Rubb Technical Report #9501

FIRE AND WIND PERFORMANCE - CASE HISTORIES

INTRODUCTION

Many companies and code authorities are interested in the performance of Rubb's PVC coated polyester cladding membrane with regard to it's behavior in high winds or fire. The actual field experience in this regard is excellent. And though the incidence of both fire and wind damage is very low, Rubb is slowly building a file of case histories which may be of benefit to those unfamiliar with Rubb membrane structure technology.

This technical report was first compiled in 1995 at which time Rubb had approximately twelve years experience in the United States. As of August 1995 Rubb is aware of only two instances of fire related damage to it's building range products. There are only three known instances of extensive wind damage to completed standard building range structures. In all these instances wind related membrane failure occurred at wind velocities measured in excess of the design specifications for the product. In no instance did damage to the steel structural frame occur. This report will be updated as Rubb receives information on new occurrences of fire or wind damage to our products.

This report deals exclusively with Rubb building range products manufactured at our U.S. manufacturing facility in Sanford, Maine. These products are characterized by the fact that they are engineered for full compliance with applicable building code requirements with respect to wind, snow and seismic loads. Rubb buildings are suitable for either permanent or temporary use.

Rubb also manufactures structures at facilities in both England and Norway. Our experience in Europe dates back over twenty five years where this type technology is now quite common Experience related to projects in Europe is detailed in other Rubb publications but is not addressed here.

Rubb has undertaken to address case histories related to fire first and then has addressed instances of wind damage second. We have listed references where possible so that those interested can contact the end user to verify the information contained herein.

FIRE CASE HISTORY #1

DATE: July 1985

LOCATION: Merrill's Marine Terminal
Danforth Street
Portland, ME 04101

CONTACT: Mr. Armand Demers
Telephone: 1-207-772-3254

BACKGROUND

Merrill's Marine Terminal is the largest U.S. dry bulk and break bulk marine terminal north of Boston, Massachusetts.

Merrill currently has three Rubb buildings in use at their facility which enclose over 1.6 million cubic feet of storage space. In August 1995 Merrill ordered a fourth Rubb structure which will enclose an additional 600,000 cubic feet. Merrill uses their Rubb structures for storage of many commodities including high quality kraft paper, waste paper, starch and tapioca flour. None of the Merrill facilities are sprinklered.

DESCRIPTION OF EVENTS

In the summer of 1985 while personnel were at lunch break in a separate structure, a propane powered forklift in one of Merrill's 26,000 square foot Rubb warehouse structures experienced an electrical fire in the engine. The heat from this fire caused a buildup of pressure in the forklift's propane tank. This resulted in a relief valve activating to relieve excess pressure. The vented propane quickly ignited. This created a geyser of flame which shot fifty feet in the air.

The intense heat melted a 5' x 10' hole in the roof of the building and the sight of the flames and smoke alerted personnel in a nearby lunch room to the fire. In minutes, the fire department was on the scene. However due to the intense heat of the fire, they were forced to wait for the propane tank to exhaust it's supply of propane.

The PVC membrane of the Rubb building melted away from the immediate source of heat and flame. However, it did not support combustion or propagate flame away from the immediate area

Rubb Building Systems, Inc. P.O. Box 711, Sanford Airport, Sanford, ME 04073 / 207-324-2877

that had melted. Rubb personnel were on site to repair all damage to the structure in two hours at a cost of approximately $200 in materials and labor. There was no damage to stored inventory in the structure or to the supporting steel frame structure.

ADDITIONAL CONSIDERATIONS

Both Merrill's Marine Terminal and the Portland Fire Department were very pleased with the behavior of the cladding membrane. The consensus was that had the building been a more conventional metal or concrete block structure, the damage would have been much more substantial with possible structural fatigue, a large amount of smoke damage and even possible explosion of the tapioca flour stored inside the building.

It was also generally agreed that the fire would have been too intense for a conventional overhead sprinklers to extinguish.

With the Rubb structure, heat and smoke were vented through the roof and property and structure damage were minimized

FIRE CASE HISTORY #2

DATE: May 1995

LOCATION: I. Zaitlin and Sons
542 Elm Street
Biddeford, ME 04005

CONTACT: BUSINESS CLOSED

BACKGROUND

I. Zaitlin and Sons was involved in recycling of paper and metal products. Their facility's primary operations involve collection and baling of waste paper. The company stores baled paper on premises prior to shipment for resale. As of the date of this report, Zaitlin's has three Rubb structures on site with additional structures under consideration.

DESCRIPTION OF EVENTS

In May 1995, a fire started in a paper storage area at the Zaitlin facility. The fire quickly generated intense heat and involved a 65' x 95' Rubb building and an adjacent covered paper storage area which consisted of steel joists covered with steel roof decking. Both of these areas were unsprinklered. As the temperatures increased inside the Rubb building, the roof membrane melted away from the fire source and vented thus allowing heat and smoke to escape from the structure. The PVC did not support combustion and areas outside of immediate contact with heat and flame were not damaged by the fire.

Physical damage was limited to a single PVC panel which was immediately above the burning bales of paper. Since the remaining PVC panels were approximately 50% through their estimated twenty year useful life and had sustained some smoke damage, the decision was made to replace the structures entire PVC covering with a new cover. However, the steel frame of the Rubb building did not sustain any structural damage. Total damage to the Rubb building attributable to the fire was under $10,000.

Damage in the adjacent metal covered storage area was much more substantial. The intense heat of the paper fire caused buckling of the steel joist framing. Though the roof did not collapse, the structure was damaged to the point of total loss. At the time of this report I. Zaitlin and Sons expected the cost of the replacement structure to be in the range of $70,000, nearly nine times the cost of the damage to the Rubb structure on a per square foot basis. It is interesting to note that the Rubb building was totally repaired and operational within two weeks of the fire. However, nearly three months after the date of the fire, the metal clad roof structure had not been replaced.

ADDITIONAL CONSIDERATIONS

REDUCED RISK FOR DAMAGE TO STORED MATERIALS AND EQUIPMENT

In terms of potential economic loss, the most important components of Zaitlin's operations are the machines

which bale paper. This equipment has a replacement cost of several hundred thousand dollars, a value which is substantially greater than the value of the Rubb building which houses the machinery. An interview with Zaitlin management following the fire indicated that a baling machine likely would have suffered substantial damage had it been located in the metal clad storage area which contained the heat of the fire. As proven by Factory Mutual tests, a Rubb building's self-venting membrane allows heat and smoke to escape the building and resulting air temperatures are significantly lower than would be expected in a non-vented metal structure.

REDUCED RISK TO FIRE FIGHTING PERSONNEL

Fires in conventional metal clad, masonry, or wood structures create an environment in which fire fighting personnel can become easily trapped inside smoke filled, walled areas with no easy means for escape. The Rubb structure by contrast will self-vent to allow heat and smoke to escape. Should a fire fighter need to make an emergency exit, the sidewall PVC of a Rubb building can be cut with knife or their sharp implement allowing quick exit.

Another major risk to fire personnel is the need to vent the roof of a conventionally constructed building to allow heat and smoke to escape. This procedure normally entails the need for fire personnel to climb ladders to the roof of a burning structure. The obvious danger is that personnel are at risk of serious injury should the roof structure fail while firefighters are on the roof. In a Rubb structure which self vents, there is no need for fire fighting personnel to be put at risk. In fact, the areas closest to the heat source will be the first to vent open thus allowing immediate access to the flame source with fire hoses.

Discussions with the City of Biddeford, Maine Assistant Fire Chief following the Zaitlin fire revealed that the fire department encountered no problems fighting the fire in the Rubb structure. The self venting roof allowed smoke to escape thereby improving visibility and reducing heat levels in the structure.

FACTORY MUTUAL CASE HISTORY

DATE: August 1994

LOCATION: Factory Mutual Research Corporation Test Center

West Gloucester, Rhode Island

CONTACT: See Factory Mutual Test Report

BACKGROUND

The U.S. Department of Energy is a major user of Rubb building range products at major facilities such as Oak Ridge, Tennessee; Fernald, Ohio; Los Alamos, New Mexico; Hanford, Washington; Savannah River Site, South Carolina and various other locations.

A concern of fire safety personnel at these sites was the performance of the Rubb PVC membrane under actual fire conditions. Of particular interest was a concern that conventional sprinkler and smoke detection systems would function properly in the event that the membrane self-vented.

The Factory Mutual Test involved the full scale testing of a 40' x 50' Rubb BVE range building erected inside the West Gloucester facility. The Factory Mutual corner test protocol called for a stack of oak pallets to be ignited in one corner and observed for fifteen minutes. A complete test report and videotape of the test is available from Rubb upon request.

DESCRIPTION OF EVENTS

The test proceeded as expected with the progressive combustion of the oak pallets. To quote the Factory Mutual abstract, "The first smoke detector (ionization type) actuated at 24 seconds after ignition and by 1 minute 7 seconds, all installed smoke detectors had actuated. Fire sprinkler actuation's occurred at 4 minutes 59 seconds and 5 minutes 34 seconds for fast response and standard response sprinklers, respectively.

After severe exposure of the test structure to the fire source for a 15 minute duration, the test concluded with no apparent self-sustained propagation of the fire by the fabric covering and no fire damage to structural support members."

ADDITIONAL CONSIDERATIONS

The Factory Mutual test provided independent testing confirmation of the behavior of a Rubb structure in an actual fire situation. All smoke detectors and fire sprinklers functioned normally and the membrane did not propagate flame.

Another important consideration was that the self-venting action of the membrane resulted in far lower temperatures than would have been expected in a building which did not vent. The post test briefing revealed that maximum air temperature within the structure reached approximately 700 degrees Fahrenheit significantly below the temperature of 1000 degrees which is considered to be the danger point for "flash over" to combustibles not immediately in contact with the flame. In addition, temperatures in the steel frame reached approximately 1000 degrees. This did not result in any structural damage to the Rubb frame, however had the structure been aluminum, structural failure most likely would have occurred.

The test results also show that near ceiling gas temperatures reached 500 degrees Fahrenheit prior to venting of the membrane. After the membrane fully vented, air temperatures fell off significantly and steel temperatures began to stabilize even as the incident heat flux from the fire increased. Had the structure roof not vented, as would be the case with a metal roof deck, both the steel and gas temperatures would have been substantially higher. This would have raised the risk of structural failure and flash over within the structure. In addition, smoke levels would have been significantly worse, thus decreasing visibility for personnel within the structure.

The Factory Mutual test report concludes with the statement, "Fabric used for construction of the tension supported membrane structure evaluated during this program will not propagate flame or sustain combustion when exposed to a severe fire. Only fabric immediately adjacent to the flaming fire source became involved in the fire. Smoke detectors will provide early warning against fire prior to burn-through or venting of the structure."

FIRE PERFORMANCE HISTORY OF FLAME RETARDANT MEMBRANE STRUCTURES

DATE: January 1984

LOCATION: Article in Building Standards magazine

In January 1984 Mr. Richard N. Seaman wrote an article for Building Standards which focused on the fire performance history of membrane structures. This article also contained information on the various flame test standards and test procedures in use for fabric structures. Much of the information in this article remains appropriate in 1995.

Mr. Seaman's article also documents several examples of membrane structure fires and membrane structure fire tests. This information provides additional evidence of the fire performance indicated by Rubb's past experience with both actual fires and the Factory Mutual test.

Rubb can provide copies of the Richard Seaman article upon request. Alternatively, the reader is encouraged to call Seaman Corporation of Wooster, Ohio, one ot the foremost U.S. manufacturers of PVC coated polyester fabrics. Their number is 216-262-1111.

WIND DAMAGE CASE HISTORY #1

DATE: September 1989

LOCATION: Naval Supply Center
Charleston, South Carolina

CONTACT: Base Closed

BACKGROUND

Hurricane Hugo directly struck Charleston, South Carolina in September of 1989. At the time the largest concentration of Rubb buildings in the U.S. was erected at the Naval Supply Center and Naval Shipyard

in Charleston. A total of five Rubb buildings were subjected to Hugo's winds. These winds were clocked at velocities in excess of 135 mph. In these type storms it is not unusual for localized tornadoes to form with wind velocities much higher than those of the hurricane itself.

DESCRIPTION OF EVENTS

When hurricane force winds in excess of 135 mph struck Charleston, there was tremendous property damage. At the Supply Center, three Rubb buildings were located adjacent to one another. Two of these buildings had substantial damage to the membrane. The third structure lost one half of it's cover. Heavy steel rolling doors on the Rubb buildings were blown in and ventilation fans were torn from their mounts. The structural frame of the Rubb buildings however was not affected and the buildings did not collapse. Sections of the Rubb membrane were found several miles away indicating the severity of the wind.

It is not possible to determine the initial cause of membrane failure, however it is surmised that roof, wall and door panels torn off metal buildings adjacent to the Rubb structures became projectiles flying about the site and piercing the Rubb fabric membrane. It is impossible to determine if impact from these panels caused the initial damage to the Rubb structures. However, it should be noted that another Rubb structure at the Supply Center and the Rubb structure at the Naval Shipyard were not damaged by Hugo.

ADDITIONAL CONSIDERATIONS

Rubb was able to provide replacement PVC sections and have the damaged warehouses totally repaired within approximately four weeks of the storm. Adjacent metal sheds were not repaired for several months thereafter.

The total repair cost to the Rubb structures totaled approximately $2.30 per square foot for the approximately 50,000 square feet of Rubb structures involved in Hugo.

The Rubb membrane does not function to structurally brace the frame as in the case with some other membrane structures. The Rubb membrane also does not provide the diaphragm action of metal roofs, which are relied upon to brace the frame of a steel building or the steel roof joists of a concrete masonry structure. Instead, the Rubb structural frame is entirely separate from the cladding material resulting in acceptable structural performance should the cladding be damaged. The results of Hugo indicate that the membrane can entirely separate from the structural frame without damage to the underlying structure or the contents of the building which could occur with wind blown metal sheets.

WIND DAMAGE CASE HISTORY #2

DATE: August 1992

LOCATION: McDermott International
Morgan City, Louisiana

CONTACT: Don Patureau
Telephone: 1-504-631-2561

BACKGROUND

Hurricane Andrew, a category 4 hurricane with winds in excess of 145 mph touched down in Morgan City in the late summer of 1992. The 65' x 100' Rubb building had it's PVC cover torn away by the high winds but did not sustain structural damage.

WIND DAMAGE CASE HISTORY #3

DATE: July 1995

LOCATION: Mid Atlantic Terminal
Salem, New Jersey

CONTACT: Mr. Butch Irvine
1-609-935-3423

BACKGROUND

In late July 1995 a severe thunderstorm in Southern New Jersey brought high winds and localized micro-bursts. Winds were clocked in excess of 110 mph at a location near the Mid Atlantic Terminal site. Mid

Atlantic Terminal operates a facility which includes an 82' span Rubb building installed in 1989. This building is designed to BOCA code standards based upon a 90 mph basic wind speed.

According to Mr. Irvine who was present during the storm, the first failure in the Rubb structure occurred when it's 18' x 24' steel roller shutter door failed. This caused a rush of air pressure into the structure which combined with exterior pressures and suctions to pull off one of the three PVC panels on the structure. The remaining panels survived the storm and no structural damage occurred. The approximate cost of the repair amounted to just over $1.30 per square foot of floor area.

Mr. Irvine also reported that conventional structures at an adjacent facility were heavily damaged by the storm and that stacked freight containers in their yard were blown over by the force of the winds.

WIND DAMAGE CONCLUSIONS

Rubb's experience in situations where it's structures have been exposed to winds in excess of design velocity has been good. In no instance has a structure collapsed and in no instance has there been injury to personnel. Repairs to the damaged membrane have generally been performed quickly and at relatively low cost.

The causes of membrane failure have been difficult to determine with certainty. In at least two of the three instances of damage, it appears that damage may have been precipitated by the failure of conventional roller shutter doors in the structures. These doors are good quality Cookson brand steel doors equipped with wind locks and designed to withstand a minimum wind force of 90 mph (about 20 psf).

In at least one instance, it appears failure of the membrane may have occurred when the structure was struck by airborne metal panels that had torn off adjacent metal clad structures. It does not appear that the flexible membrane panels which tear from the Rubb structure present the hazard to personnel and stored equipment that is present when rigid panels tear loose from metal structures.

The evidence available supports the conclusion that Rubb structures are properly designed to resist substantial wind loads. When wind loads have greatly exceeded design capacity, Rubb structures have not suffered structural damage and the membrane appears to separate from the frame before the point of structural failure is reached. Repair costs to damaged membrane panels have not been excessive.

DCN 8/95