Special Commission on the 1999 Texas A&M Bonfire

Final Report

May 2, 2000

Contents

Acknowledgements

Many people in the Texas A&M community helped make this effort possible -- far more that can be acknowledged here. A few merit special thanks, however:

- ¶ President Ray Bowen, who, being under considerable pressure during this trying period, spared no effort in marshalling the full resources of the University to support the Commission's effort. Without his dedication to a thorough and independent inquiry, the Commission's task would have been impossible.
- ¶ Dr. John Weese of the Mechanical Engineering Department, whose invaluable assistance and full-time dedication helped us understand the history and physical aspects of Bonfire, as well as the Texas A&M culture and traditions.
- ¶ Mr. Robert Bisor, assistant to the president, who served as a liaison to the University administration and solved many problems for the Commission behind the scenes.
- ¶ Ms. Linde Newman and Ms. Bettyann Zito, who provided first-rate administrative help.
- ¶ And finally, the Bonfire student leadership – their openness with the investigators during the interview process and their Bonfire construction demonstrations were extremely helpful.

The Commission would like to express special thanks to Mr. Jon Zagrodzky and Mr. Kent Lietzau of McKinsey & Company, who served as Chiefs of Staff to the Commission. Their expert management of this investigation and tireless efforts to ensure a quality final report were truly invaluable.

The Commission would also like to thank Mr. Robert Stillwell of Baker Botts in Houston, who served as General Counsel. His insightful views and advice on a variety of matters added greatly to the quality of our deliberations. The Commission is especially grateful to McKinsey & Company and Baker Botts, for providing their services on a pro bono basis.

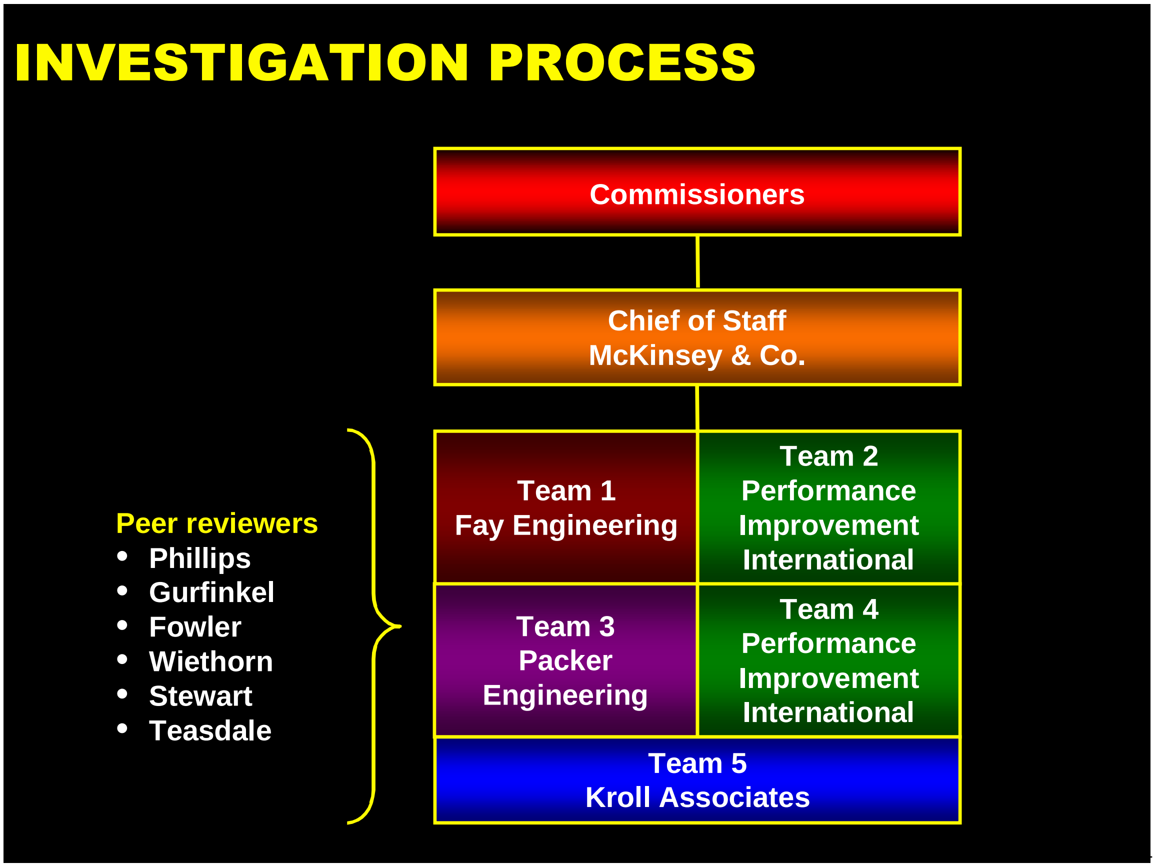
Finally, the Commission would like to dedicate this work to the lasting memory of those who lost their lives in this tragedy.

Introduction

INVESTIGATION PROCESS OVERVIEW

Immediately following the Bonfire collapse on November 18, 1999, The Texas A&M Administration asked Mr. Leo Linbeck, Jr., from Houston to chair an independent Special Commission to investigate the tragedy. The charter of the Special Commission was to determine what caused the Bonfire to collapse. Mr. Linbeck agreed, and subsequently asked four other individuals: Ms. Veronica Callaghan from El Paso, Mr. Hugh Robinson from Dallas, Mr. Allan Shivers, Jr., from Austin, and Dr. William Tucker from Fort Worth, to join him on the Commission. All of these individuals also agreed.

To complete their task, the Commission selected several teams, each charged with a specific area of analysis. Dr. Rex Paulson of Fay Engineering led Team 1, which focused on understanding and evaluating historical Bonfire design. Dr. Tage Carlson of Packer Engineering led Team 3 in investigating the physical aspects of the collapse. Mr. Carlson was assisted by Wood Advisory Services, Inc., McBride Ratliff and Associates, A.C. Engineering, and Dr. Raymond Krizek of Northwestern University. Additionally, the Commission engaged several outside engineers to provide peer reviews of all the engineering work. Mr. John Fowler, Dr. German Gurfinkel, Dr. Monte Phillips, and a team from Haag Engineering – Mr. Jim Wiethorn, Mr. John Stewart, and Mr. David Teasdale – all provided review and comment on the engineering reports.



The analysis of both past and present Bonfire organizational and behavioral issues was combined into one team (Team 2/4), which was led by Mr. Kerry Johnson and Mr. Craig Clapper of Performance Improvement International. Finally, J. Kieffer of Kroll Associates led Team 5, which conducted interviews, coordinated document and data collection, and investigated the effects of external factors on the Bonfire.

These teams and individuals have examined all of the main aspects of the 1999 Bonfire collapse and have come to some firm conclusions.

SUMMARY OF FINDINGS

The 1999 Bonfire collapsed due to a number of both physical and organizational factors. Structurally, the collapse was driven by a containment failure in the first stack of logs. Two primary factors caused this failure: the first was excessive internal stresses driven primarily by aggressive wedging of second stack logs into the first stack. The second was inadequate containment strength. The wiring used to tie the logs together provided insufficient binding strength. Also, steel cables, which in recent years had been wrapped around the first stack, were not used in 1999, further reducing containment strength. These two factors – excessive internal stresses and weakened containment strength – combined to cause the collapse.

The physical failure and causal factors were driven by an organizational failure. This failure, which had its roots in decisions and actions by both students and University officials over many years, created an environment in which a complex and dangerous structure was allowed to be built without adequate physical or engineering controls.

This organizational failure is complex but includes such things as the absence of an appropriate written design or design process, a cultural bias impeding risk identification, and the lack of a proactive risk management approach.

Report Summary

ENGINEERING ANALYSIS

The purpose of the engineering analysis was to understand the physical causes of the collapse. The Commission's work focused on understanding not only the collapse itself, but also relevant aspects of Bonfire design history and evolution. Through this work, The Commission determined with reasonable certainty the key collapse factors.

Introduction

The engineering analysis of the Bonfire collapse turned out to be much more challenging than originally anticipated. The physical factors ultimately determined to be drivers of the collapse were not obvious to the engineering teams at the outset. In fact, it took a number of weeks and considerable effort before the collapse mechanism and sequence were determined.

The engineering analysis is divided into two parts, each beginning with a brief overview of the analytical processes used. The first section deals with Bonfire design – how it has evolved, when key features were introduced, and how the composite design appears. The second section deals with the collapse – key collapse mechanisms, causal factors, and the collapse sequence.

More detailed perspectives of the engineering findings are contained in the individual engineering team reports. Those with an interest in more details should consult these sections directly.

Historical design

The analysis of historical design started with a careful review of available historical records. This work involved examining old photos and videos, testimonials from those who participated in earlier Bonfires, and newspaper accounts. Additionally, past student Bonfire leaders were interviewed in order to discern changes in design and construction methodology.

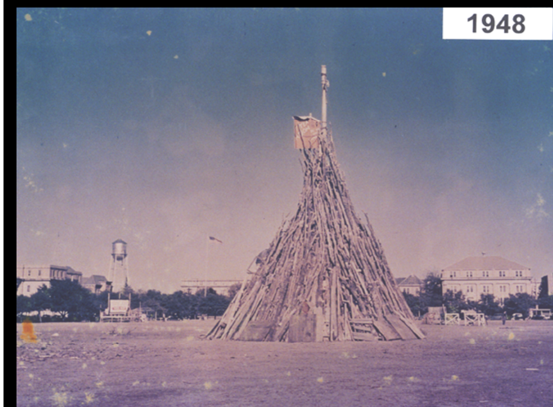
Team 1 assembled Bonfire physical statistics for the last 20 years and used them to develop a composite, or baseline, design. This composite design was evaluated to determine critical design elements. Outside engineers were then retained as peer reviewers to examine this work; they subsequently issued a favorable opinion as to methodology and findings.

Design evolution

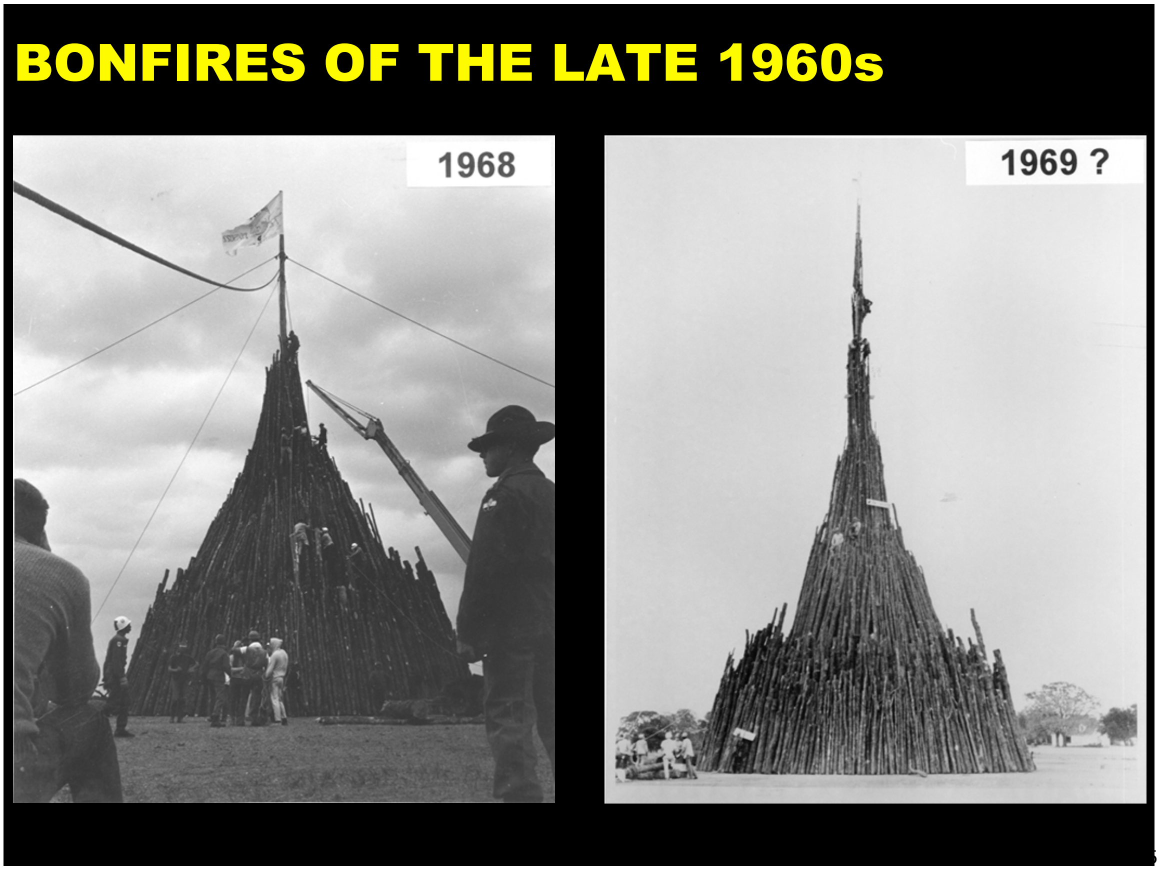
Early Bonfires were not nearly as large or complex as they are now. They were nothing more than piles of wood and trash, as you can see from this 1928 photo. Complexity increased over time, however, with students adding features and increasing the size almost every year.

The mid 1940s saw the introduction of center poles and a teepee-shaped design, both of which can be clearly seen in photos of the 1948 and 1958 stacks.

EARLY BONFIRE DESIGNS (CONTINUED)



Because a pure teepee-like Bonfire can only be built as high as the tallest log, multiple layers of logs were introduced by the 1960s, allowing the construction of much taller Bonfires. Both the 1968 and 1969 stacks utilized this multi-tier design, with the 1969 stack reaching 109 feet – the tallest Bonfire ever recorded.



Bonfires in the late 1970s began to take on a more wedding cake-shaped design. Since the 1980s, all Bonfires appear to have had the design features listed below:

RECENT DESIGN FEATURES

- Wedding cake structure
- 60 feet to 80 feet tall
- Six tiers bound with wire
- Two-part spliced center pole
- Four perimeter poles with guy ropes

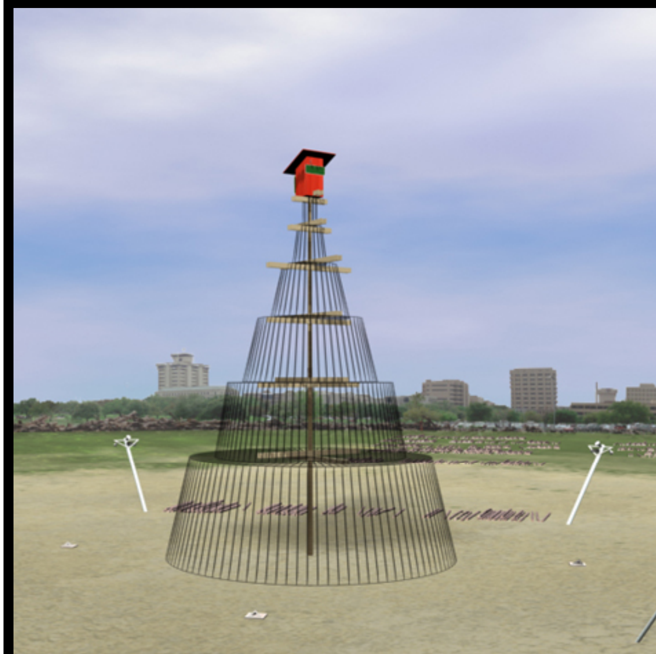
Today's structures are truly massive. A completed Bonfire can weigh over 2 million pounds – more than twice the weight of the world's largest 747 jumbo jets.

Yet design and construction have remained almost the exclusive purview of students. Involvement by the University in Bonfire design has historically been very limited. The only significant restrictions were height and diameter – both imposed after 1969. These restrictions were never well communicated or enforced.

Composite Bonfire design

Team 1's first analytical task was to characterize a "typical Bonfire" so that it could evaluate it from an engineering perspective. Team 1 collected data from past Bonfires and assembled what is referred to as a "composite" design – an average Bonfire based on stack statistics of the last 20 years. The illustration shown on the next page is a computerized rendition of this composite design.

COMPOSITE BONFIRE DESIGN



Critical design elements

- **Maximum stack containment**
- **Minimum internal stress**
- **Maximum lateral cohesion**

This stack has all the standard features of the 1980s and 1990s – wedding cake design, six tiers, etc. When Team 1 modeled and examined this composite design, it became apparent that there were several design elements particularly important to structural integrity. It is critical to ensure that these elements, listed here in approximate order of importance, are handled properly from year to year:

1. **Maximum stack containment** – requiring the use of strong wires and cables
2. **Minimum internal stress** – requiring minimal use of wedging, symmetrical build-out of each stack, and lower stacks that are much wider than the stacks above them.[1]
3. **Maximum lateral cohesion** – requiring extending or interlacing lower stack logs into upper stacks.

While examination of the composite design clearly indicates the importance of these elements, their importance becomes even clearer in light of findings regarding the 1999 collapse.

1 This implies that, unless there are similar limits on upper stack diameters, the University's first stack diameter restriction could be inconsistent with structural integrity

1999 Collapse

This phase of the investigation began with the examination of numerous documents, pictures, and videos related to Bonfire. Team 3 collected and examined all physical evidence found at the Bonfire site and conducted a site survey to characterize site geometry. Team 3 also reviews interview reports from eyewitnesses, University officials, and individuals involved in rescue operations.

After gathering evidence, Team 3, began its analysis work. Photogrammetry was used to determine stack dimensions and specifications. Specialists were engaged to test soil, guy ropes, wire, and the center pole. Team 3 also weighed and measured several hundred logs.

Using this information, Team 3 created computer models of the stack. This enabled it to test different collapse hypotheses, determine key causal factors, ascertain the collapse mechanism, and map out the collapse sequence. Lastly, as with the historical design work, the Commission retained outside engineers to critique the engineering work. The peer reviewers issued a favorable opinion regarding Team 3's collapse analysis methodology and findings.

Non-causal factors

Several factors widely rumored to be causal were in fact determined to not be relevant. For example:

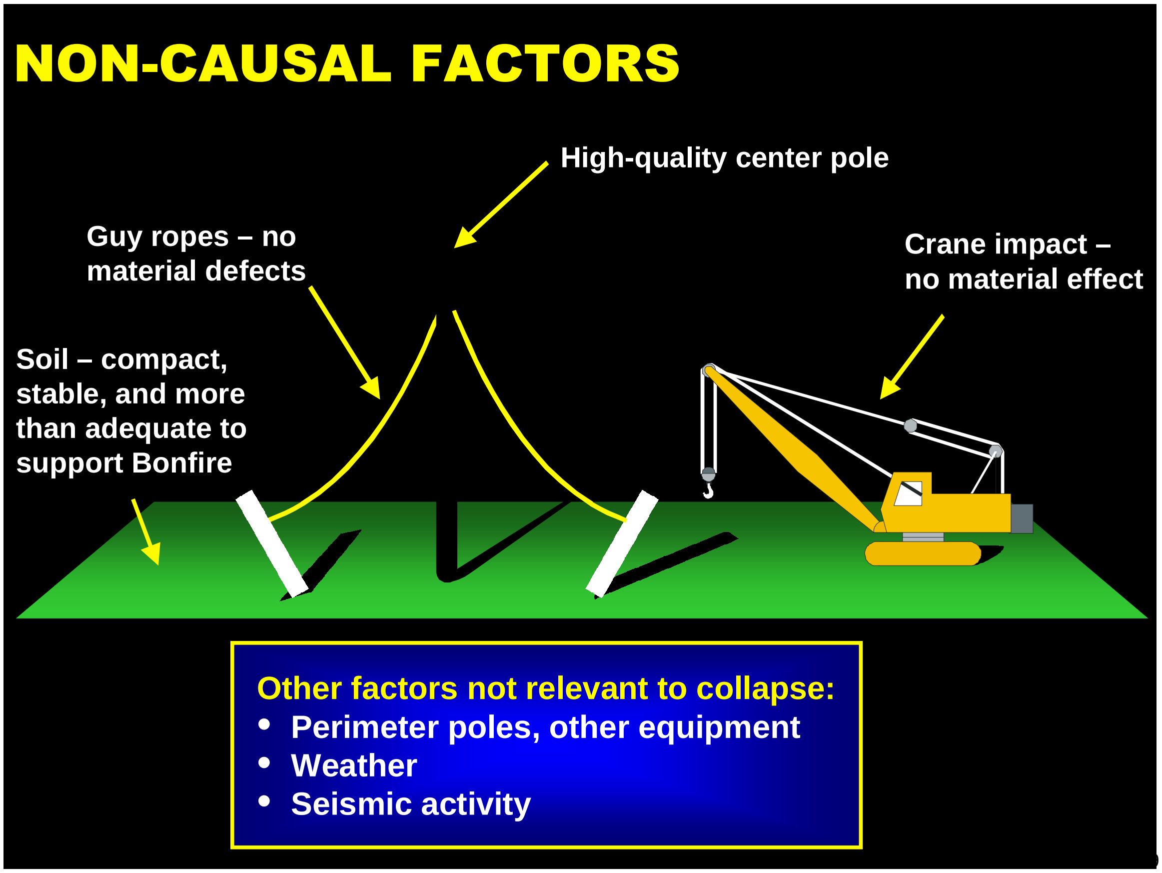
1. **Center pole** - Team 3 examined strength and wood quality, checked for weakness due to fungus or decomposition, examined breaks and cracks, and examined the splice. The center pole passed all tests comfortably. It is also important to note that given the enormous weight of the stack, even a perfect center pole could not have played a significant role in providing structural strength.

2. **Soil** - Analysis showed the soil to be sufficiently compact and stable and that it could easily support a structure at least twice as heavy.

3. **Guy ropes** - All ropes tested were of good quality, with no material defects found. Although one of the guy ropes did fail during the collapse, it was not a contributing factor because it broke after the collapse sequence had started.

4. **Crane impact** - Interviews and evidence indicate that a few days before the collapse, a crane struck and broke off a small piece of a cross tie attached to the center pole. As a test, Team 3 modeled the maximum force that such an impact could have generated. Team 3 determined conclusively that the impact of the crane could not have materially affected the center pole or contributed to the collapse.

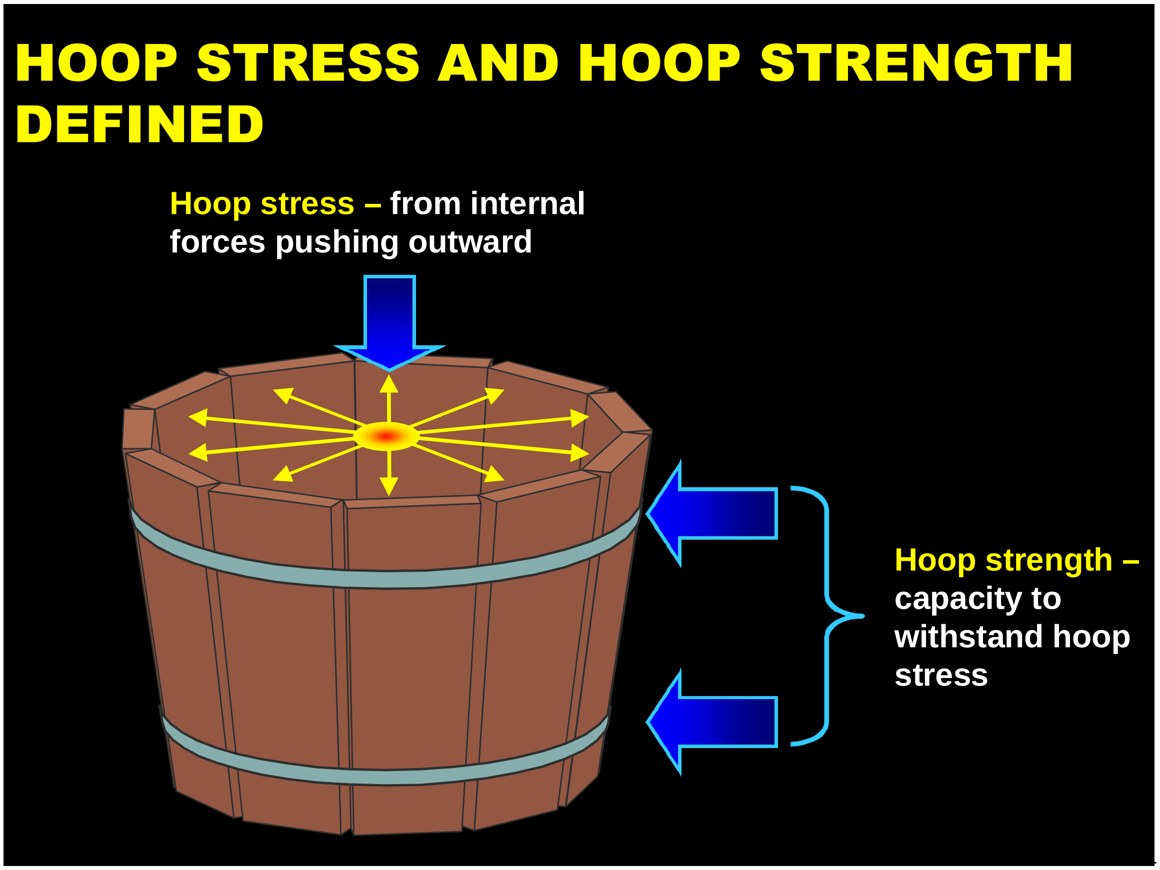
5. **Other factors** - Lastly, it was determined that there were no defects in the perimeter poles or other equipment that could have contributed to the collapse. Also, no material evidence was found that any external factor such as weather or seismic activity played a role in the collapse.



Causes of the collapse

The collapse was the result of a structural failure – a loss of containment strength around the first stack.

These terms are more clearly defined as follows: hoop stress results from outward pressure in a cylindrical structure, like a barrel, that is due to internal lateral forces. Design, shape, or even gravity can drive these forces. Hoop strength is the ability of a cylindrical structure to contain hoop stress. Hoop strength is normally provided by some containing mechanism – in the case of a barrel, it is provided by the metal bands wrapped around the wooden slats. The metal bands must sustain the hoop stress in order to keep the barrel together.



Containment strength is typically called "hoop strength." The actual failure resulted from excessive "hoop stress" that overcame the Bonfire's hoop strength.

A hoop strength failure results in an opening up or flowering out of the barrel slats, or in the case of Bonfire, first-tier logs. This is referred to as the initial Bonfire collapse mechanism, and is what led to other failures such as stack shifting, center pole fractures, and a guy rope failure.

Determining this mechanism was a difficult task. The reason for this is that a number of interdependent causal factors come together at the same time to generate the hoop stress overload. Several causal factors acted to increase hoop stress, including wedging, vertical log orientation, overbuilding of the second stack to the southeast, and ground slope to the southeast. Other factors reduced hoop strength, including inadequate wire strength and the absence of first stack wrap-around cables.

Not all of the causal factors had the same impact, however – analysis showed some to be far more significant than others. Wedging, wire strength, and lack of cables are all primary causal factors; the others contributed to the failure but were clearly secondary.

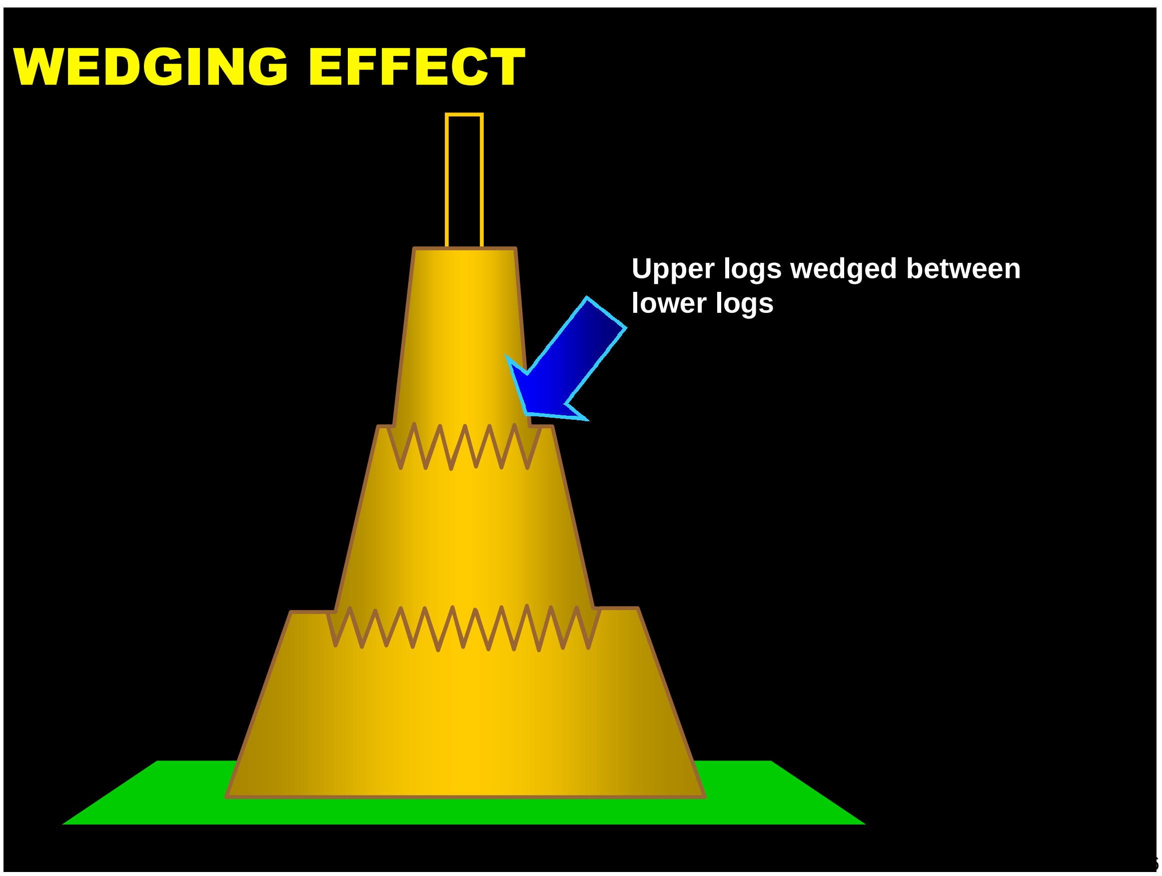
Understanding these causal factors in some detail is important to understand the collapse itself. The following factors increased hoop stress:

1. **Wedging** – this is the practice of inserting upper-tier logs into a lower tier during construction – something that increased hoop stress dramatically in Team 3's computerized model.

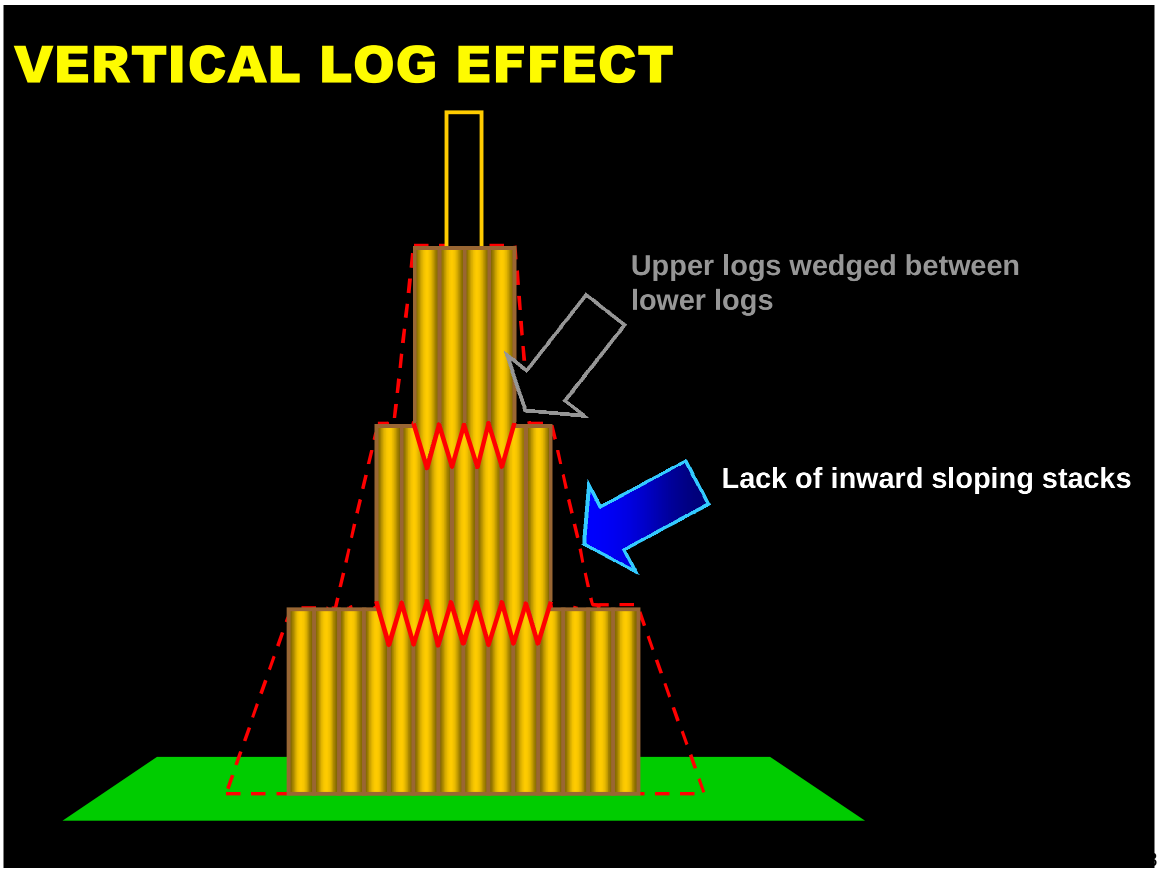
   Wedging can most readily occur when there are gaps between the tops of the lower-tier logs. In 1999, these gaps were more pronounced than they have been historically because the logs used were more crooked than usual. This made it difficult to build a densely packed and tightly wired stack. As a result, it was easy to use wedging during construction.

   Additionally, interviews with student leaders showed that while wedging was used only moderately or not at all in previous years, it was used very aggressively in 1999.

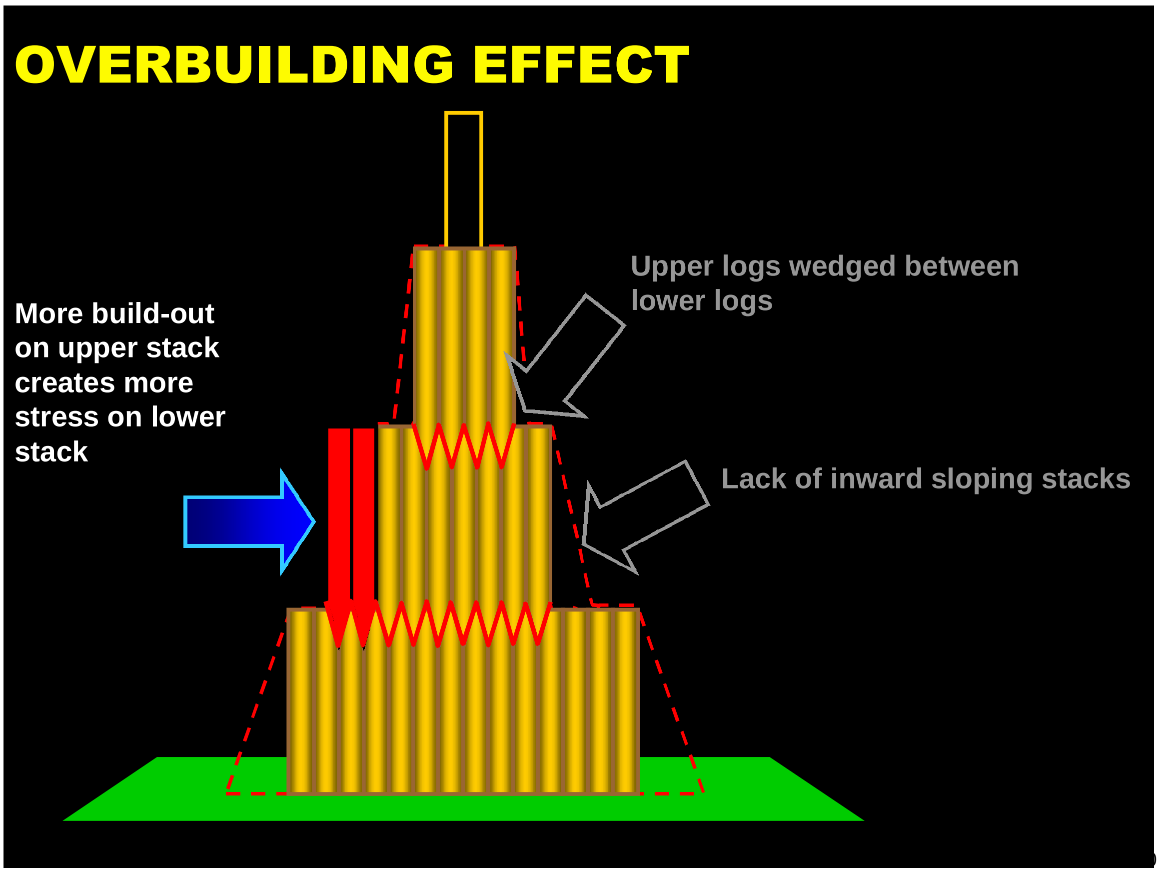
   Please note that the factors illustrated in the following four drawings have been exaggerated for the sake of clarity.



2. **Vertical log orientation** – as was evident from the previous photographs, early Bonfires had a teepee-shaped design. Logs in later Bonfires, especially 1998 and 1999, were stacked much more vertically. Vertical logs by themselves might not have caused the collapse, but they did increase the forces acting on the wires.

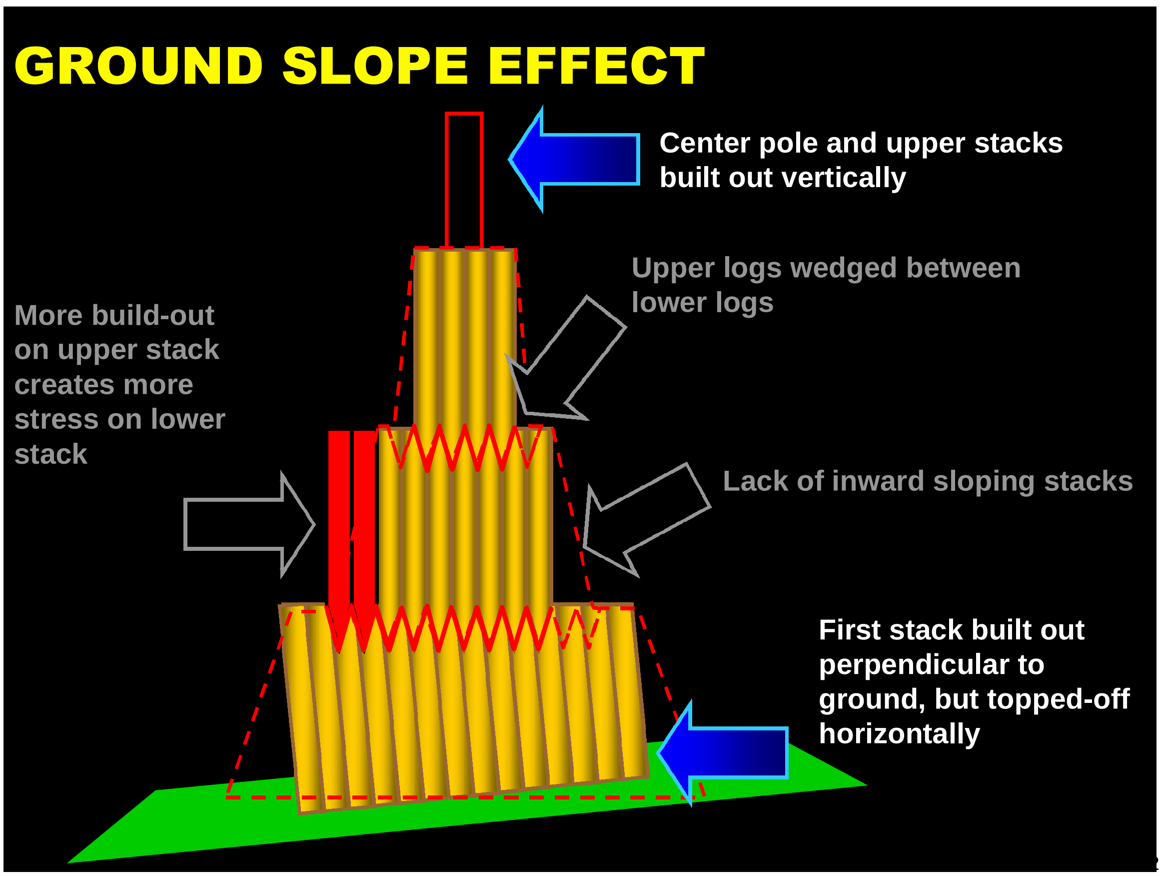


3. **Overbuilding** – results when an upper stack is built-out too closely to the edge of a lower stack. The result is increased localized hoop stresses on the lower stack. Hoop stress is less when the lower stack is built out much wider than the upper stack. According to interviews, the overbuilding of the 1999 stack was toward the southeast, with a distance of just one foot or so from the second stack to the edge of the first stack. This overbuilding amplified the wedging effect to the southeast, contributing to the failure.



4. **Ground slope** – increases hoop stress on the downhill side of Bonfire. Two problems in this regard are worth noting. First, the ground at the polo field where Bonfire has been built since 1992 slopes very slightly from the northwest to the southeast. The engineers estimated this slope at just over 1 degree. This implies about a one-foot drop off from the northwest to the southeast side of the stack. This is a very slight drop, but it did contribute to increased hoop stress on the southeast side, which was the direction of failure.

The second problem is that, according to interview reports, the first stack was built perpendicular to the ground, implying a very slight lean to the southeast. However, the second and higher stacks were built perpendicular to the forces of gravity and parallel to the center pole. Pre-collapse photo quality is such that the teams could not firmly corroborate reports of this condition. But it appears likely that it was present and contributed slightly to the collapse due to a leaning and prying effect of the logs.



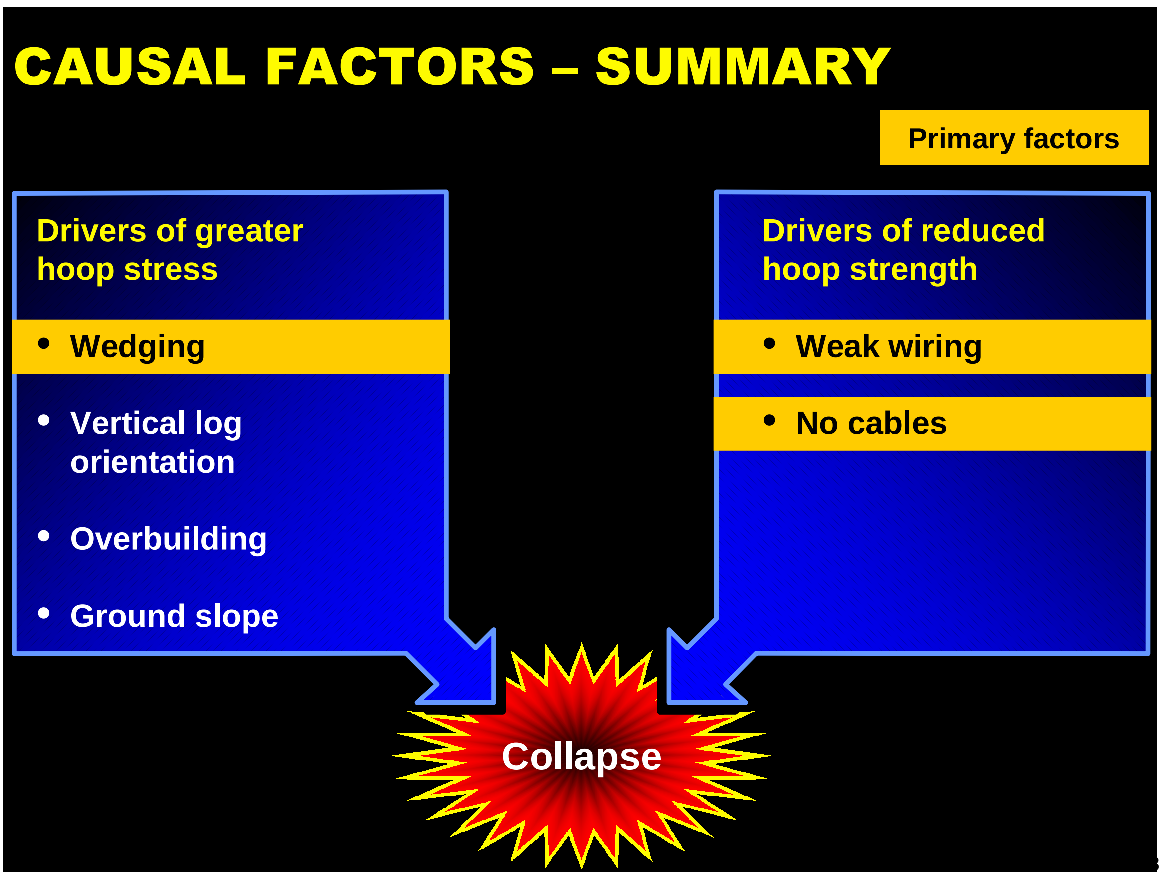
Turning now to decreased hoop strength, we see two primary causal factors:

1. **Inadequate wire strength**. Wiring provided the only source of hoop strength and was the first component of Bonfire to actually fail. Also, evidence suggests that intended wiring techniques were not always followed. Lastly, analysis shows that to restrain the hoop stresses adequately, vastly stronger wiring would have been required. As a point of explanation, each log is wired to at least three others – one behind and two on each side. The wires are wrapped around logs in a

figure 8 fashion and are regularly tested for tightness by Bonfire workers.

2. **Absence of first stack restraining cables**. Beginning with the second 1994 stack (perhaps earlier) and continuing through 1998, steel cables were wrapped around the first stack at interim points during construction. These cables, which were not introduced with structural integrity in mind, dramatically increased hoop strength. Although using cables would have greatly reduced the likelihood of collapse, it would not have solved the other significant factors driving containment failure.

In summary, wedging, vertical log orientation, overbuilding, and ground slope combined to increase hoop stress, while weak wiring and lack of wrap-around cables combined to reduce hoop strength. The combination of these caused the Bonfire collapse.



It is important to note that a combination of these factors, and not any one particular factor, led to the collapse. This is what made the initial engineering work so difficult and the initial public speculation about the causes so wide-ranging. It is only by understanding how several disparate factors work in unison that the pieces of the puzzle come together.

Collapse sequence

Following is a description of the collapse sequence of the 1999 Bonfire:

The collapse begins when hoop stress finally exceeds hoop strength, and a few wires begin to break on the southeast side of the stack. Wire failure accelerates, and logs begin to fall away from the stack.

As support on the southeast side weakens, second stack logs begin to shift laterally, with some logs falling into large gaps being created below. The second stack accelerates, and it is at this point that the first center pole break occurs between the first and second stacks. The third and fourth stacks also begin to shift, and the entire structure begins to fall to the southeast.

Simultaneously as the stacks fall to the southeast, tension on the northwest guy rope increases dramatically, temporarily restraining the center pole. The tremendous momentum of the third and fourth stacks causes this guy rope to snap, and the center pole whips forward and continues its motion to the southeast. At some point, the center pole breaks again, this time at ground level.

As the stack approaches the ground, the northeast and southwest guy ropes begin to restrain the center pole. Again, the center pole is snapped back, this time breaking once more and ending up on top of the stack in the opposite direction of the fall. Some eyewitness accounts indicate that the top of the center pole hit the ground prior to snapping back.

One important point is that this collapse happened very quickly. Eyewitnesses were stunned at how fast the stack fell to the ground.

Team 1 developed an animation of the collapse sequence that should be viewable on the Texas A&M web site. This animation is only a representation of the collapse sequence, as there are no known videos of the event. However, the animation was previewed by several eyewitnesses, who, along with the engineering teams, believe it represents a reasonable rendition of the actual collapse.

Conclusion

In summary, the Bonfire collapse was the result of complex interactions among several causal factors. But this analysis covers only the physical dimensions of the collapse. Following is a discussion of the behavioral factors contributing to the collapse.

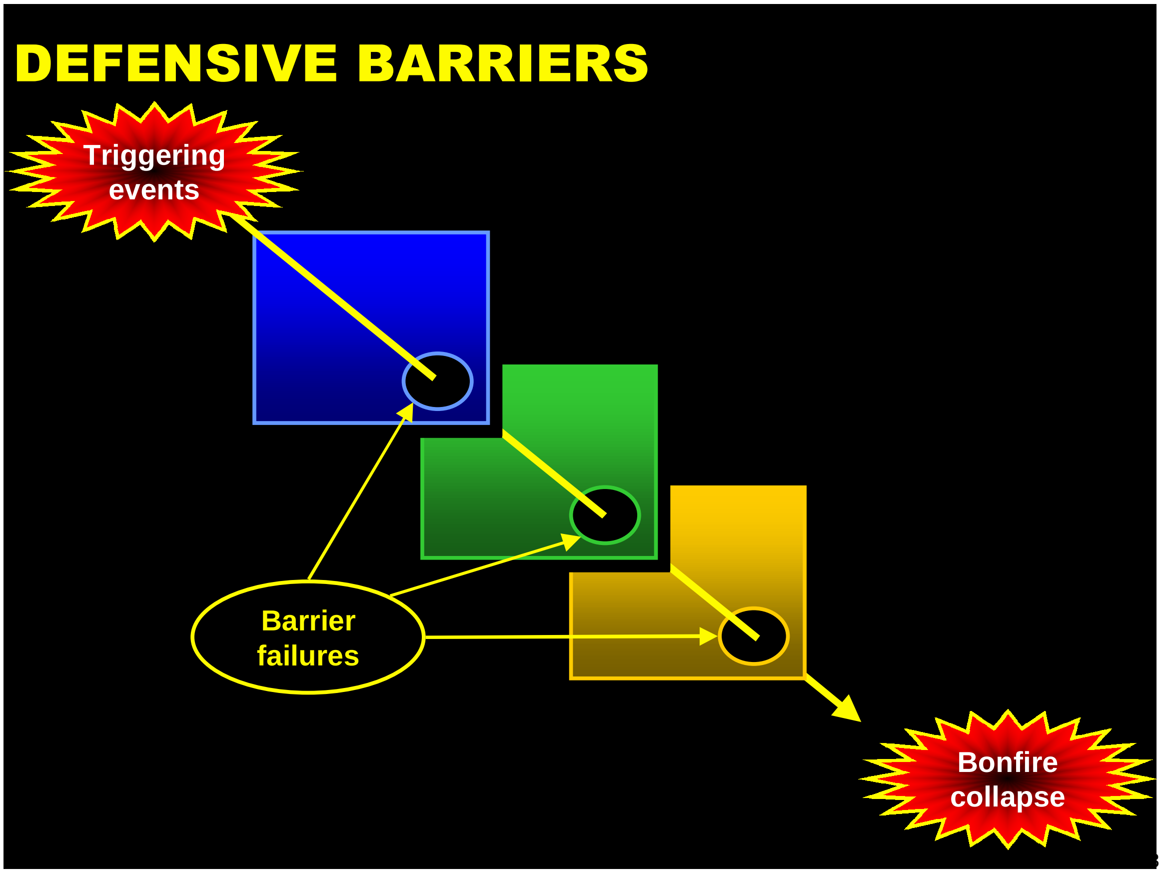
BEHAVIORAL ANALYSIS

The purpose of the behavioral analysis work was to understand whether, in addition to the physical causal factors, there were any behavioral factors that contributed materially to the collapse. Performance Improvement International conducted this part of the investigation and is referred to as Team 2/4 throughout this discussion.

Framework description

In any complex system, there is always a risk of significant failures or accidents. To reduce this risk, organizations typically adopt a variety of controls designed to govern individual and group behaviors. These controls, or barriers, serve to prevent potential problems and ensure safe and reliable operations. While not all barriers work all the time, a well-designed system of multiple barriers prevents unavoidable triggering events or mechanisms from leading to a serious problem.

Sometimes, however, the system of barriers is inadequate, and they all fail at once. This allows some triggering event to drive through the barriers and result in a serious failure. In the case of Bonfire, it is the Commission's belief that this is exactly what happened. The analysis of behavioral factors is built around this framework.

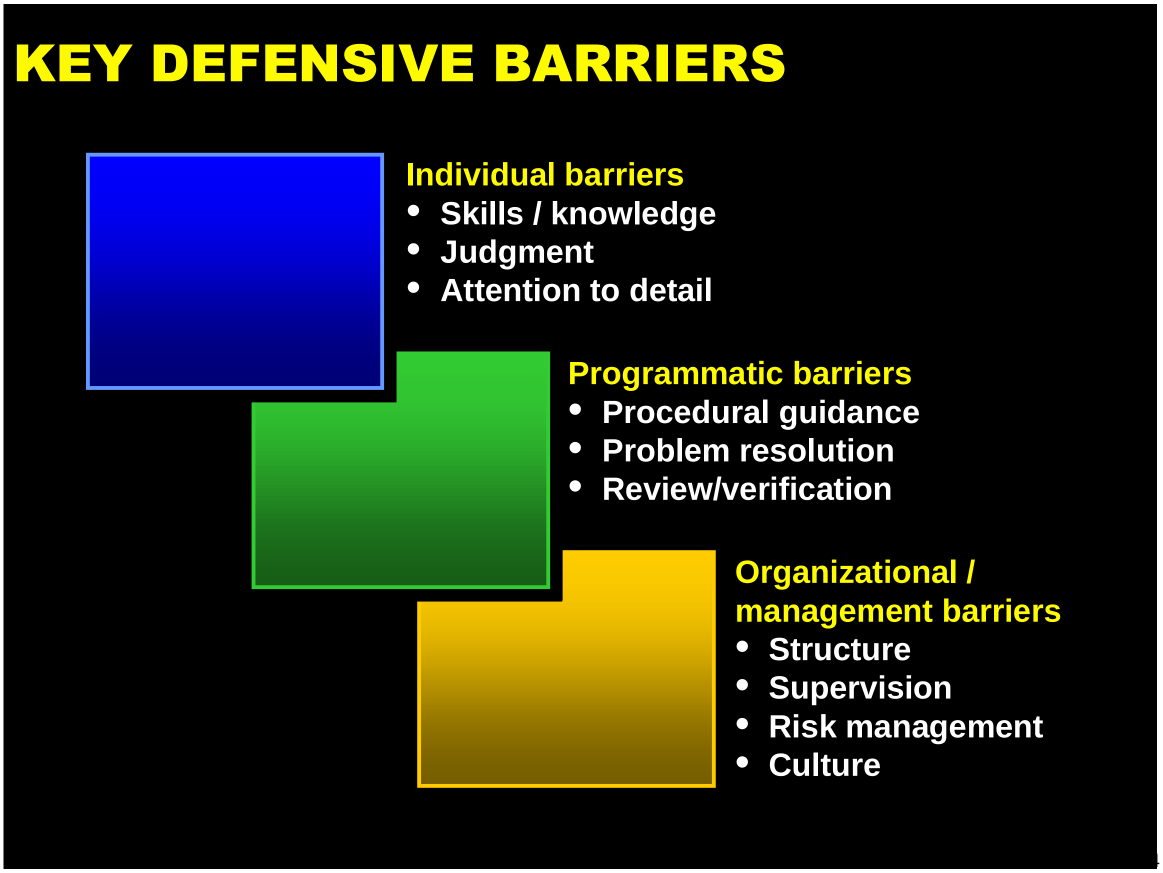


The major barriers for discussion are organized into three major areas:

1. **Individual human performance barriers**, which include adequate skills and knowledge, exercising good judgment, and paying attention to detail.

2. **Effective programmatic barriers**, which include adequate levels of procedural guidance, methods to identify and resolve problems, and appropriate levels of review and verification for critical activities.

3. **Strong organizational and management barriers**, which include a defined and controlled organization structure, adequate management and supervisory actions, effective risk identification and management, and the establishment of a strong organizational culture.



Investigation approach

Before discussing the findings, it is important to understand how this investigation was conducted.

Team 2/4 spent considerable time collecting and analyzing information from a variety of sources, both inside and outside the A&M community. A great deal of fact gathering focused on analyzing interviews, surveys, and documents made available by Team 5 and the University.

¶ Over 260 interview reports prepared by Team 5 were analyzed. Interviews included eyewitnesses, current and former student leaders and workers, University officials, and University faculty who had expressed concerns publicly about Bonfire

¶ Team 2/4 surveyed over 500 student workers not interviewed by Team 5 to collect information in the area of safety, work stress, task commitment, supervisory effectiveness, and compliance. Just over half of these surveys were returned and tabulated

In addition to interviews and surveys, Team 2/4 conducted an extensive review of available data and documents. This work involved analyzing police reports, photographs, internal memos, newspaper accounts, and documentation of past Bonfire problems. All told, over 4,800 separate documents and photographs were examined.

Team 2/4 conducted an organizational analysis of both the University and student leadership, seeking to understand structure, hierarchy, decision-making, culture, and history. It reviewed guidance documents describing Bonfire construction and safety requirements. It also analyzed management at the stack site as well as individual and personal behaviors.

Team 2/4 worked with the engineering teams to test whether observed behaviors could be linked directly to some physical evidence regarding the collapse.

Team 2/4 also looked outside the Texas A&M community and conducted a benchmarking study to understand how other institutions and universities manage high-risk, student-run activities.

Lastly, for each piece of information gathered that ultimately supported the Commission's conclusions, Team 2/4 qualified the source and corroborated the information with other facts where possible.

Findings

Three lines of inquiry were pursued in analyzing the behaviors associated with Bonfire:

1. Where did barrier failures occur that were relevant to the collapse?
2. Can any of these barrier failures reasonably be corrected?
3. How do the failed barriers fit together?

Barrier failures

Individual barriers

There are several "sub-barriers" that were tested as part of the analysis:

¶ Attention to detail – did individuals pay close attention to details that really mattered?

¶ Sound judgment – did they exercise sound judgment in making important decisions?

¶ Committed actions carried out – did they follow through on required actions?

- Adequate knowledge and skills – did they possess the right capabilities to design and build Bonfire?
- Adequate mental states – were their mental states impaired in any relevant way?

To understand where and how any of these sub-barriers might have failed, Team 2/4 evaluated individual behaviors in several key areas:

- Personal behaviors by individuals, both at the stack and the cut sites
- Bonfire construction, primarily looking at whether individuals made construction mistakes, and
- Student leadership, where Team 2/4 examined how student leaders made decisions and supervised the work force

Team 2/4 found considerable evidence of irresponsible behavior in Bonfire. Alcohol use was substantial, although student leaders reportedly prohibited alcohol. Also, evidence of hazing and harassment by student workers and student leaders as well as unnecessary horseplay and fighting was significant, despite University efforts to control it. Team 2/4 documented dozens of examples of these behaviors, some of which have led directly to accidents in which students have been hurt or hospitalized. In the experience of the investigation team, Texas A&M is unique in allowing this level of irresponsible personal behavior in and around a construction project of this magnitude. Clearly, there is the potential for these behaviors to impact worker performance and thus perhaps structural integrity. This is why these behaviors are strictly prohibited at professionally managed construction sites.

These behaviors were closely examined to find any evidence that they might have contributed materially to the collapse. After careful review, Team 2/4 found no such evidence. Thus, while the behaviors are viewed as a barrier failure, this failure is not relevant to the collapse.

Next, Team 2/4 analyzed the construction practices of individual students. It evaluated log cutting, center pole assembly and transport, perimeter pole preparation and installation, log positioning on the stack, and wiring. No evidence was found that any single error by an individual led to the collapse of Bonfire. The 1999 Bonfire as-built structure was generally constructed as student leadership had planned. Additionally, no evidence was found that supervision of these activities by student leaders was materially inadequate.

Finally, no evidence was found that fatigue was a contributing factor despite the all-night construction schedule. Additionally, all reports of potential sabotage or other malicious acts were investigated, and none of them were found to be credible.

However, Team 2/4 did find a relevant barrier failure in the area of student skills and knowledge necessary for a project of this magnitude and complexity. The investigation showed that student leaders over many years made design and construction decisions that adversely impacted structural integrity. Evidence is also conclusive that student leaders lacked the proper knowledge to make better decisions than they did given the complexity of recent Bonfires.

As was alluded to in the engineering discussion, a number of critical design decisions affected structural integrity. Some were made in 1999. Wedging has been used since the early 1990s, but it was decided to use wedging aggressively in 1999. Also in 1999, student leaders discussed the use of wrap-around cables and elected not to use them.

Other critical design decisions were made in prior years. The more vertical design evolved over many years, though both the 1998 and 1999 stacks were the most vertical. Also, some asymmetric build-out of the upper stacks apparently has been a common practice for years.

In interviews with past and present student leaders, the teams asked how some of the key design decisions were made. Asymmetric build-out was dictated by how often the crane was moved around the stack. Wedging was introduced to improve structural integrity, but clearly it had the opposite effect. The wire gage, which included some lighter gages in 1999, is dictated by what donors give. First stack cables were not used for two reasons – one, it was believed that cables resulted in wider interior air columns that accelerated the burning process; and two, it was believed that tightening cables loosened the individual log wirings and weakened the structure. On the contrary, cables would have greatly increased structural strength.

These are just a few examples from the interviews that were conducted. But the conclusion is clear – student leaders made important design decisions and choices without understanding their impact on structural integrity. In the Commission's view, this resulted in a barrier failure relevant to the collapse.

Programmatic barriers

Several sub-barriers were tested. These ranged from design, construction, and inspection processes to safety and problem identification processes. To understand where and how these sub-barriers might have failed, Team 2/4 looked at several Bonfire-related activities:

- How Bonfire design were developed, reviewed, and communicated over time
- How Bonfire materials were acquired, transported, and stored
- How students met to identify and resolve problems
- How safety regulations were developed and enforced

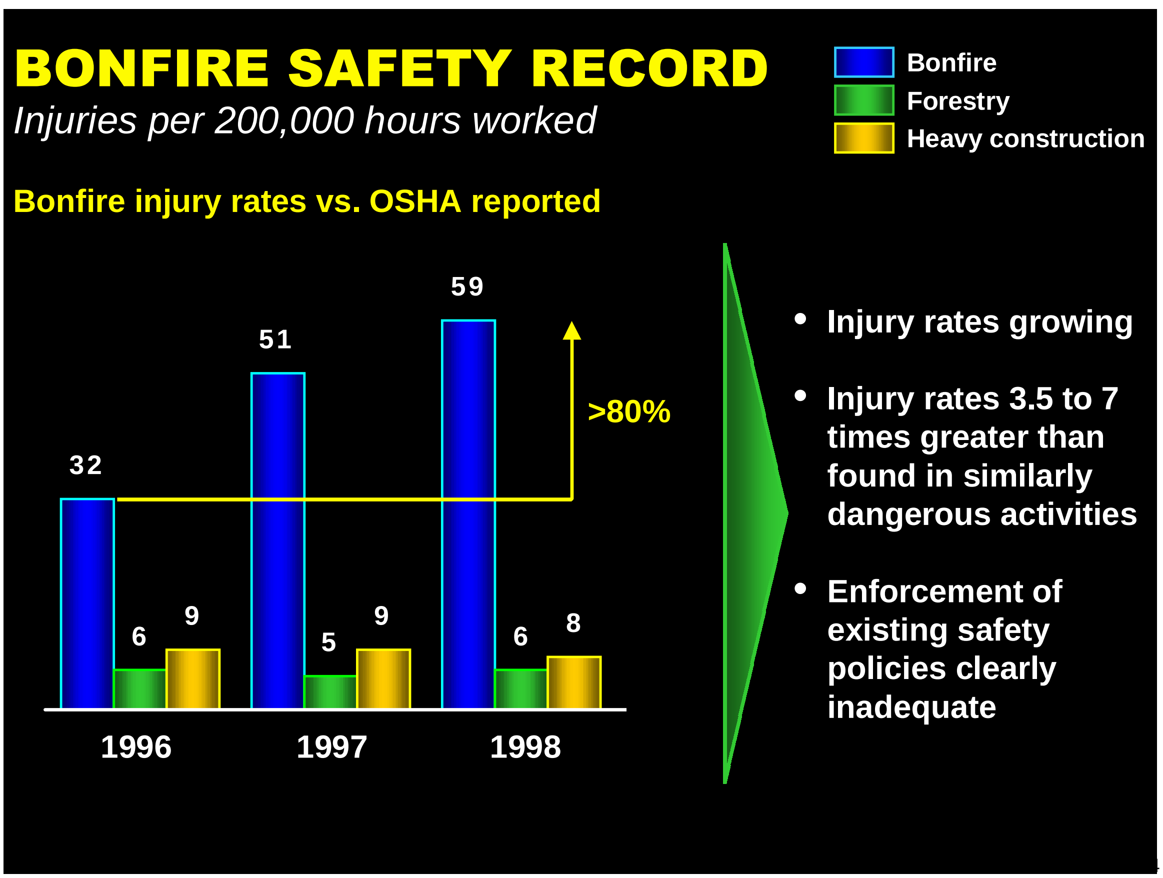
¶ And finally, how lessons learned each year are captured and communicated over time

Team 2/4 found no evidence of problems with the processes that students used to identify and resolve problems or to manage Bonfire materials.

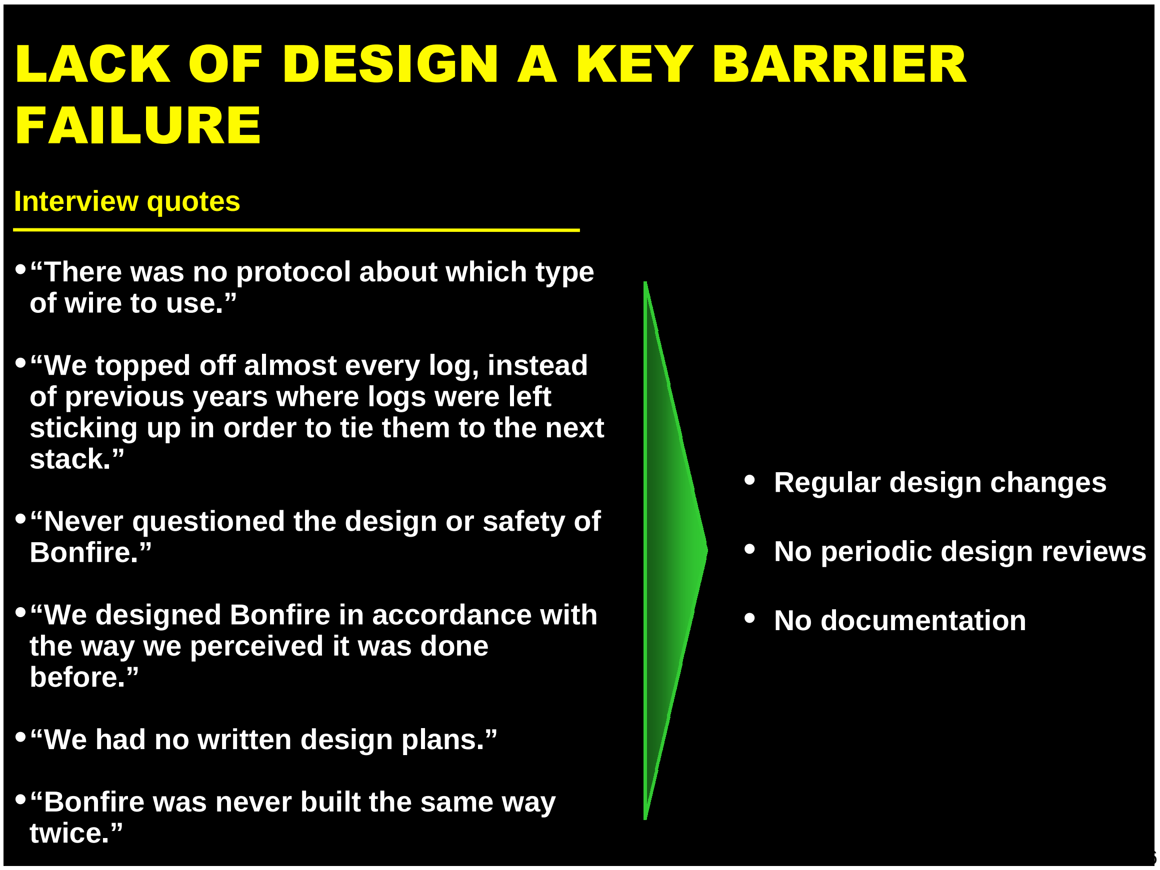
It did find, however, clear evidence that worker safety processes were either inadequate or not sufficiently enforced. At the same time, it also found that none of these safety problems could be directly linked to the collapse.

Despite good overall safety intentions (both University and student leaders stated frequently in the interviews that safety was important to them), the enforcement track record of Bonfire safety programs is poor by any standard. First, the injury incident rate has been growing in recent years – increasing by more than 80% from 1996 to 1998.

Second, comparing these injury rates to those reported by the Occupational Health and Safety Administration for related activities – in this case logging and construction – suggests that the Bonfire safety record is clearly substandard. But, again, despite this track record, the Commission could find no evidence linking poor safety enforcement to the collapse.



Lack of a written Bonfire design or construction methodology is in the Commission's view both an important barrier failure and very relevant to the collapse. This deficiency has resulted in multiple design changes year-to-year, no established process for design reviews, and no documentation of critical design factors. This was clearly evidenced in interviews with University officials and students. On numerous occasions, interviewees described a world in which design decisions were made with no written guidance, no formal reviews, and no knowledge of critical design factors.



<u>Organizational and management barriers</u>

Lastly, Team 2/4 looked at the organizational and management barrier. The applicable sub-barriers covered a wide range of topics, which will not be discussed in detail here; only a few areas merit discussion.

Organization structure itself is one of the strong traditions of Bonfire. The group is cohesive and functions very effectively; this was found to be a beneficial feature of Bonfire management.

Team 2/4 did find a potential barrier failure in the area of compliance culture. Students involved in Bonfire are both very compliant and very non-compliant. When group pressure to conform is strong, such as Bonfire traditions or student leader instructions, non-compliance rates are very low. When group pressure not to conform is strong, such as to consume alcohol and participate in horseplay, non-compliance rates are high. While this barrier failure is not relevant to the collapse, it could easily have been.

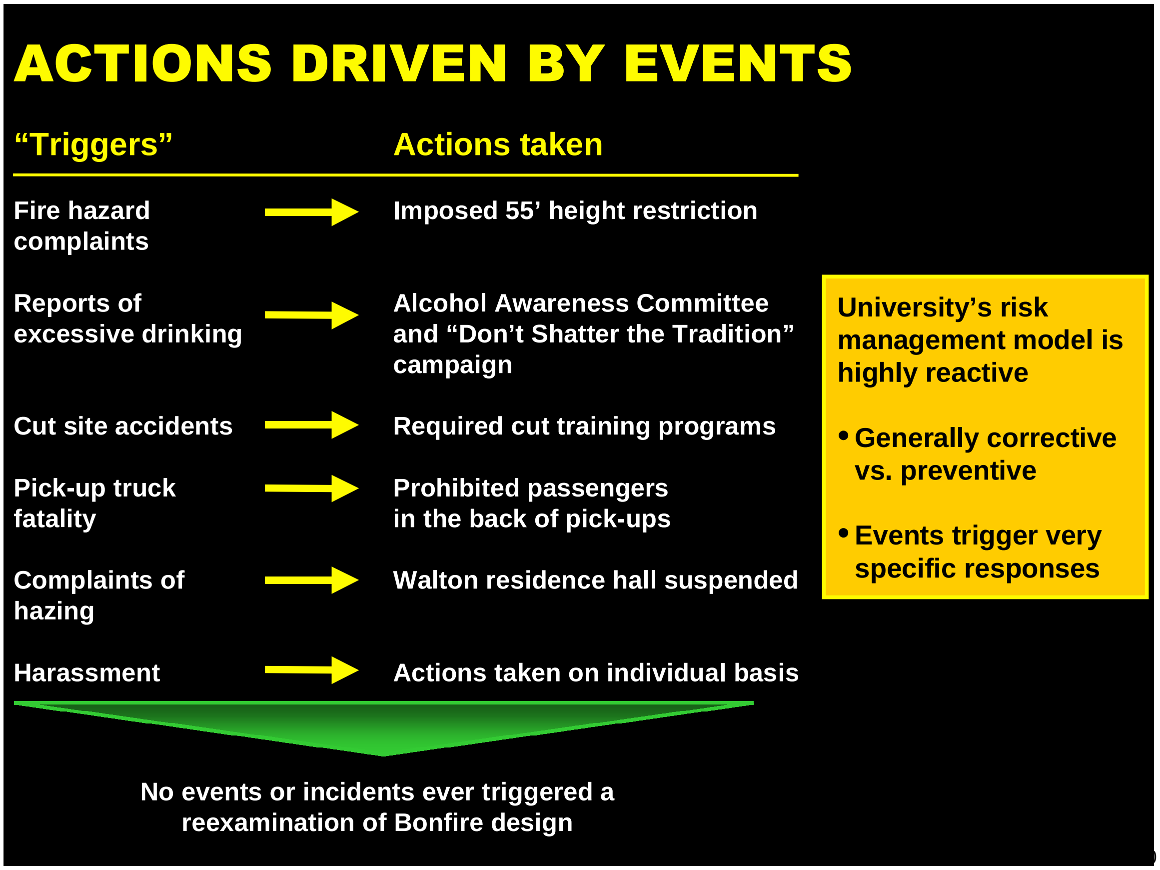
The story for management barrier failures starts out much the same way. Evidence is conclusive that the University's formal safety policy (as opposed to safety enforcement) is satisfactory and did not contribute to the collapse. University officials were found to value safety very highly and stated this in an articulate and convincing manner.

Also, evidence suggests that University practices are such that decision-makers have access to information needed to adjust management controls. Interview data with student leaders cite frequent visits to the cut and stack sites by the Bonfire Advisor and even by the president, Dr. Bowen himself.

An area of barrier failure not relevant to the collapse is independent internal oversight. While there is both a Bonfire Advisor and a Bonfire Advisory Committee, neither of them is responsible for structural safety. While independent internal oversight with these responsibilities might have reduced the possibility of collapse, such oversight is not a standard for administration in higher education. Thus, this failure is not considered relevant to the collapse.

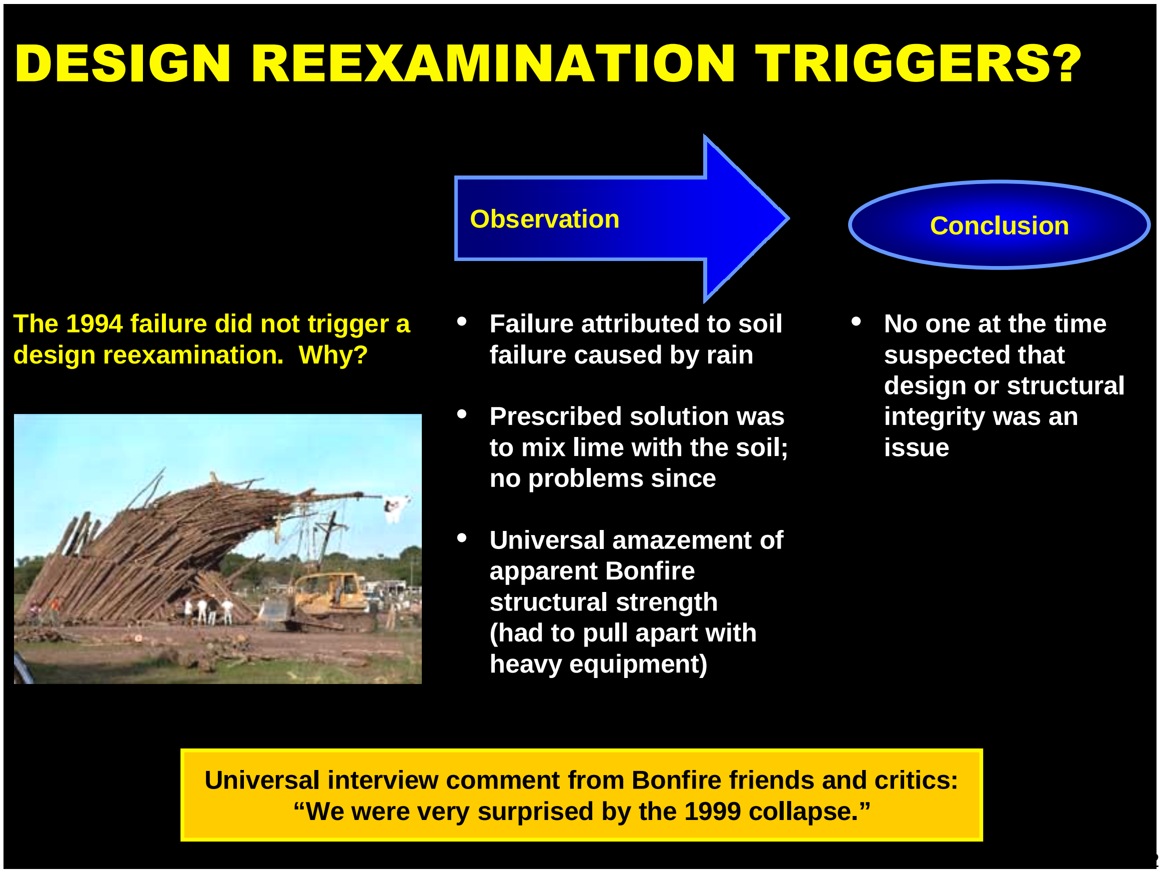
However, the investigation did uncover two significant management barrier failures that were relevant to the collapse. The first had to do with the University's reactive risk management model and a cultural bias that resulted in missed opportunities to identify structural problems.

Texas A&M addresses risks in student organizations reactively. Over the years, a number of incidents have set this model in motion, but always in a particular way. Specific triggers result in very specific responses. In no case did anything ever trigger this reactive model to look into Bonfire design.



But what about all the safety warnings issued over the years? It is commonly argued that people have been warning the University about Bonfire for a long time. The investigators examined these warnings carefully, read press accounts, and interviewed the most credible critics. It turns out that critics' warnings primarily addressed worker safety, environment, and burn time issues. No one interviewed recalled ever thinking that Bonfire structural integrity was an issue.

What about the 1994 mishap? A number of people claim that it should have been interpreted as a warning sign. Yet, it was attributed by everyone involved to wet and unstable ground, not structural integrity. In fact, structural integrity was praised because it required heavy equipment to pull the stack apart. It is easy to see why nothing triggered a design re-examination. It is also easy to see why Bonfire friends and foes alike agree – the 1999 collapse came as a complete surprise.



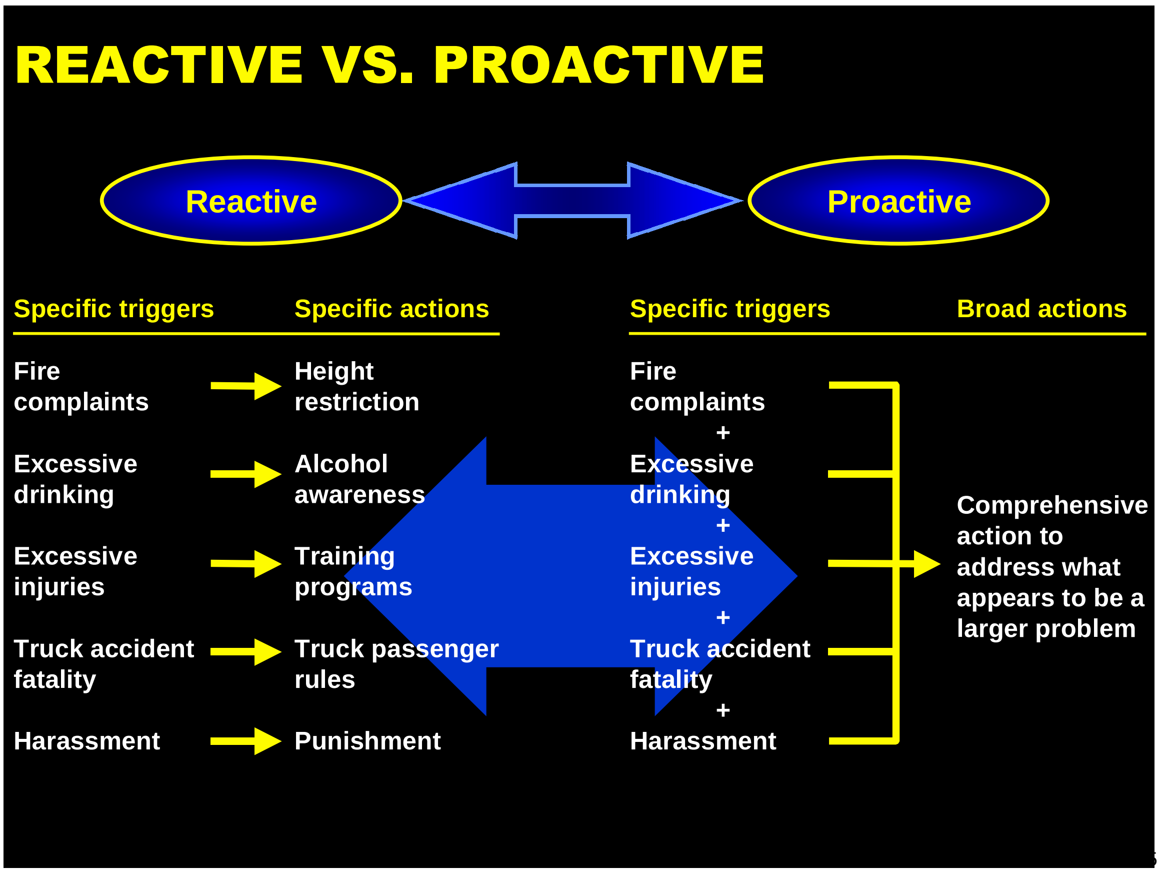
Actually, the Commission does not think this is a valid argument. The Commission’s view is that reasonable people obviously concerned with Bonfire safety, did in fact misinterpret these events and missed clear warning signs about structural integrity. This tunnel vision in decision making is due, in the Commission’s view, to a cultural bias in which legitimate courses of action outside past experience or contrary to the University’s pre-disposition are often not considered.

For example, the standard interpretations of the ’57 collapse, the height of the ’69 stack, the ’94 failure, and the fast recent burn times are all well known. In the Commission’s view, however, more objective interpretations or more conservative interpretations, which might have led to a structural reassessment, could reasonably have been considered. For example, why did no one consider the ’69 stack as a potentially hazardous 10-story structure held together with baling wire? Why didn’t anyone interpret the quick recent burn times as a problem with wire strength? Again, this is a result of cultural bias and represents a management barrier failure relevant to the collapse.

The second management barrier failure involves the lack of a proactive risk management model, which the Commission believes resulted in missed opportunities to interpret multiple, individually less significant problems as suggestive of a need for a broad and comprehensive Bonfire review.

Proactive risk management assesses risks and adjusts management controls based on lessons learned from other events. In the context of Bonfire, an example of proactive risk management would be if the University were to interpret intractable alcohol and hazing problems as an indication that the Bonfire organization could no longer successfully construct the structure.

In the Commission's view, the evidence of ongoing problems with Bonfire is so overwhelming that collectively these problems should have triggered a broader overall re-examination of Bonfire – one that included Bonfire design and construction. Unfortunately, this did not occur.



To support this conclusion, Team 2/4 benchmarked Texas A&M against several other universities and military academies to understand how it manages student-run, high-risk activities. Best practices gleaned from this work suggest that having a proactive risk management approach – where processes are designed to prevent rather than merely correct problems – is entirely reasonable and practical.

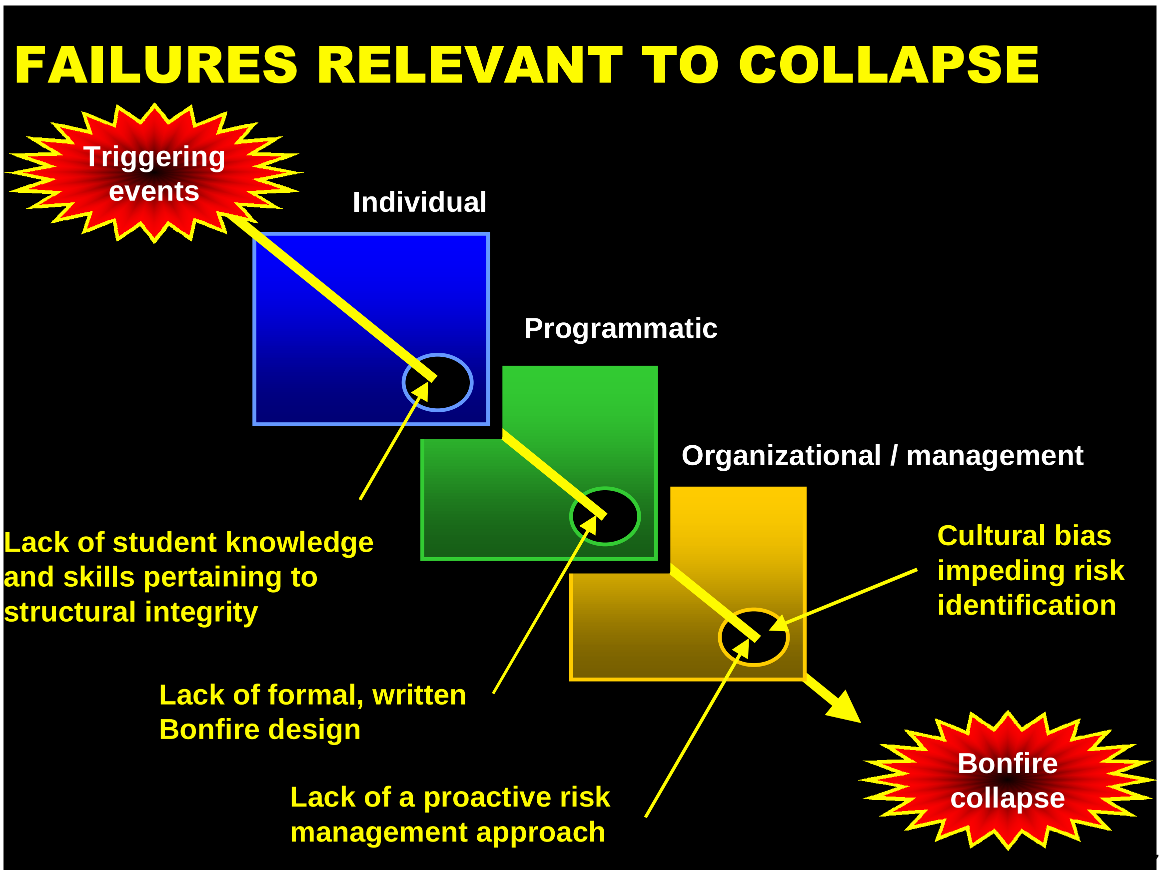
BENCHMARKS SUPPORT PROACTIVE APPROACH – EXAMPLES

Results from survey of 8 military academies and universities

	Observed best practice	A&M practice
Risk management process	• Active identification and mitigation of potential risks	• No proactive risk management for Bonfire
Management expectations and policies	• Formalized, clearly defined, and written	• Some safety-related policies, but not well enforced
Monitoring and trending	• Aggressive involvement by faculty / staff	• Peripheral / informal faculty involvement
External benchmarking	• Reasonable attempts to understand standards at other institutions	• None to minimal

In summary, the Commission identified four barrier failures that were relevant to the collapse:

- Lack of student leadership knowledge and skills pertaining to structural integrity
- Lack of formal, written Bonfire design plans or construction methodology
- Cultural bias impeding the identification and resolution of potential structural integrity risks
- Lack of a proactive risk management approach



Can any of these barrier failures reasonably be corrected?

To determine whether any of these barrier failures could be corrected, Team 2/4 applied a test to each barrier failure.

This test was designed to determine whether a barrier failure was a root cause and thus correctable. It was developed over the course of hundreds of failure evaluations and has proven to be a reliable mechanism for determining correctability. Failure of any part of the test means that it is not reasonable to expect that the barrier failure can be corrected and therefore cannot be considered an area of root cause.

- ¶ Test #1 – can leadership correct the problem?
- ¶ Test #2 – is it substandard, in other words, do comparable organizations clearly do a better job in preventing this failure?
- ¶ Test #3 – is it possible to correct the problem cost effectively?

In the Commission's view, skills and knowledge inadequacy of student leaders cannot be easily corrected. There is no evidence that students at other institutions demonstrate meaningfully greater skill and knowledge levels when engaging in similarly risky projects. Also, it would likely be cost prohibitive to train students, and given class turnover, it would have to be repeated regularly. However, with regard to lack of design, the cultural bias problems, and the lack of proactive risk management, the Commission feels these barrier failures pass the tests and are therefore correctable.

PREVENTABILITY TESTS

	Inadequate skills/ knowledge	No written design and no critical attributes	Cultural bias	No proactive risk management
Are leaders capable of correcting the barrier failure?	YES	YES	YES	YES
Is the barrier failure substandard?	NO	YES	YES	YES
Can the barrier failure be cost effectively corrected?	NO	YES	YES	YES

Preventable root causes (the last three columns)

How do the failed barriers fit together?

The 1999 collapse is neither a 1999 problem, nor a 1999 student leadership problem, nor a 1999 administration problem. It is instead a true example of an organizational accident with causes that existed for some time before the event. While no one person is responsible for the collapse, the aggregate effect of actions and decisions by students and University officials over many years created the physical conditions that made the collapse possible.

For the current administration, Bonfire was, and is, an institution. And leaders do not change institutions unless there is a clearly perceived need for change.

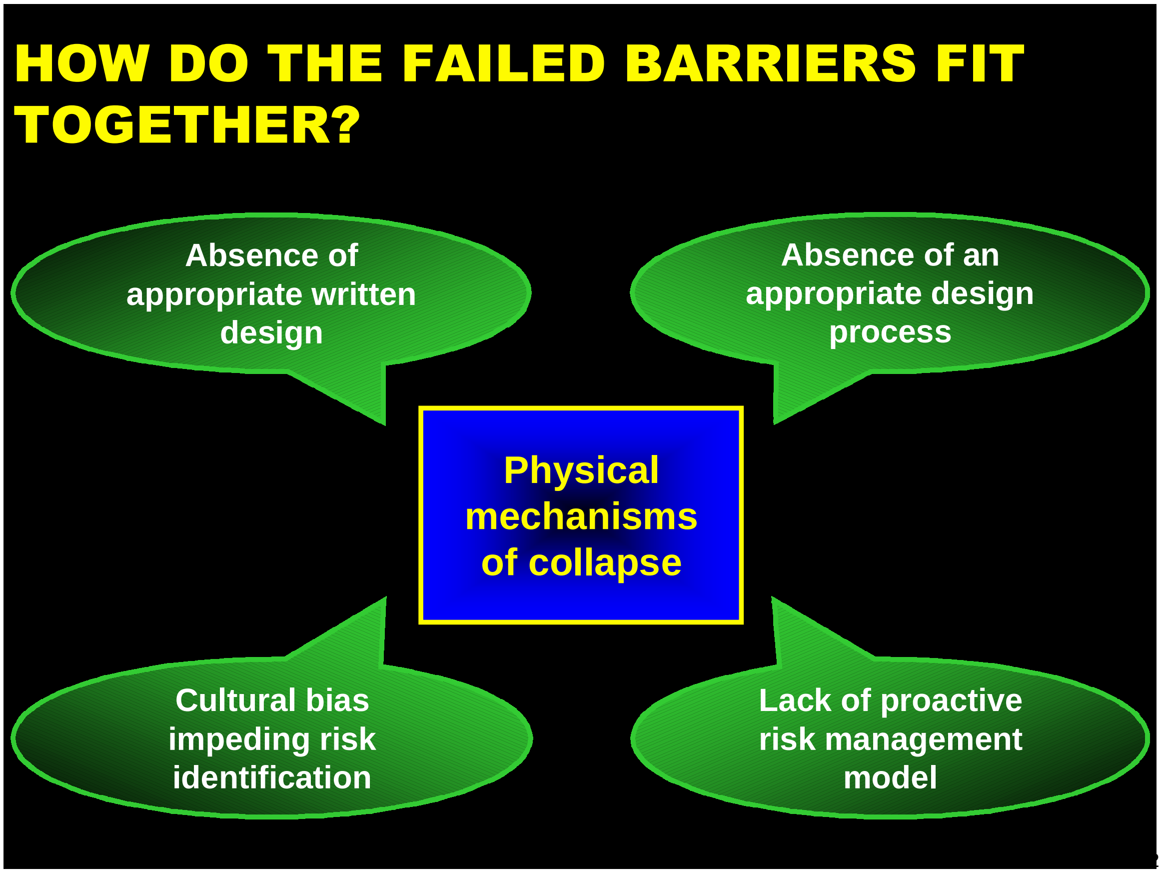
Bonfire has grown from a trash pile into a massive structure. From just a few participants to thousands. From minor mishaps to serious injuries. From a simple structure that could be designed and built by students, to a complex and risky structure that could not. For Bonfire, the University's role was to ensure that controls were in place so that if and when a failure occurred, the results would be non-consequential. But as Bonfire has grown in this complexity, the design and construction controls have remained the same.

¶ The University does not have a proactive risk management approach for student organizations. As a result, behavioral and safety problems never prompted past or present administrations to reassess Bonfire more broadly, perhaps, missing an opportunity to correct Bonfire design problems.

¶ The University has a culture that instills bias and tunnel vision in decision making. No credible source ever suspected or thought to inquire about structural safety. No one in the administration ever interpreted ongoing behavioral problems as indications that safe Bonfire design and construction was beyond the capabilities of student leaders.

¶ There was no appropriate design for Bonfire. Instead, important design details were communicated through an oral tradition. As a result, Bonfire was never built the same way twice, even though the accepted basis for safe design was "we have always done it this way, and it has always worked." Thus, changes made in the absence of a sound engineering construct reduced critical margins of structural safety.

¶ Student leaders were the sole design authority for the Bonfire structure. Yet they were not structural engineers and thus did not have the knowledge or skills necessary to identify and correct structural deficiencies of the type that caused the 1999 collapse.



Though its individual components are complex, the central message is clear. The collapse was about physical failures driven by organizational failures, the origins of which span decades of administrations, faculty, and students. No single factor caused the collapse, just as no single change will ensure that a tragedy like this never happens again.