Safety Alert: Study Reveals Sharp Increase in Deck Failures

A landmark study reveals that there have been 179 reported deck collapses from January 2000 through November 2006, killing 33 and injuring 1,122.

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In September 2006, a particularly violent deck collapse occurred. What made this collapse so frightening was it was caused by surprisingly little impetus. The potential purchasers, a family of five, were doing a final walkthrough on a single-family house in a quiet, older subdivision in Lawrenceville, Georgia. The house was situated on a lot that sloped away from the street. The back sliding door was about 12' above grade. There was a well built and well maintained 12' by 15' deck out the sliding door, overlooking a wooded backyard. When the husband, wife, and two of their teenage children stepped out onto the deck, it pulled off the house… but it did not just fall down.

As the deck pulled away, the house side of the deck swung underneath, struck the support columns, and landed upside down in roughly the same location. The family fell to the ground and the deck landed upside down on top of them. They were trapped underneath the deck, injured and traumatized. Emergency services were called and the family was transported to the hospital. Fortunately, the deck's guardrail acted like a roll bar and held the deck off the ground, preventing the victims from being crushed.

Why did this happen? How could a solidly built structure just detach and collapse? While the deck itself was structurally sound, the connection of the deck to the house was not. When the people out walked onto the deck and then stopped, their momentum was transferred to the fasteners that held the deck to the house. That little bit of movement was just enough to overcome the friction holding the fasteners in the house rim joist. The deck simply pulled away from the house.

Since the deck was built to the standards prescribed by national building code, it was to be capable of accommodating the weight of 48 people, but it only took four to bring it down. Why?

Scope of the problem

There is no reliable source for statistics on how many decks are in the United States, how many decks are being built annually, or by whom. Several indirect approaches were used to generate reasonable estimates relating to deck construction and the number of decks there are in the United States. Information was collected referencing housing starts, home design trends, and the do-it-yourself market.

Home Builders

Growth of the decking industry is partly driven by sales of new homes. The National Association of Home Builders (NAHB) estimated housing starts in 2006 reached nearly 2 million units[1]. According to the NAHB, decks are included in nearly a third of all new houses being built today[2]. This translates into approximately 600,000 decks included as new home options in 2006. This number does not include new decks installed on older homes, or renovations of older decks.

Deck Builders

The North American Deck and Rail Association (NADRA) estimates the annual retail installed value of deck components and accessories in the United States to have been between $9 and $10 billion in 2005[3], and sees no evidence of sales slowing down in the coming years. In fact, NADRA was started in response to this terrific growth. Based on a 2005 survey performed by national retailers, the average cost of a deck is approximately $11,300[4]. Using these estimates (annual retail value and average cost of a deck), 800,000 decks were constructed in 2005 alone.

Homeowners

Deck construction appears to be simple and straight forward, and many homeowners undertake the project themselves. With readily available calculators, guides, and pre-made construction plans, it is easy to see why deck building has become one of the most common 'do-it-yourself' projects. Although this group makes a significant impact on the decking market, there was no apparent way to quantify its contribution.

House Design Influence

In 2005, more than 60% of all new homes either came with a deck, or incorporated the opportunity for future outdoor living space[5]. While some homeowners may choose to delay the construction of a deck, the layout of the house includes, and anticipates, this future addition.

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[1] Erica Filipek, Raemeka Mayo, "U.S. Census Bureau News Joint Release", U.S. Census Bureau, December 2006, 29, Dec. 2006 <http://www.census.gov/indicator/www/newresconst.pdf>

[2] Curtis Rist, "Building a Safe Deck" This Old House 29, Dec. 2006 <http://dc37.dawsoncollege.qc.ca/stylesheet/mla-foot.htm>

[3] Terry Dempsey, President "Deck Expo Inc." February 2006

[4] "Remodeling's Payoff" Realtor Magazine Online December 2005, Hanley-Wood LLC, 29, Dec. 2006 <http://www.realtor.org/rmoprint.nsf/pages/feature1dec05_deck>

[5] "The Outdoor Room: Trends in Decks…," North American Deck and Railing Association, 8 March 2006, NADRA, 03 January 2007 <http://www.nadra.org/industry_news/hearth_and_patio.pdf>

Subdivisions, such as this town-house community, can be found across the United States. It is clear that these homes were designed to include a structure outside of the rear door. The rim joist located just below this door was intended to be the point of attachment for the future deck.

Building Codes

The International Residential Code (IRC) is one of the primary references for both deck builders and code officials. It contains instructions on how to build reliable and safe structures. General requirements for all structures, including decks, are in Chapter 3, Section R301 Design Criteria. This section states that:

> "Buildings and structures, and all parts thereof, shall be constructed to safely support all loads, including dead loads, live loads, roof loads, flood loads, snow loads, wind loads and seismic loads as prescribed by this code. The construction of building and structures shall result in a system that provides a complete load path capable of transferring all loads from their point of origin through the load-resisting elements to the foundation."

Specifications concerning decks are found in the chapter on floors (Chapter 5) of the IRC. One section that is written specifically for decks (R502.2.2 Decks), provides a very brief and non-prescriptive recap on how decks must be attached and supported.

> "Where supported by attachment to an exterior wall, decks shall be positively anchored to the primary structure and designed for both vertical and lateral loads as applicable. Such attachment shall not be accomplished by the use of toenails or nails subject to withdrawal. Where positive connection to the primary building structure cannot be verified during inspection, decks shall be self-supporting."

All other guidance must be derived from sections that do not specifically cite deck construction, which are written with house building, not deck building, in mind.

The Study of Reported Deck Collapses

This study seeks to better define the scope of deck failures in the United States by providing statistical evidence of the problem. This report includes deck, porch, and associated collapses that were reported from January 2000 through the end of 2006. Although a few Internet sites referenced deck failures, no central source of data was found.

Methodology

Until now, conclusions drawn on deck collapse were based on a very limited sample size. This report hopes to establish a database with a statistically significant sample size and then identify trends, characteristics, or weaknesses. In order to draw accurate conclusions on deck failure, there must be adequate data to analyze.

Deck collapse or deck failure, for the purpose of this report, is defined as a single negative structural event that renders a deck non-functional. If a deck either detaches or shifts away from the primary structure, it would be included in the study.

An incident report form was developed, completed, and archived for every collapse. Data sought for each event includes: the height and size of the deck, construction materials, occupancy at time of collapse, and cause of failure. These data points were analyzed to identify trends or patterns.

The data used for this report was gathered through comprehensive searches of Internet and periodical archives using key phrases including deck collapse, deck injury, rail collapse, etc. Great care was taken to include all legitimate events; that is, events based on construction technique rather than an unrelated accident.

Source of Information

The primary source of information detailing deck collapses is the news media. News reports focus on injuries sustained rather than the actual cause of the event. Reporters reflect the statements of emergency responders or eye witnesses, neither of which are focused on the physics or engineering of the deck structure. The cause that was initially reported may be different than what a subsequent investigation would find. This lack of complete information can lead to flawed assumptions as to the cause of deck failure. Correcting the design defects that cause deck failure is impossible if solutions are based on inaccurate information.

Deck collapses are reported as isolated events. Very little background information is provided on the scope of this problem. Subsequent reporting could include the reasons why decks go down in the United States. There have been news segments on building a better deck; there also should be stories on the actual causes of failures and segments on preventing deck collapse.

Data, Trends, and Analysis

Data

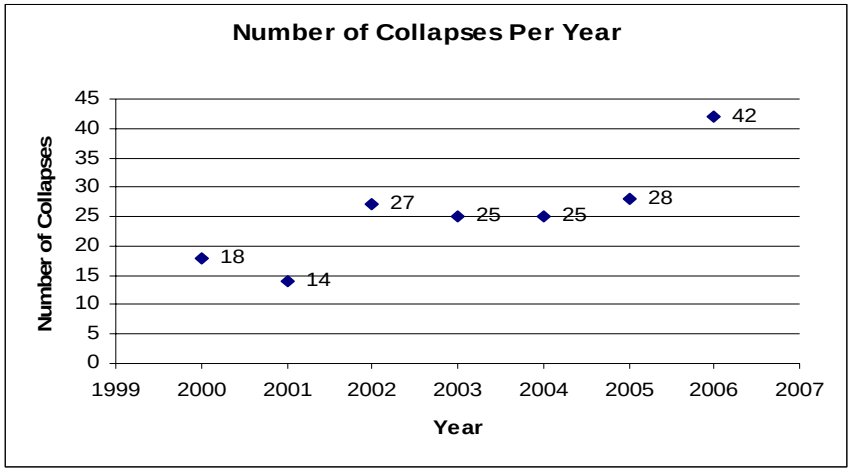
From January 2000 through December 2006, there were 179 reports of deck and railing failure. In these events 1,938 people were exposed to injury; they were either on or under the deck when the failure occurred. Of those involved, 1,122 sustained injuries, and 33 people died. This translates into 58% of the people involved in reported deck and railing failure were injured or killed.

Virtually no municipalities perform an investigation that documents the cause of the deck collapse. A smaller sample was used to investigate this trend. Out of all the collapses included in the subcategory, only one such report was found[6].

Trends

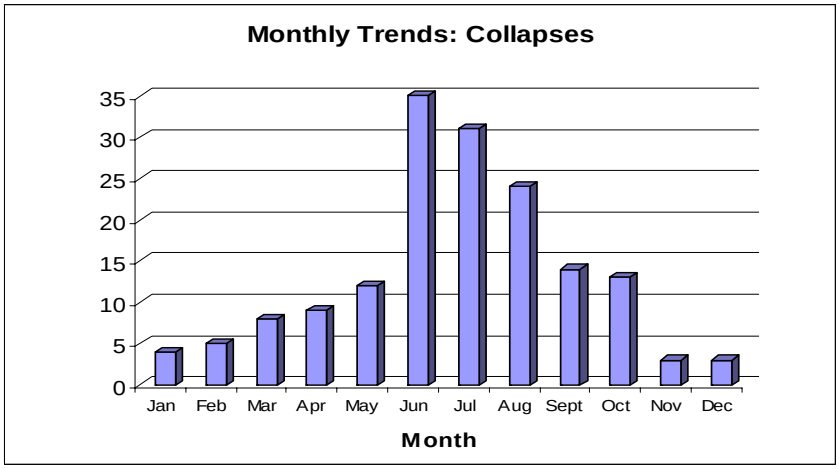
An examination of the data on reported deck collapses reveals several interesting trends.

- Deck collapses are increasing at an average rate of 21% per year.



[6] Subcategory included all the reported deck or railing failures for the year 2005.

- There is a well-defined deck collapse season (June through August) in which over twice the number of deck collapses occur compared to the rest of the year.



- Virtually all reported deck collapses occur while the deck is occupied.
- There is no apparent relationship between the age, height, size, or presence of a building permit and the tendency of a deck to collapse.

Analysis

An analysis of the data and trends for deck collapse has led to the following observations.

DECK CONSTRUCTION

- Failure of the house to deck ledger connection accounted for over 90% of all reported deck collapse. This type of failure includes the separation of the rim joist from the house floor joists, the separation of the ledger board from the rim joist, and the separation of the ledger board from deck joists.
- Decks are built to the same codes and standards that houses are, yet decks are more prone to collapse.
- Current deck connections and/or the deck components are subject to failure long before the end of the service life of the deck.
- Deck collapse occurs with loads well below the design load criteria.

REPORTING COLLAPSES

- There is a lack of specific information available on the number, damage, and causes of deck collapses.
- Deck collapses are treated as isolated events rather than a systemic problem.
- Deck collapses are not tracked, nor are reports available from rescue services, local building code officials, police, national associations, or government agencies.
- Follow up investigative reports on the cause of collapses are rarely generated.
- A collapse is more likely to be reported if people are involved or when personal injury occurs. 95% of reported collapses occurred when the decks were occupied.

- There is no agency or organization to which deck collapse is reported on either a regional or national level.

Conclusion

Are there right ways (or, more importantly, wrong ways) to build decks? Is anyone watching?

An analysis of deck collapse data indicates that deck connections are subject to failure long before the end of the service life of the other components of the deck. The lack of structural redundancy, especially at the critical connection points, leads to deck collapse. Specifically deck collapse is related to the connection assembly of the deck ledger board to the house substructure.

In the scenario where the house was built to accommodate a deck, it is assumed that the house-floor joist system was constructed to support a deck. This intention was know by the architect, the builder, and the homeowner. Was it known by the framing contractor? A better question is: did the framer prepare the point of attachment (the rim joist) for the loads associated with a deck in use? Can this rim joist resist the pull out force exerted by a deck, no matter how large?

When a deck collapses, people are injured, or worse. A design flaw in deck construction may lead to catastrophic events. One can dispute how the estimated numbers were derived, but the underlying fact is that the growing number of decks in existence will directly translate into a proportionally larger number of collapses, which presents a significant public health risk.

When a deck is bolted to a house, the strength and durability of this attachment depends primarily on the house rim joist to be able to transfer the load to the house foundation. The rim joist was not designed to resist the pullout action imposed by a deck. This issue should be reflected in all code used for constructing decks and/or houses onto which decks will most likely be attached.

As with any new development, there is a learning curve to discover the long-term performance of a product. The shortcomings of current deck construction must be studied, understood, and addressed. A factor that complicates this process is the incredible number of new decking products and techniques that are constantly being introduced. There is no time to slow down and evaluate the effect that one individual product or new technique has on the overall structural performance. With new products and new techniques being introduced so quickly, there is no easy way to generate a base line of deck performance against which to evaluate change.

The popularity of outdoor living space is growing despite the increasing number of deck collapses. There is a perception that each collapse is an isolated event dependant on the quality of the deck builder, as opposed to part of a larger trend predicated on a design or structural flaw in the deck's critical connections. The public is not aware of the

increasing danger associated with deck failures, largely because of a lack of conclusive data. A central database is needed to collect and analyze reports on deck collapses, the cause of the collapse, the number and severity of injuries, and the associated costs. Only after this information is assembled can the effect on public safety be evaluated and addressed.

A central database is now being created to allow for the archiving of deck collapse events. The purpose of this new database is to provide information for the further study of deck collapses.

Readers are encouraged to submit reports of deck collapses. If you know of a deck collapse, please email details and your contact information to info@deck-collapse.com. Please provide as much of the following details: date, city, state, number of people on deck, number of people injured, approximate height of deck, age of deck, material of deck, mode of failure. Your contact information will be used only to verify specifics on the collapse and to avoid multiple counting of the same event. For your convenience, an incident report form is available online at www.deck-lok.com/collapse-form.htm .

About The Authors:

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Appendix A

A Bad Winter

The winter of 1996 saw an unusual amount of snowfall in North Dakota. As the inches of snow accumulated in the Fargo area, a repetitive phenomenon occurred. Deck after deck collapsed under the weight of the accumulating snow.

Several things made Fargo a unique laboratory for observing the mechanics of - deck failure. With virtually every deck collapse covered by this report the impetus of failure was from movement of occupants on the deck. Virtually every deck that we studied had people moving at the time the collapse occurred. Not so in the collapses in Fargo.

- Due to the uninviting weather conditions these series of collapses occurred without the movement of people on the deck.
- The loads that caused the deck collapses increased very slowly and over an extended period of time. As it snowed, the weight grew greater and greater exerting a sustained load on the decks throughout the winter months. Normally, loads that a deck is subjected to are applied quickly and over a much shorter duration. For example, a homeowner will have a gathering where over a period of several hours a deck will be loaded and then, as people leave, the load diminishes. All of this occurs over a several hour span as opposed to snowflake upon snowflake throughout the winter months.
- The deck connections and deck components were in a constant wet service condition. Any warm up or heat from the house induced snowmelt. Typically, this would occur in areas closest to the ledger board which in turn would affect the critical connections to the house.

OBSERVATIONS

- The number of collapses intrigued a deck builder in Fargo, North Dakota. Mr. Todd Funfar, president of Deck Masters, began keeping a photographic log of deck failures after the thaw. He has cataloged over eighty separate collapses that occurred during the winter of 1996. A review of his photographs suggests similarities in the modes of failure among these decks. Failure occurred at the critical points of connection. Rather than the floor joists breaking mid-span, the deck either detached from the house or from the outside support beam and dropped. This suggests that the deck joist system was capable of carrying load in excess of the capacity of the ledger connection and/or outside load beam connection.
- The most common point of failure was the connection of the ledger board to the house. While the mechanics of ledger failure varied, the result was the same; the interface between the deck and the house floor joists separated and the deck collapsed. The observation drawn is that the connection of the deck to the house has not been adequately designed or implemented to transfer the loads from the deck, through the boards and hardware, to the foundation of the

house. The deck floor joist system continued to support the load while the ledger/band joist assembly did not.

As an aside, while researching deck collapses (covering hundreds and hundreds of hours in national archives and internet search engines) none of the collapses from the North Dakota winter were discovered.