WALKWAY SAFETY

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Walkway Safety: An Overview

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ABSTRACT: At the 1995 American Academy of Forensic Sciences meeting in Seattle, Washington, the Engineering Science section hosted two program sessions on walkway safety. Of the dozen papers presented at that meeting, five papers were distilled into four of the six papers, technical reports, and case reports which follow in this journal. The two other papers were first submitted to the *Journal of Forensic Sciences,* and later abstracted and presented at the walkway-safety track in the Engineering Science section of the 1996 American Academy of Forensic Sciences meeting in Nashville, Tennessee. Together, the six papers that follow this introduction should give the reader an understanding of many of the major issues in walkway safety.

KEYWORDS: forensic science, engineering, walkway safety, fall accidents

Walkway safety is big business! Fall-generated injury vies with vehicular and gunshot injury for first place in the total-cost-to-society contest. For example, guns and vehicles have a higher mortality cost for the young, but falls have the highest mortality cost for seniors. The workman's compensation costs to industry and insurance have been described by those who have studied the problem as "tremendous"; in many industries, fall accidents are the leading generator of workman's compensation costs. Fall accidents are the leading generator of workman's compensation costs. Fall accidents are a significant generator of civil litigation and associated litigation costs.

On the other hand, the prevalent attitude today towards walkway safety: "*Watch where you walk, Dummy!*" is akin to the pre-1960s *nut-behind-the-wheel* attitude that pooh-poohed systematic efforts to minimize vehicular carnage. For those too young or old to remember, it was thought in the pre-seatbelt era that car accidents, because they occurred as isolated, low-probability events, would not be amenable to systematic attempts to minimize accident frequency and harm. In those good-old days, only sissies wanted seatbelts. And in those good-old days, head-on impacts often resulted in the steering column dealing mortal injury to the driver. Today, and for the past generation, steering columns absorb collision energy, mitigating injury, rather than causing it. Steering columns are now not solely designed to let the driver move the car's front wheels; rather, they are designed as an element of the vehicular subsystem that helps minimize injury in the event of an accident. Similarly, the attitude that suggests that shoe soles may be more than something which prevents your socks from wearing out on the concrete, that floor surfaces are for more than keeping you from falling down to the floor below—a systematic approach to minimizing walkway accidents—is today not well established. It is not generally seen that a systematic approach to the minimization of walkway accidents would benefit society in the same manner that the systematic approach to the minimization of harm from vehicular accidents has benefited us.

Both issues and attitudes slow progress towards safer walkways. Some examples make this clear:

- Many falls occur in commercial kitchens and food preparation areas. There is an intractable tradeoff between fall prevention and hygiene: the more texture built into the floor, the less slippery the floor will be, but the harder it is to clean that floor. (Because health inspectors will cite a facility if the floor is not squeaky clean, but there are no floor-safety inspectors to cite the facility if the floor is slippery, material selection and maintenance often gives floor slipperiness short shrift.)
- Many falls occur on stairs, especially stairs in homes. It is well known that optimal stair geometry and strict maintenance of step-to-step uniformity will minimize stair accidents. The home-building industry objects to codes further restricting stair geometry because those code provisions which would ensure safer stairs would also slightly reduce the *useable area* of the home. Further, step-to-step uniformity requires construction practices closer to cabinetmaking than house framing.
- A subtle factor complicating the acceptance of a systematic approach to the minimization of fall-accident harm is the fact that some incorrectly consider the issues underpinning walkway safety somewhere between trivial and relatively simple: no need is seen for any systematic approach. What constitutes optimal stair geometry, e.g., has been known for centuries.

Again, thirty or forty years ago, many felt that automotive safety issues were trivial. Those who thought that automotive safety was simple—or who thought that there were no real benefits attainable through a systematic approach—were proven incorrect. I expect that, over time, those who think similar thoughts about walkway safety, will also be proven wrong. Of course, simply asserting that naysayers will be proven wrong is a lot easier than actually proving them wrong. To justify many of the rules and standards imposed upon the vehicular industry, a significant body of research had to

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be accomplished. Research in walkway safety is at a progress point not unlike the point where automotive safety research was thirty-or-more years ago. Much more research needs to be conducted. There has been, e.g., significant research in the areas of gait dynamics and in non-Amontons-Coulomb friction, but relatively little research has been accomplished in the area of walkway safety that lies at the intersection of these areas.

Discussion

The six papers that comprise the Walkway Safety portion of this issue of the *Journal of Forensic Sciences* were presented either at the 1995 or the 1996 Annual Meetings of the American Academy of Forensic Sciences. Together, these papers provide a fair indication of the direction that the field of walkway safety is taking.

First, more work is needed to characterize fully the cost of fall accidents to society, to the business community, and the utility to society of any proposed standards or regulations.[2] Englander, Hodson, and Terragrossa's paper in this journal summarizes research that explores the cost of fall accidents, extrapolates that cost into the future, and develops a cost-benefit framework within which proposed remedial measures can be evaluated.

It is an occasionally disputed tenet in walkway safety that if the *available* friction—a function of the walking surface, the footwear, and the condition of the interface between the floor and the shoe—exceeds the *utilized* friction, a pedestrian will not slip. Much of the standards development work in the walkway-safety area today is concerned with establishing test methods to guarantee repeatability in measuring the available friction: the specification of tribometric (friction-measuring) instruments, standard test feet and test surfaces, standard test designs, methods of test-foot and test surface preparation, and so forth. (A portion of the Marpet and Brungraber paper in this journal is devoted to experiments which characterize test-foot changes as a result of sliding. This is an important issue underpinning any test-foot preparation standard.)

To date, there are few standards that specify acceptance thresholds: friction values below which a candidate material will fail (and conversely, at or above which a candidate material will not fail). The ASTM Test Method for Static Coefficient of Friction of Polish-Coated Floor Surfaces as Measured by the James Machine (D 2047) allows a floor polish to be considered slip resistant if the available friction determined by a carefully specified test using a James tribometer meets or exceeds a 0.5 threshold. The regulations promulgated by the government as a result of the Americans with Disabilities Act (ADA) mandates a 0.6 acceptance threshold for level surfaces, but is equivocal as to what test to use. In general, the connection between any available-friction acceptance threshold and the friction utilized in a given activity is hard to establish because available and utilized friction are measured in fundamentally different ways. Safety specialists and forensic engineers need to consider, given the present state of the art, what constitutes a slippery or not slippery floor. My paper "*On Threshold Values . . .*" discusses these issues in some detail. I have tried to look at the differing views and give general recommendations about how to set thresholds. It should be clear that this portion of the road to safe walkways is still *under construction.*

Also under construction is the research needed to underpin the development of new tribometers and tribometric test methods. Medoff's paper on the viscoelastic characteristics of tribometric-test materials looks at the relationship between loading rate and tensile strength. Marpet and Brungraber's paper on contact pressure explores the relationship between contact pressure and the coefficient of friction. (The latter relationship is often bandied about in spurious advertising claims for tribometric test equipment.)

Finally, two papers, one by Sacher and the other by Sloane, look at the forensic biomechanics aspects of falling, albeit from rather different perspectives. Sacher shows how the litigation record can give insight into fall mechanics. Sloane shows how one can use a physics simulation program to gain insight into the mechanics of various falls. (Interestingly, I recently got a copy of the newest version of the computer program that Sloane used; its publisher used Sloane's work to show the modeling capability of the package.)

There has been, over the years, only a small contribution to the *Journal of Forensic Sciences* by members of the Engineering Science section of the academy. These papers will put a dent in that dearth. In walkway safety, lots of research still needs to be accomplished. Hopefully, some of that future research will also find its way into this journal. If you are interested in walkway safety, I recommend that you attend a meeting of the ASTM Committee F-13 on Safety and Traction for Footwear. That group seems to be the catalyst for much of what is happening in the field; the ASTM Committee F-13 on Safety and Traction for Footwear has, in the last five years, conducted two research workshops; the results of these workshops are beginning to appear in the literature.

Conclusion

With any luck and a lot of work, a decade from now—or a generation from now—we will be able to see declines in the harm generated by fall accidents. Again, the analogy to the auto industry seems apt. Not only has the conformance to safety standards put the fatality rate per mile driven on a long decline, but the discipline imposed upon designers by safety and economy standards have been responsible for what appears—at least to me—to be another golden age in the design of automobiles.

[2]To date, to my knowledge, there have been only three regulations promulgated to minimize the probability of fall accidents: the Consumer Product Safety Commission rules on bathtub-surface friction, the Federal Trade Commission Regulations on labeling floor polishes as slip resistant, and the ADA. There are also a number of standard test methods promulgated by the American Society for Testing and Materials (ASTM) and others covering friction testing for various polishes, floors, bathtub surfaces, and shoe-bottom materials.

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