The Elimination of Unsafe Guardrails—A Progress Report

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Since 1988, ***Mr. Stephenson*** *has reported on the results of his extensive investigations of the dimensions of the head breadths and chest depths of young children. These efforts led to the revision of the* Uniform Building Code™ *(U.B.C.) at ICBO's 67th Annual Conference in Palm Desert, California. His article "The Silent and Inviting Trap" appeared in the January-February, 1989, issue of* Building Standards, *with additional information provided in the March-April, 1989, issue. Section 1712 (a) of the 1991 edition of the U.B.C. limits the size of openings of guardrails used on balconies, landings and open stairways to a maximum of 4 inches.*

In addition to sharing this research with Building Standards *readers, he has traveled throughout the world in an effort to circulate the facts presented in his articles to building officials and building code authorities. The following report provides an update on this issue and reflects the need for energetic, productive and democratic organizations such as ICBO.*

Mr. Stephenson was named a 1990 Marksman by Engineering News-Record, *the McGraw-Hill construction weekly, for his significant achievements in limiting the size of openings between guardrails.*

The views expressed here are those of the author and do not necessarily reflect the opinion or agreement of the International Conference of Building Officials.

Since the publication of the article "The Silent and Inviting Trap" by the International Conference of Building Officials, Building Officials and Code Administrators International (BOCA), and the Southern Building Code Congress International (SBCCI) during late 1989 and early 1990, substantial progress has been made in the following important areas:

1. All but one of the model building codes and standards applicable to new construction within the United States have been revised to reduce to 4 inches the previously allowed 6-inch-wide openings in guardrails and balustrades. Those codes and standards include the following editions:

1990 *BOCA National Building Code*

1991 *CABO One and Two Family Dwelling Code*

1991 *Uniform Building Code,* ICBO

1991 *Life Safety Code®*, NFPA

In addition, the *BOCA National Building Code* now includes provisions which require the consideration of climbability in the design of guardrails.

2. The planned or actual modification of existing unsafe guardrails at numerous locations has been completed. For example, at the suggestion of David A. Bassett, building safety director, City of Medford, Oregon, and a past chairman of ICBO, the Department of Lands and Natural Resources of the State of Hawaii promptly acted to improve guardrail safety on a pedestrian trail bridge leading to the IAO Needle on the island of Maui. Mr. Bassett cited the facts reported in "The Silent and Inviting Trap" in his communication with the Hawaiian authorities.

3. Building codes enforced in several other countries of the world have been or are being modified to limit allowable openings in guardrails to a maximum width of 100 millimeters (mm) (3.92 inches) instead of a previously permitted 150 mm (almost 6 inches). Examples include the *National Building Code of New Zealand,* the national building codes of the Fijian Islands, those of five other South Pacific islands and the Building Code of the Republic of Singapore.

Joan Greenwalt of Sun City West, Arizona, is shown here beside one of the modified bridge guardrails on a pedestrian bridge on the island of Maui, Hawaii. Wire mesh has been added at the large openings.

My article, which was distributed in more than 20,000 copies to virtually every building official in the United States, clearly proved the following:

- That almost every child six years in age and younger can pass completely through an opening 6 inches in width.
- That approximately 95 percent of all children 18 months old can pass completely through an opening $5^1/_2$ inches in width.
- That approximately one half of all children 13 to 18 months in age can pass completely through an opening 5 inches in width.
- That virtually no child one year old or older can pass completely through an opening 4 inches in width.

Special Four-sided Guardrail Assembly Constructed

The series of four separate guardrail patterns shown in the photographs in this article were designed to provide a means of comparing the level of safety they provide against children trying to pass through or climb over them. The captions describe the purpose of each of the four different sides of the assembly. The ages of the 35 children involved in the testing of these four guardrail designs ranged from 18 months to six years.

Children Can Slip between Widely Spaced Horizontal Rails

Some have argued that guardrails with horizontal rails having 6-inch-high openings between them are safer or are just as safe as guardrails with horizontal rails only 4 inches apart. The arguments presented were that the larger spacings are more difficult to climb and will stop children from "walking" through them. Two different types of tests were conducted to evaluate those arguments. The children were asked to climb two guardrails, one with horizontal rails 6 inches apart and the other with rails 4 inches apart. *With the exception of the 18-month-olds, the children climbed the guardrail having the rails 6 inches apart more easily and more quickly than the one having the horizontal rails 4 inches apart.* Even the two-year-olds were able to easily climb the guardrail with the 6-inch spaces.

The most important finding, however, was that in every instance each child in each age group could easily slip between the horizontal rails spaced 6 inches apart, but none could slip between those spaced 4 inches apart. The demonstration clearly proved that it is improper to assume that guardrails with a series of widely spaced horizontal rails will provide adequate safety for young children. See accompanying photograph for an illustration of a child readily slipping between such rails, spaced 6 inches apart.

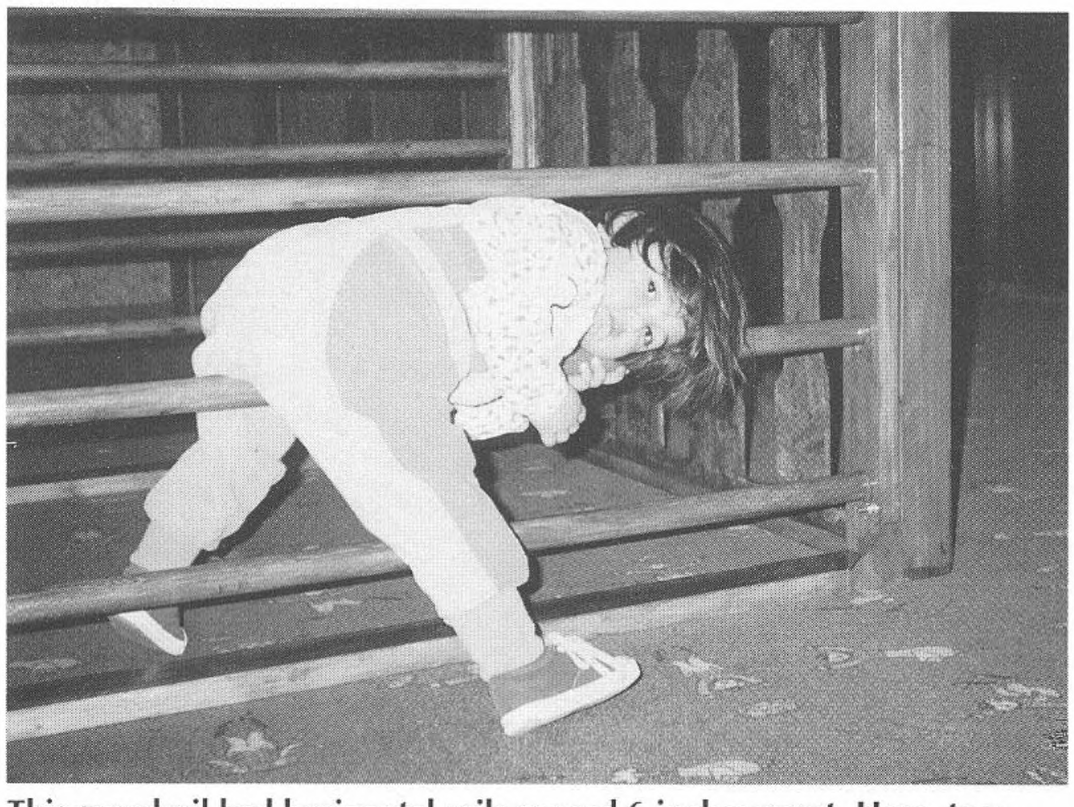
Regardless of the spacing, horizontal rails should not be accepted as providing adequate safety. Children will climb any guardrail design that offers a toehold, and horizontal rails certainly do.

Climbability of Guardrails Is an Important Problem

Much still needs to be done to properly address the climbability of guardrails in our building codes. However, some important progress has been made. The 1990 *BOCA National Building Code* now contains the following provision: "Guards shall not have an ornamental pattern that would provide a ladder effect."

The *National Building Code of New Zealand,* in addition to now including a 100-mm (3.92 inches) opening width limitation, contains the following:

> In any building likely to be used by children under the age of 6 years, an acceptable barrier has no components between the two heights of 150 mm (about 6 inches) and



This guardrail had horizontal rails spaced 6 inches apart. Here, two-year-old Stephanie demonstrated how easily she could slip between the rails. All children participating in the demonstration could do the same.

Two-year-old Bridget had no difficulty climbing the guardrail with horizontal rails spaced 6 inches apart.

This side of the guardrail demonstration assembly had vertical rails with clear spacings of 6, $5^1/_2$, 5 and 4 inches. All children participating in the demonstration easily passed through the 6-inch-wide openings. Here, six-year-old Bobby showed his ability to negotiate the $5^1/_2$-inch-wide openings without difficulty.

> 760 mm (about 30 inches) above floor level or stair nosings which can provide a toehold.

The *National Building Code of Australia* includes the following provision: "A required balustrade must prevent as far as practicable children climbing over or through it."

And the Building Code of the City of Tucson, Arizona, was revised January 1989 to include the following:

> Open guardrails and stair railings shall have intermediate vertical rails or be of solid material such that a sphere 4 inches in diameter cannot pass through. Such guardrails and stair railings shall have no horizontal rails or ornamental pattern which could provide a ladder effect to defeat the purpose of the guardrail.

James R. Singleton, building code administrator for the Development Services Department, City of Tucson, noted that his department has experienced no significant problems in enforcing the City of Tucson guardrail design provisions. He believes it is "essential to have guardrails that truly provide safety for young children at elevated locations accessible to them, not only within buildings but elsewhere at locations at which they may be subject to falls that can cause serious injury or death."

The 1991 NFPA *Life Safety Code* includes the following recommendation as a supplement to its provision limiting openings in guardrails to a width of 4 inches: "Vertical intermediate rails are preferred to reduce climbability."

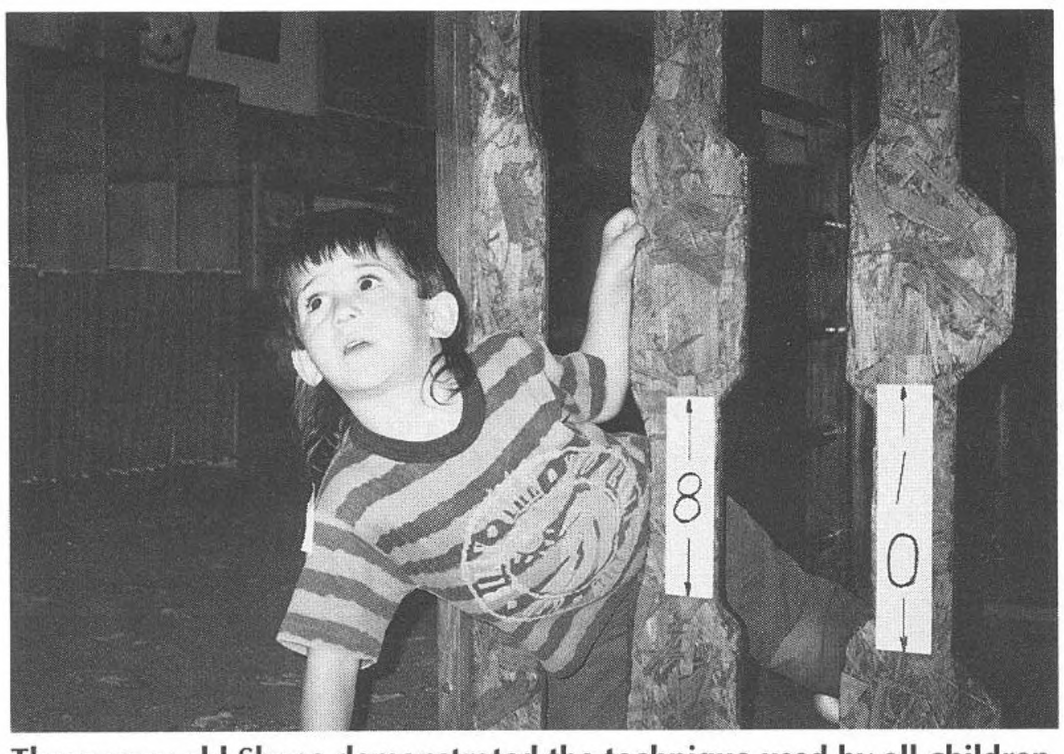
It is abundantly clear that either solid guardrails or those having vertical rails spaced 4 inches or less apart are superior to those of any other design in providing safety for young children. This applies equally to guardrails on balconies and elevated decks and porches, at the open sides of stairways and landings, and at pedestrian bridges and other elevated locations used by the public.

Contoured Openings May Also Be a Hazard

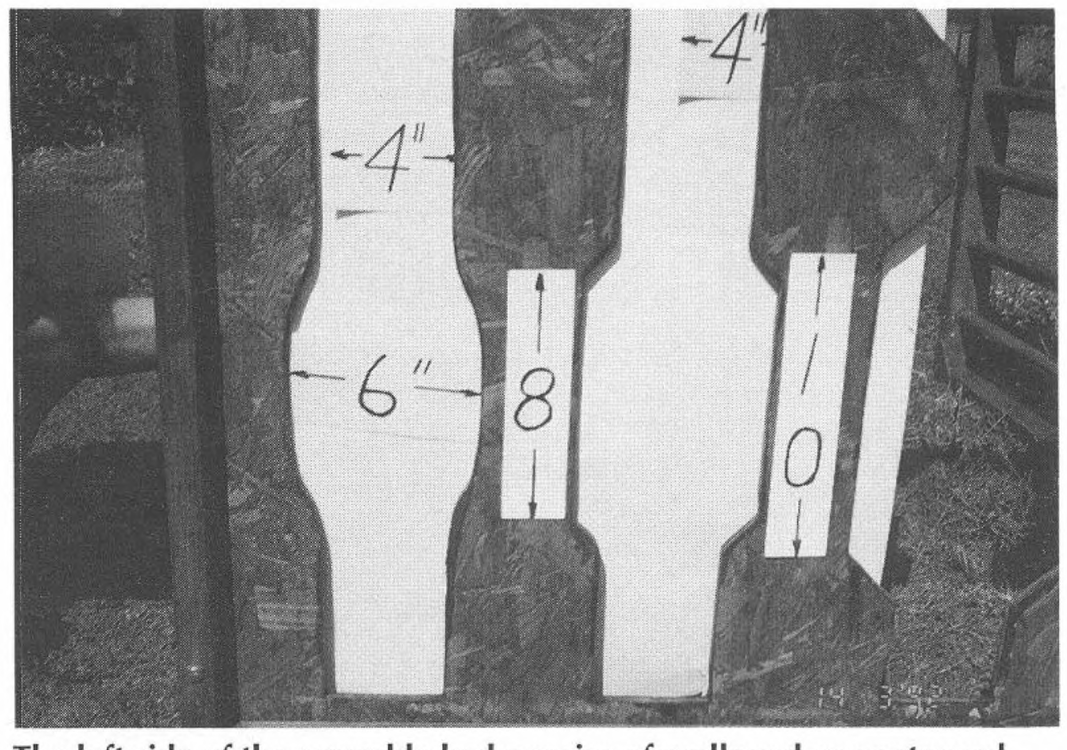
The special guardrail assembly also included a guardrail with openings of various dimensions as shown in the photograph. The test demonstrated that every child in each age group could easily pass completely through each of the four sizes of openings, including the smallest one shown at the left. One of the photographs shows a child climbing through the scalloped opening that has a width of 6 inches and a height of 8 inches. All children six years in age and younger could easily pass through this smallest opening.

All of the children first put their heads through the larger portion of the opening and then, by turning their bodies 90 degrees, were able to slip their shoulders through the 4-inch-wide spaces at the top or bottom of the 6-inch by 8-inch opening. Once this ability was determined, it was obvious that all openings in the side of the guardrail assembly would not provide an acceptable level of safety. The actual dimensions of small, irregular openings which children of crawling or toddler age can pass completely through should be investigated thoroughly. Only with the results of such data will we be able to determine what limits should be established by regulatory agencies. It appears that dimensions of $4^1/_2$ by 8 inches may be adequate to ensure safety for young children, but such limitations have not yet been fully investigated.

Positive proof that an opening of $5^1/_2$ by 11 inches does not provide safety is given by what happened to 18-month-old Tara Nicole



Three-year-old Shane demonstrated the technique used by all children to pass through the 6-inch-wide, 8-inch-high opening. By turning his body 90 degrees after placing his head through the opening, he was able to slip his shoulders through the 4-inch-wide openings above and below the scalloped 6- by 8-inch opening.



The left side of the assembly had a series of scalloped or contoured openings intended to provide a way to demonstrate a young child's ability to climb through such openings in guardrails. All children in the demonstration easily climbed through the smallest opening shown at the left side of this close-up of two of the contoured openings.

The star of the demonstration, 18-month-old Janelle showed how she could easily pass completely through the 5-inch opening. Approximately one half of all children 13 to 18 months old can pass completely through a 5-inch-wide opening as shown.

Schmidt. On September 24, 1989, Tara drowned in the family swimming pool in Tucson after crawling through an opening $5^1/_2$ inches high and 11 inches long at the bottom of a fence separating the pool from an adjacent play area. Her parents had been erroneously assured by the building contractor that the fence was safe and conformed to the existing codes. Part of the $300,000 out-of-court settlement of the case is currently being used by Tara Nicole's parents to help fund the activities of the Tucson Drowning Prevention Committee and to provide a memorial scholarship in her name at the University of Arizona.

Wide Openings between Guardrail Verticals Proven Unsafe

As expected, every child in the demonstration quickly walked through the openings that had a clear width of 6 inches, and few children had any difficulty passing between those spaced $5^1/_2$ inches apart, a common dimension that occurs when verticals are installed on 6-inch centers. An 18-month-old child is shown passing through the 5-inch-wide opening. None of the children in the demonstration could pass completely through the 4-inch-wide opening. The demonstration clearly proved that a limitation of 4 inches is needed if young children are to be prevented from walking or climbing through such openings between vertical rails in guardrails.

Action Is Needed to Modify Existing Unsafe Guardrails

Not only is there a need to further improve our building codes and standards to include better provisions related to opening sizes and climbability, but attention also needs to be given to the modification of the literally tens of thousands of existing unsafe guardrails in our homes, hotels, motels, apartment houses, schools, shopping centers, and other buildings and structures to which the public has access. Much can be done toward this end by alerting parents, newspaper editors, building owners, insurance underwriters and others to the hazards of unsafe guardrails wherever they currently exist.

In some cases, temporary action can be taken by a family renting living quarters from a building owner who refuses to modify the unsafe guardrails in the rented home or apartment. Specially designed kits for applying a flexible screen to the framework of an existing guardrail are now available on the market. Renters can also purchase screening, plywood panels or an equivalent from local sources and fasten them to existing unsafe guardrails on a temporary basis.

Around-the-World Travel to Investigate Building Codes

During the 12-month period from September 1989 to September 1990, I traveled more than 50,000 miles visiting 20 different countries and dozens of major cities and states. In each location I met with the building control authorities, including federal, state and municipal officials, to discuss their building code provisions. In every instance, those officials were friendly, helpful and interested in learning about the promulgation and enforcement of building codes and standards in the United States.

These discussions clearly show that building officials everywhere are concerned about the design of guardrails that are accessible to young children. Most of these officials believed that their existing regulations, most of which permitted openings to be 150 mm in width (about 6 inches) warranted revision. I, of course, urged that their codes be revised to limit such openings to 100 mm as soon as possible, and I can now report that the codes of several of those jurisdictions have already been revised to include the 100-mm limitation as a direct result of my efforts. In other countries, committees are now reviewing the problem, and many will ultimately conclude that the 100-mm limitation is appropriate and necessary.

Summary of the Demonstration Results

The following is abundantly clear:

1. Openings of 6, $5^1/_2$ or 5 inches between vertical rails in guardrails will not provide safety for young children.
2. Horizontal rails spaced 6 inches apart provide absolutely no degree of safety for young children. Horizontal rails spaced 4 inches apart can also be easily climbed and should not be used.
3. Special attention needs to be given to the limitation on the size of scalloped, turned or contoured openings within a guardrail. Additional detailed study should be given to the problem. ■