November 2003 - ISSUE 1

Aspec Newsletter

ASPEC ENGINEERING PTY LTD
ABN 22 105 267 016

Level 3, 349 Coronation Drive
Milton QLD 4064

PO Box 1843
Milton QLD 4064

T (07) 3842 3114
F (07) 3371 7300

www.aspec.com.au

INSIDE THIS ISSUE

For any enquires regarding this newsletter including adding or removing your name from the newsletter distribution list please email: ksmithcottrell@aspec.com.au

Introduction

This is the inaugural newsletter for Aspec Engineering. We are a new company providing quality engineering to the mining and resource industries and ports. The benefits to our customers include:

- Keeping new and existing assets in a safe condition
- Optimisation of investment in fixed assets through refurbishment.
- Minimising disruption to the operation of facilities during modifications.

We provide a full range of services including investigation, design, construction and maintenance using the most appropriate tools and technologies. In addition to our own expertise we have a commitment to Strategic Alliances with specialist organisations and practitioners to ensure that leading expertise is available in our service areas, categorised as follows:

- Engineering advice and design solutions
- Materials handling machine investigations and risk studies
- condition assessments and remediation works

The objective of this newsletter is to share knowledge and experience gained during the course of our work. We would be pleased to receive suggestions from readers as to the subjects and types of articles of interest.

by Frank Gatto *(fgatto@aspec.com.au)*

Wind Loading - What About Older Structures?

Owners and operators of industrial and mining facilities and ports in Australia are generally aware that the ability to resist wind loading is a major consideration to ensure the safety of their assets. However given the many changes to wind loading standards and building regulations over the years there is a lot of confusion as to what design conditions should be adopted and how this might affect older structures. Before elaborating on this it is useful to go over some background as to how wind loadings are determined.

If we design for an “average” wind speed then there will be many occasions when this is exceeded, sometimes by a large amount. This would result in many failures when a “worst case” storm hits. Consequently the design wind speed is set at a level that has only a small chance of being exceeded in the life of a facility but at the same time is not so high as to increase costs excessively. For a normal building the design ultimate wind speed has approximately 1 in 10 chance of being exceeded during the next 50 years. This wind speed should occur, on average, around once in every 500 years.

Australia does not have wind speed records over the past 500 years, so how can an estimate be made? The wind speed data from anemometer stations all over Australia has been collected and analysed. The combined data makes it possible to make reasonable estimates of this design wind speed. Some areas are affected by cyclones and the wind speeds in these areas are higher than in other areas. Under the latest Australian Standard AS 1170.2 2002 there are 4 major wind speed regions in Australia to account for this effect.

Once the regional wind speed has been found other factors have to be considered. It is well known that exposed areas, such as the beachfront, or the tops of hills, are more windy than sheltered areas. Wind speed usually increases with height, so taller structures have higher wind loads than low level structures. These effects are taken into account by applying factors published in the wind loading standard.

Once the wind speed has been estimated, design pressures are determined and these converted to loads on the structure or building. Shape is important eg. the wind load on an H-beam will be higher than on a pipe. Wind can cause uplift on many roofs, but if the wind can get inside the building and create a positive pressure at the same time the loads on the roof will be much higher. It has been found that in small areas around the eaves, ridges and corners, the pressures are higher than in other parts of the building. Many tests have been carried out, both on models in wind tunnels and on full-scale buildings, to find the wind pressure distribution for different shapes and configurations so good guidance is now available.

There has been a gradual increase in design wind pressure over the years. Standards prior to 1971 did not consider the increase in wind speed with height, so this is a limitation, which needs to be realised on older structures. The following table gives some appreciation of how wind design pressures published in Australian Standards increased from the period prior to 1971 up to 1989 in central Queensland. One of the reasons for this was the knowledge obtained following devastating cyclones such as Althea, which hit Townsville in 1971, and Tracy, which hit Darwin in 1974. From the table below it can be seen that the wind pressure (and design pressure) for a structure designed between 1989 and 2002 would be twice that for a structure designed prior to 1971.

Based on our experience, the following recommendations are made:

- If a structure is to be modified or extended, it should be assessed to the latest wind standards and upgraded where possible.

- For existing structures, owners need to know the wind standard for which the structure has been designed, how susceptible is the structure to wind (for some structures the dominant load is not wind) and what is the consequence of a major wind storm. They need to be aware of the risks involved and have risk reduction measures in place in the event of a major wind storm.

Year	Australian Standard	Basic Wind Velocity	Formula for Pressure	Height Multiplier	Design Pressure
Pre 1971	SAA Int 350	90 mph	$P=V^2/100$	None	0.97
1971	CA 34.2-1971	100 mph	$P=V^2/400$	1.08	1.3
1973	AS 1170.2-1973 1st Edition	45 m/s	$qz=0.6\ Vz^2 \times 10^{-3}$	1.08	1.42
1989	AS1170.2-1989 5th Edition	49 m/s	$qz=0.6\ Vz^2 \times 10^{-3}$	1.12	1.82

Engineering Drawing Management

Mining and resources-based companies have a large investment in physical assets that require on-going maintenance and refurbishment. Access to accurate, up-todate drawings is essential for the efficient operation of these companies. Electronic drawing management can help achieve this objective. Advantages of electronic document management include:
- Fast retrieval
- Flexible indexing
- Share drawings easily
- Improved security
- Disaster recovery

Imaging of Drawings

This involves scanning manual drawings and converting them to a standardized electronic format. Issues include:
- Which drawings to scan-convert? Do you convert whole drawing groups or do this on an as-needed basis?
- Is the document imaging to be done in-house or outsourced?
- What is the quality of drawings to be converted? Do the drawings require some form of clean-up?
- What is format of the drawing image? Raster (pixelbased image formats such as TIFF, JPG or PDF) or vector based images (for use in programs such as AutoCad).
- What storage method is preferred? Storage options include magnetic media (hard drives), compact discs and DVDs

Indexing of Drawings

A drawing management system should provide methods for organizing information for future use. Indexing of drawings needs to be easily used and understood. Issues for indexing of drawings include:
- Is the indexing system to be integrated with the company's Enterprise Resource Planning System (eg SAP)?
- Which category fields should be used? Index fields such as drawing number, title, issue date and version number should be included as a minimum.

Along with index fields, an imaging system should provide a visual method of finding documents similar to the folder structure in Microsoft Explorer. A flexible folder structure eases the transition from paper filing to electronic filing and makes drawing management systems more successful.

Retrieval of Drawings

Retrieval is where a powerful indexing system pays off. Users need to be able to use common sense tools to find any documentwithin the system based on what they know. Issues with retrieving of documents include:
- Who has access to the drawings? A fully featured imaging system should provide different levels of user access.
- Are the drawings available on-line?
- To maximize the effectiveness of drawing retrieval, a good search system should be able to combine index field searches with folder name searches into one comprehensive search.

Some Questions About Structural Engineering

Over the years, a number of questions that people ask of structural engineers keep coming up. Some of these question include:
- Why is a structure that has stood without incident for over 20 years suddenly become "unsafe" when checked against the new standard?
- Why is this structure still standing 3 years after I was told to take some remedial actions immediately?
- If the "factor of safety" is 1.5, does this mean I have 50% more capacity in the structure?
- How far can I reduce the "factor of safety" before the structure becomes "unsafe"?
- What is the service life of a typical structure?

In order to answer these questions, we need to understand some of the basics of structural theory. Consider a steel bin as shown in the figure. We wish to assess the structural integrity of one of the steel columns.

The main aim in assessing a structure is to ensure that the loads which act on the structure are less than the capacity of the structure. For this example, the loads acting on the bin structure are the dead loads, material loads and wind load.

Dead loads include the weight of the structure, any supporting equipment and any other permanent loads. Generally dead loads are calculated by measuring the bill of quantities although sometimes dead loads can be measured directly by weighing the structure or its components. For this example, the dead load supported by the column is calculated to be 100 tonnes.

Material loads include the weight of the material in the bin and the forces due to the dynamic effects of loading and unloading the bin. The material weight is calculated by multiplying the volume of the bin by the material density. The dynamic effects of loading and unloading are calculated from material flow theory and test results. The methodology for calculating material loads is given in AS 3774 - Loads on bulk solids containers. For this example, the material load supported by the column is calculated to be 400 tonnes.

Wind loads are calculated based on wind speed, location and type of structure. The calculation of the wind loads is given by AS 1170.2 - Wind loads. For this example, the wind load per column is assumed to be 1000 tonnes.

Therefore, in summary, the total load supported by the column is calculated to be:

Dead load	100 tonnes
Material load	400 tonnes
Wind load	1000 tonnes
Total load	1500 tonnes

The capacity of the column is calculated using structural analysis techniques including formulas based on theory and testing and computer modelling techniques such as finite element analysis. For this example, the column capacity is calculated to be 2250 tonnes. The loads on the column are less than the capacity of the column and therefore the column should be "structurally safe". In fact, we have a "factor of safety" of 1.5.

Unfortunately the world is full of inaccuracies and we cannot calculate the loads or capacity precisely. If we assume that the loads and capacity are not known precisely but have some form of probability distribution then we would give a range and confidence level for the loads and capacity. For example, we may say that we are 90% confident that the dead load is between 90 tonnes and 110 tonnes. Similarly, we may say that we are 90% confident that the material loads are between 300 tonnes and 500 tonnes and that the capacity is between 1900 tonnes and 2600 tonnes.

Wind speeds are generally assessed in a different manner. For the average structure the design wind speed should have a 10% chance of being exceeded during the next 50 years, that is, this wind speed should occur, on average, about once every 500 years.

If we fit some form of probability distribution functions to each of these parameters and do a simulation, we find that there is a 0.06 probability that the loads will be greater than the structure's capacity.

What does this mean? From a practical point of view, this figure means very little.

In order to illustrate the significance of the probability of failure, let us look at an example such as a weather forecast. If you asked someone what the weather is going to be like tomorrow, they may answer that there is a 30% probability of rain. From a practical point of view, this figure is of little use. It does not say that it will rain for 30% of the time nor does it say it will only rain 30% of a particular intensity. What you really want to know is: do you need to bring an umbrella. The only way to know when to bring an umbrella is to set a target of say, 20%. If the probability of rain is greater than 20%, you bring your umbrella, otherwise you leave your umbrella at home. You hope that over an extended period of time you will not get too wet.

Similarly for structural engineering: a target safety level is set such that over an extended period of time not too many structures will exhibit distress or failure. Fortunately, the codes of practice for structural design, such as AS4100 - Steel structures and AS3600 - Concrete structures, have considered and included a suitable level of safety in the form of load factors to allow for the uncertainty in calculation of loads and capacity reduction factors to allow for uncertainty in material strength.

Let me now try to answer the questions presented at the beginning of this article.

1. Why is a structure that has stood without incident for over 20 years suddenly become "unsafe" when checked against the new standard?

As new information concerning the behaviour of structures becomes available, the design codes of practice are upgraded. For example, after Cyclone Tracey devastated Darwin in 1974, it was decided to upgrade the wind code. A particular structure may not comply with the relevant design standard but may still be standing because it has not experienced the design loads.

2. Why is this structure still standing 3 years after I was told to take some remedial actions immediately?

The answer to this question is similar to the answer of the first question. A structure such as the bin described in the previous example may experience the dead loads and material loads all the time, but there is only a 10% chance of the wind load being exceeded within the next fifty years.

3. If the "factor of safety" is 1.5, does this mean I have 50% more capacity in the structure?

The answer is no. The "factor of safety" is to provide a level of safety due to the uncertainties in the calculation of the loads, the structural capacity and the overall uncertainty in the design process. It is not a measure of the extra capacity of the structure.

4. How far can I reduce the "factor of safety" before the structure becomes "unsafe"?

Most design codes of practice provide guidelines for the design of new structures. Generally, the safety levels incorporated into the codes of practice are suitable for all types of structures from small sheds to high-rise buildings. For new structures there does not appear to be any great saving in reducing the factor of safety by undertaking a comprehensive analysis. However, for existing structures, this is not the case. The cost of retrofitting on existing structures can be very high compared to the cost of new construction. Therefore if information about the actual structure is available, it may be possible to reduce the load factors and still have the same level of safety.

A paper by D.E. Allen, Limit states criteria for structural evaluation of existing buildings (Can. J. Civ. Eng, Vol 18, 1991) describes a methodology to evaluate existing structures. For example, if the dead load is measured and if the failure is of a local nature and unlikely to injure people, then the dead load factor may be reduced from 1.25 to 1.12. Similarly, the variable load factor may be reduced from 1.5 to 1.2.

5. What is the service life of a typical structure?

This is a difficult question to answer and is dependent on a number of factors including the original design criteria, the level of deterioration and the level of maintenance. Theoretically, if a structure is well-maintained and the service requirements do not change, it is possible to keep a structure indefinitely. In fact, there are many examples of bridges and cathedrals that are well over 500 years old. The question of service life becomes a question of economics. Generally for industrial type structures that are part of a business delivery process, it is more cost-effective to extend the life of the structure as long as possible.