Gas Station Canopy Failures

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Snow related canopy failure in Cleveland Ohio during the winter of 2006/2007. Courtesy of WKYC.com.

Gas station canopies are inviting and provide protection from rain, snow, and hot sun when filling vehicles with gas. During the winter of 2006-2007, several canopy collapses were reported in the media. The collapses were reportedly attributed to the weight of ice and snow.

The canopy collapses should increase public awareness of the important role that structural engineers play in protecting the safety of the public. The collapses also serve as a warning to structural engineers and building officials not to sacrifice basic building standards or to submit to demands for more economical structures.

Failure Classification

There are several categories of canopy failure including framing, cladding, foundations, and connection of framing to the foundations i.e. base plates and anchor bolts. Canopy collapse is a result of any one or a combination of failure of these components. Failure investigations revealed a lack of foundation engineering, incomplete construction documents, and poor construction.

Canopy Design and Construction

It is easier to understand what can lead to a failure if one has an idea of how a canopy is purchased and constructed. In most cases, the service station owner or operator purchases the standardized, pre-engineered canopy from a dealer specializing in gas station equipment. The canopy can be either a standard product, or one that is customized to meet specific needs.

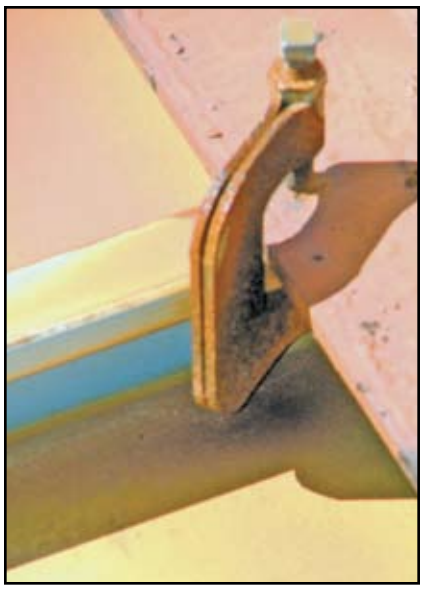
Foundation design and construction are most likely not included with the purchase package. The engineer who designs the framing does not know where the canopy will be erected, is not familiar with the site, and/or has not been retained to design the foundations. The foundation and anchorage of framing to foundations is given less priority, and in many cases is left in the hands of the builder.

Large canopies are supported on four or more columns. Smaller canopies that are supported by one or two columns are more vulnerable to framing failure due to lack of redundancy.

Cladding Failure

Light gauge metal cladding forms the canopy fascia and the soffit. The fascia displays the oil company's logo and colors. The soffit forms the canopy ceiling. For ease of construction, the soffit panels are suspended from the roof framing with clamps only. This type of fastening system is unsafe and has led to failures.

The soffit panels are installed with a slight pitch to drain to perimeter roof drains. The accumulation of debris and leaves, as well as trash thrown on the roof, can lead to partial or complete clogging of the roof drains. The fascia and the soffit form an open dish and support the full weight of snowfall.



Clamp used to suspend ceiling panels from steel framing.

The weight of accumulated ice and snow build up has resulted in cladding failures. Fascia and soffit panels have detached from the framing and fallen on cars, people, and equipment below.

In two cases of snow related canopy failures in Cleveland, Ohio, failure occurred due to detachment of cladding suspended from the framing. The first failure occurred after a prolonged period of freezing temperatures accompanied with high accumulation of snow fall. Weather records and measurements made by the authors indicate that the weight of accumulated snow did not reach the snow load design values required by local and national codes. The second failure occurred as soon as temperatures warmed above freezing, suggesting concentration of loading from ponded snow melt as the cause.

Typical flat canopy framing, ceiling, and fascia panel construction.

Some have suggested that pitched roofs will eliminate the canopy failure, because pitched roofs are less inclined to ponding and the build up of snow. However, regardless of the shape and configuration of the canopy roof, failures can only be prevented with proper design and construction followed by regular maintenance.

Foundation and Connection Failure

In one failure investigation in which wind speeds less than 50% of code requirements caused a two column canopy to lean, the culprits were found to be improperly designed and fabricated base plates, insufficient anchor bolts, and insufficient footing size. Occurrence of code specified wind load would have been a disaster. Imagine carrying an umbrella in a strong wind.

When drawings were reviewed as part of canopy failure investigation, the authors found that the framing design complied with the appropriate codes and standards. That is, with the exception of base plate and anchor bolt design which were found to be less than stellar.

What Can be Done to Avoid Failures

Steps required to reduce the likelihood of canopy failure include design and analysis by a competent structural engineer, preparation of detailed construction drawings and specifications for the superstructure, foundations, and connections, building in accordance with construction documents, and routine maintenance by the station owners.

Building officials should make sure that the construction documents contain adequate information for construction, and that drawings conform to the building codes and standards. The building inspectors must make sure that the contractor follows the construction documents.

Proper construction will protect the public, and in turn will reduce liability for the owners and the insurance companies.▪

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Anchor bolts and washer are being pulled through oversized holes in the baseplate, causing the canopy to lean.