifiés comme étant impliqués dans les bris de trottoirs. Il apparat que les arbres jouent un rôle mineur dans la diminution de la durée de vie d'un trottoir. L'augmentation de la durée de vie des trottoirs va exiger la coopération des forestiers urbains, des architectes paysagistes et des ingénieurs.

Zusammenfassung. In Cincinnati, Ohio, wurden in der Stadt Vergleiche angestellt zwischen defekten Bürgersteigen und verschiedenen Bodenkomplexen. Es wurden Böden identifiziert, deren Anteil an Reparaturarbeiten höher war als der Anteil an Bodenbedeckung. Der Urban Stonelick Bodenkomplex hatte eine niedrige Frequenz bei den Reparaturaufzeichnungen. Der Switzerland-Urban Bodenkomplex hatte eine mittlere Frequenz, während die Bodenkomplexe Rossmoyne-Urban und Urban-Martinsville im Verlgleich mit allen anderen Böden in der stadt sehr häufig repariert werden mußten. Die bodenkundlichen Erhebungen kategorisierten den Switzerland-Urban Bodenkomplex mit einigen Einschränkungen als geeignet für Strassenbauarbeiten und die anderen mit erheblichen Einschränkungen als tauglich. Die vier Bodengruppen wurden selektiert und die angegliederten Gehwegabschnitte stichprobenartig untersucht, um auftretende Schäden festzuhalten. Die Bürger-steige mit integriertem Baumbestand hatten keine höhere Schädigungsrate. Bürgersteige mit einem Alter über 20 Jahre waren zu einem größeren Anteil geschädigt. Bürgersteige in dem Bereich von Switzerland-Urban und Urban-Martinsville Bodenkomplexen, die jünger als 20 Jahre waren, erschienen weniger anfällig als Rossmoyne-Urban und Urban-Stonelick Bodenkomplexe. Weniger als fünf jahre alte Bürgersteige wurden nirgends durch Bäume zerstört. Es wurde eine ganze Reihe von Problemen identifiziert, die für die Schäden an Gehwegen verantwortlich zu machen sind. Es scheint, daß Bäume eine untergeordnete Rolle dabei spielen. Eine Ausdehnung der Pflege und des erhalts von Gehwegen erfordert eine Zusammenarbeit von Baumpflegern, Architekten und Ingenieuren.

Resumen. Se compararon diferentes tipos de suelos con las banquetas defectuosas en Cincinnati, Ohio. Fueron identificados los suelos con un porcentaje de reparación mayor que el porcentaje de suelo cubierto. Los suelos Stonelick tuvieron una buena frecuencia de reparación, Switzerland tuvo un registro moderado, y Rossmoyne y Martinsville tuvieron registros pobres comparados con los de otros tipos de suelos en la ciudad. Los estudios de suelos dieron a los suelos Switzerland limitaciones moderadas para construcción de carreteras y limitaciones severas a los demás tipos de suelos. Los cuatro tipos de suelos fueron seleccion-ados y asociados con banquetas y fueron aleatoriamente estudiados para determinar las frecuencias de las fallas de las banquetas. Donde los árboles estuvieron presentes las aceras no alcanzaron las frecuencias de daño más altas. Las banquetas de más de 20 años de antigüedad fallaron en un alto porcentaje. Las aceras menores de 20 años en suelos Switzerland y Martinsville parecen los más estables y menos propensas a fallar que los suelos Rossmoyne y Stonelick. Las baquetas con menos de 5 años no fueron afectadas por los árboles en cualquier tipo de suelo. Se identificaron una variedad de problemas envueltos en la falla de las aceras. Parece que los árboles juegan un papel menor en la reducción del servicio de las banquetas. La extensión de la vida útil de las banquetas requerirá la cooperación de dasónomos urbanos, arquitectos del paisaje e ingenieros.

Table 1. A comparison of percentage of soil cover to percentage of sidewalk repairs, arranged by soil limitations and soil complex. Sidewalk repairs were made during the 1992–1996 time period. Soil limitations relate to the soil's ability to support road construction.

Soil complex and limitations	Area (ft²)	Number of sidewalk repairs	Soil cover (%)	Sidewalk repairs (%)
Soil limitations: slight				
Urban Elkinsville soil complex	42,135,094	58	1.11	0.99
Wea silt loam	78,737,883	1	2.14	0.02
Parke-Urban soil complex	13,705,399	24	0.37	0.41
Slight subtotal	*134,578,376*	*83*	*3.67*	*1.41*
Soil limitations: moderate				
Parke-Urban soil complex C	2,601,657	1	0.07	0.02
Genesee Urban soil complex	58,646,694	8	1.6	0.14
Switzerland-Urban soil complex C	14,909,674	2	0.41	0.03
Switzerland-Urban soil complex B	10,444,423	21	0.28	0.36
Urban Huntington soil complex	158,158,189	236	4.32	4.01
Urban Elkinsville soil complex	28,620,694	237	0.78	4.03
Switzerland-Urban soil complex C	201,745,823	409	5.5	6.95
Moderate subtotal	*475,127,154*	*914*	*12.96*	*15.54*
Soil limitations: severe				
Ava-Urban soil complex	263,386,633	320	7.19	5.44
Rossmoyne silt loam	7,102,460	1	0.19	0.02
Rossmoyne-Urban soil complex A	113,075,843	496	3.09	8.43
Rossmoyne-Urban soil complex B	825,707,281	1762	22.53	29.96
Urban Martinsville soil complex B	172,690,899	630	4.71	10.71
Rossmoyne-Urban soil complex C	266,489,107	712	7.27	12.11
Pate-Urban soil complex	92,379,431	144	2.52	2.46
Urban-Martinsville soil complex C	14,701,659	17	0.40	0.29
Urban-Rossmoyne soil complex B	90,477,864	59	2.47	1.00
Urban-Stonelick soil complex	130,464,900	40	3.56	0.68
Ava-Urban soil complex C	32,035,182	4	0.87	0.07
Princeton sandy loam B	1,466,949	1	0.04	0.03
Pate silty loam D	13,617,693	20	0.37	0.34
Eden flaggy loam F	201,676,625	116	5.50	1.97
Avonburg-Urban soil complex A	17,945,115	5	0.49	0.09
Bonnell silt loam D	45,076,988	22	1.23	0.37
Bonnell silt loam E	73,135,726	11	2.00	0.19
Eden silty clay loam D	25,174,122	54	0.69	0.92
Eden silty clay loam E	326,013,816	86	8.89	1.46
Wakeland silt loam	5,472,070	2	0.15	0.03
Eden-Urban soil complex D	95,529,110	149	2.61	2.53
Eldean-Urban soil complex B	31,555,321	27	0.86	0.46
Eldean-Urban soil complex A	25,470,520	51	0.69	0.87
Severe subtotal	*2,870,645,314*	*4729*	*78.32*	*80.41*
Other	184,905,179	155	5.04	2.64
Grand total	***3,665,256,023***	***5,881***	***100***	***100***

Table 2. The number of blocks studied in various age categories and various soil types.

Soil complex/ block age	Total blocks studied	Total block failures	Blocks with trees	Blocks without trees	Blocks with trees failed	Blocks without trees failed	Blocks raised with trees	Blocks raised without trees
Rossmoyne								
0–5 yrs	35	4	0	35	0	4	0	4
5–20 yrs	67	12	2	65	0	12	0	10
20+ yrs	196	67	5	191	2	65	1	42
All ages	*298*	*83*	*7*	*291*	*2*	*81*	*1*	*56*
Stonelick								
0–5 yrs	17	2	0	15	0	2	0	1
5–20 yrs	61	16	1	60	0	16	0	12
20+ yrs	199	70	7	194	1	69	0	20
All ages	*277*	*88*	*8*	*269*	*1*	*87*	*0*	*33*
Switzerland								
0–5 yrs	20	0	2	18	0	0	0	0
5–20 yrs	24	5	3	21	0	4	0	3
20+ yrs	228	77	17	211	4	73	1	18
All ages	*272*	*82*	*22*	*250*	*4*	*77*	*1*	*21*
Martinsville								
0–5 yrs	2	0	0	2	0	0	0	0
5–20 yrs	24	2	3	21	0	2	0	1
20+ yrs	261	34	8	253	1	33	1	7
All ages	*287*	*36*	*11*	*276*	*1*	*35*	*1*	*8*
Grand total	***1134***	***289***	***48***	***1086***	***8***	***280***	***3***	***118***

Table 3. Failures of sidewalk blocks less than 20 years old in 16 samples of 4 soil complexes. Samples are approximately 80 ft (24.4 m) long. Percentages in the table are the average of the percentage of the blocks that were less than 20 years old in each category for each sample.

Soil complex	Blocks failed with trees (%)	Blocks failed without trees (%)	Blocks raised with trees (%)	Blocks raised without trees (%)
Rossmoyne-Urban	0	11.7	0	10.4
Urban-Stonelick	0	22.2	0	14.1
Switzerland-Urban	0	9.1	0	7.7
Urban-Martinsville	0	7.6	0	2.9

Table 4. Failures of sidewalk blocks more than 20 years old in 16 samples of 4 soil complexes. Samples are approximately 80 ft (24.4 m) long. Percentages in the table are the average of the percentage of the blocks that were older than 20 years old in each category for each sample.

Soil complex	Blocks failed with trees (%)	Blocks failed without trees (%)	Blocks raised with trees (%)	Blocks raised without trees (%)
Rossmoyne-Urban	33.3	42.3	16.7	25.6
Urban-Stonelick	16.7	37.7	0	11.6
Switzerland-Urban	18.5	34.8	5.5	8.7
Urban-Martinsville	16.7	11.9	16.7	2.5

Table 5. A failure of sidewalk blocks of all ages in 16 samples of 4 soil complexes. Samples are approximately 80 ft (24.4 m) long. Percentages in the table are the average of the percentage of the blocks that were of any age in each category for each sample.

Soil complex	Blocks failed with trees (%)	Blocks failed without trees (%)	Blocks raised with trees (%)	Blocks raised without trees (%)
Rossmoyne-Urban	25.0	27.4	16.7	19.1
Urban-Stonelick	16.7	32.6	0	11.8
Switzerland-Urban	15.0	31.3	5.0	8.8
Urban-Martinsville	12.5	12.6	12.5	3.3