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Practical and FEA Result Analysis of Selected Casement and Sliding Windows

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Abstract-Glass is used for huge number of applications. But normally glass is the main part of the windows. Nowadays the walls of the building consists lot of glasses on the behalf of the packed walls. There are two types of windows used in general and they are casement and sliding type windows. Normally glasses are available in various forms or types but the cast glass is only suitable for window application purpose. In this paper, analysis & calculation for the deflection of window is done, and tested for its correct installation. Each manufacturer of the window has responsibility to give defect free window to the customer. So this method will help the manufacturer in calculating the deflection of window. Glass manufacturer has already list of calculations for deflection of glasses but there is one permissible limit for their deflection, when glass reaches that limit then the scratches are forms and after sometimes glass will be breaks into square forms.
Keywords-Glass window, Deflection, Casement, Sliding

I. INTRODUCTION

Glass is used for huge number of applications. But normally glass is the main part of the windows. Nowadays the walls of the building consists lot of glasses on the behalf of the packed walls. There are two types of windows used in general and they are casement and sliding type windows. Normally glasses are available in various forms or types but the cast glass is only suitable for window application purpose.Glass manufacturer has already list of calculations for deflection of glasses but there is one permissible limit for their deflection, when glass reaches that limit then the scratches are forms and after sometimes glass will be breaks into square forms. The window manufacturing company takes the permissible limit of the glass deflection for a particular pressure from the glass manufacturer. Then the glass is assembled into the frames of windows. Then the manufacturer of the window has responsibility to check the deflection of window. Deflections are sometimes calculated in order to verify that they are within tolerable limits. For instance, specifications for the design of casement and sliding windows usually place upper limit on the deflections. Glass breakage can be hazardous for insiders and for outsiders in case of high altitude structures.

One of the disadvantage of using aluminum for mullions is that its modulus of elasticity is about one-third that of steel. This translates to three times more deflection in an aluminum mullion compared to the same steel section under a given load. Building specifications set deflection limits for perpendicular (wind-induced) and in-plane (dead load-induced) deflections. It is important to note that these deflection limits are not imposed due to strength capacities of the mullions. Rather, they are designed to limit deflection of the glass (which may break under excessive deflection), and to ensure that the glass does not come out of its pocket in the mullion. Deflection limits are also necessary to control movement at the interior of the curtain wall. Also, if deflection of a wall is quite noticeable, public perception may raise undue concern that the wall is not strong enough.

II. METHODS

A. Practical Method

For calculating the window deflection by practical setup, the machine setup is used normally named as window test machine (WTM). The equipment is performance Chinese National Standard. It can be used to test Air Permeability, Water tightness, Wind Resistance of building windows. The equipment consists of pressure system, water system, control system, data collect system, data processing system and etc

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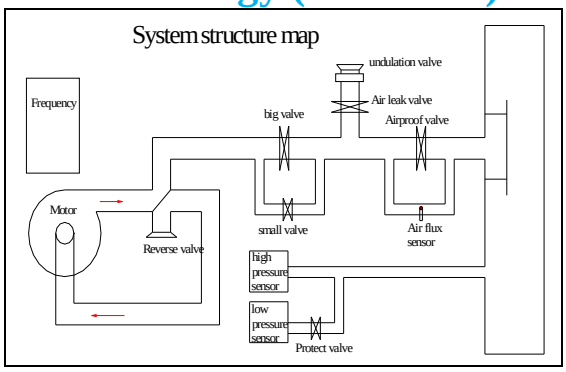


Fig.01 Practical Setup of WTM

The software is main to use for auto control, examination, the data collect, data processing etc. Software interface consist of menu, tool bar, status bar, control board, test setting window, test window, result windows etc. Its operation is simple and convenience.
For experimental testing procedure we select the casement window of following specification
Casement window – Open –Fix –2700 x 2700 mm
Thickness- 12mm
Modulus of elasticity for glass- 70 Gpa

Modulus of elasticity for support frame (aluminum)- 69 Gpa

The method of test specimen is mounted on window test machine is as below

Measure the size of the testing window.

Adjust top board and the right board; assure that height and width of the chamber is smaller than that of window about 20 mm.

Right board is an assembled board, for acquire appropriate of height, we should choice some proper board to assemble. It should be put in appropriate position to get the width of the chamber.

To turn around the windlass can move the top board. Put the testing window on the chamber.

Choose some clamp to fix the top board, the right board and the testing window. Check all gaps, and insure air Permeability good.

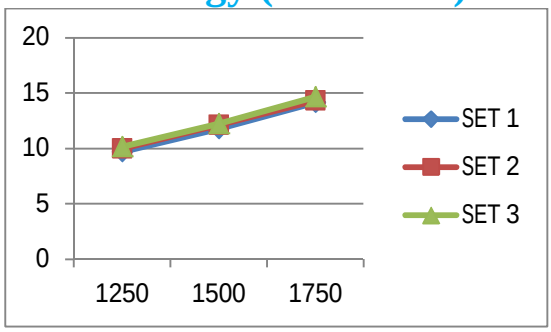
In order to measure the append leak, we should seal completely all the gap of the testing window.



Fig.02Final assembly with sensors

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Graph No.01 pressure vs. deflection for Practical analysis results

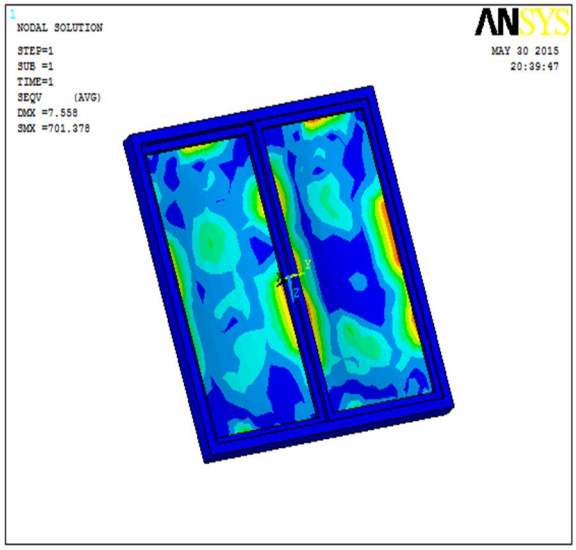
B. Finite Element Analysis

Inthis method we are going to discuss the concept of the reason why non-linear analysis leads to an economical design is explained and the finite element program, is employed to demonstrate the large deflection behavior of thin glass plates. Surface stress is plotted for the ease of understanding of nonlinear behavior when the glass undergoes large deformation. Owing to possible saving in material weight, nonlinear and large deflection plate theory has been commonly used in western countries like United States and Canada. With the trend of globalization, it appears that Hong Kong engineers need to equip themselves on various new techniques for enhancing their competitiveness and non-linear analysis and design is considered to be one of these advanced techniques. Glass panel is commonly used in curtain walls and glass structures.

Glass plates are widely used as glazing panels in buildings to date and it has a unique and important quality of transparency and acceptable strength. Its provision of unobstructed view to the occupants has made it highly competitive against other types of facades. However, in Hong Kong and elsewhere, the failure of glass panels is common and the direct falling of glass debris onto the street level may also cause casualties. Studies have shown that breakage of glass is due to the concentrated tensile stress on the surface flaw. Due to the difficulty in estimating the density, orientation and location of these flaws in glass panels, the failure probability instead of direct specification of failure load for a glass panel is usually used as a reference for safety of glass structures. Generally speaking, the probability of failure (POF) of 8/1000 is acceptable for most purposes. In congested area, the POF should be further reduced.

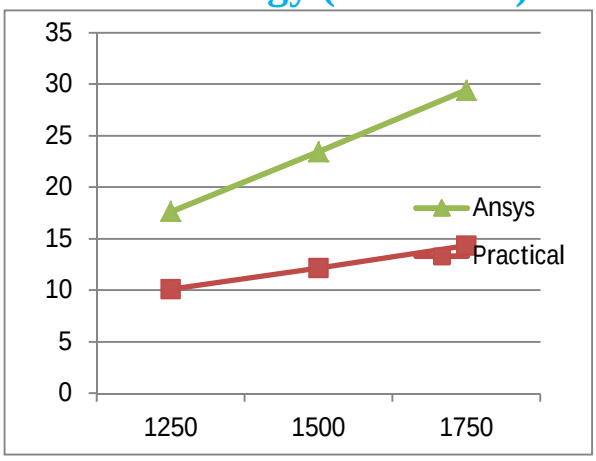
Above figure shows the stress patterns by linear plate bending theory analysis of glass panel subjected 750Pa wind load respectively. Because the linear theory does not consider the change in geometry of the plane, therefore, the stress pattern does not changed with respect to increase in the wind load. The maximum stress occurs at its center.

FEA RESULTS for pressure 1250 Pa



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Graph No.02 pressure vs. deflection result for FEA analysis

III. RESULT & DISCUSSION

The test pressure load varies considerably from in static pressures. There are no strategies or stipulations provided for different wind-driven rain exposure conditions (i.e. climate zones). Fenestration products come in a wide variety of design pressures and all have the potential to perform differently. A default minimum of 50 Pa, in existing static pressure tests, rather than a percentage of the design pressure may not suit the requirements necessary in all areas. This issue becomes apparent in a location such as Delhi where the lowest pressure rating for any window sold is approximately 600Pa and 15% of which is 90 Pa. Therefore all windows intended for use in Delhi would pass ASTM E331-00 without meeting their lower bound infiltration criteria. While this issue is accounted for in TAS 202-94 by specifically stating that the pressure shall not be less than 15% of the design pressure, it is a standard that is only used in Delhi.Following Graph shows the relation between length vs. deflection for different coordinates

It excludes the use of 50 Pa as passing criteria for water intrusion. It is done intrinsically by mandating the successful completion of TAS 202-94 prior to performing TAS 203-04. It should be noted that this is only for Delhi.

Additionally there is no stipulation on how to test for, quantify or record any water infiltration. Infiltration rates or observing minimum pressures at which the products exhibit water infiltration are not observed. “As the specified or median test pressure is increased, the maximum test pressure in this procedure is also increased to 1.5 times the specification median test pressure. This higher maximum test pressure may not be representative of actual building service conditions.

For this reason the maximum recommended median test pressure is 380.0 Pa which corresponds to a maximum test pressure of 1750 Pa.” Testing of products to 1750 Pa to view water penetration behavior may not be sufficient and requires further research and discussion. No distinction in performance is made from product to product. Factors such as infiltration rates or minimum pressures at which the products do exhibit water infiltration are not observed. Such factors may play a major role in the insurable damage incurred and merit further study which cannot be obtained from minimum performance standards.

This raises the question if water penetration resistance should be related directly to wind exposure zones and merits further research. Edge effects are not considered. UV, ozone, and environmental exposures, over time, adversely affect the water penetration resistance of fenestration components such as weather-stripping and sealants. Aging of the finished wall system may also yield new infiltration paths.

Sr. No.	Method	Pressure (Pascal’s)	Deflection in mm
2	Practical Method	1250	10.00
		1500	12.15
		1750	14.33
3	Finite Element Method(ANSYS)	1250	07.55
		1500	11.33
		1750	15.11

Table 01: Results of Different Method

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Above tables it is observed that the results obtained by Analytical Methodare nearly equal to practical results and that of by practical are very close to ANSYS of selected casement window. It is also observed that percentage variation of from ANSYS is very small near about ±5% as compared to the percentage variation of from practical results of selected casement window system.As the results of analytical and practical analysis of selected casement window are quite similar hence for the analysis of selected casement window system analytical& ANSYS analysis will be used.

IV. CONCLUSION

Following are the reasons due to which the theoretical, practical & software results are not exactly match with each other

Distribution of air on window is not exactly uniform due to leakage of air in practical set up but in case of ANSYS it is taken as exact uniform.

Boundary conditions in the ANSYS are fixed it cannot be change, but boundary conditions of practical get disturb due to the factors like temperature, improper material properties throughout the length etc.

Non linear stress strain relationship of materials will cause a structural stiffness to change at different levels.

In actual practice wind load on window is not continuous i.e. intensity of wind acting on window varies frequently but in case of practical & software analysis it considered as a constant.

Selected casement window deflection can be successfully calculated but the accuracy of the result can be depend on choosing right young's modulus (E), & flexible rigidity (D) of both frame & glass.

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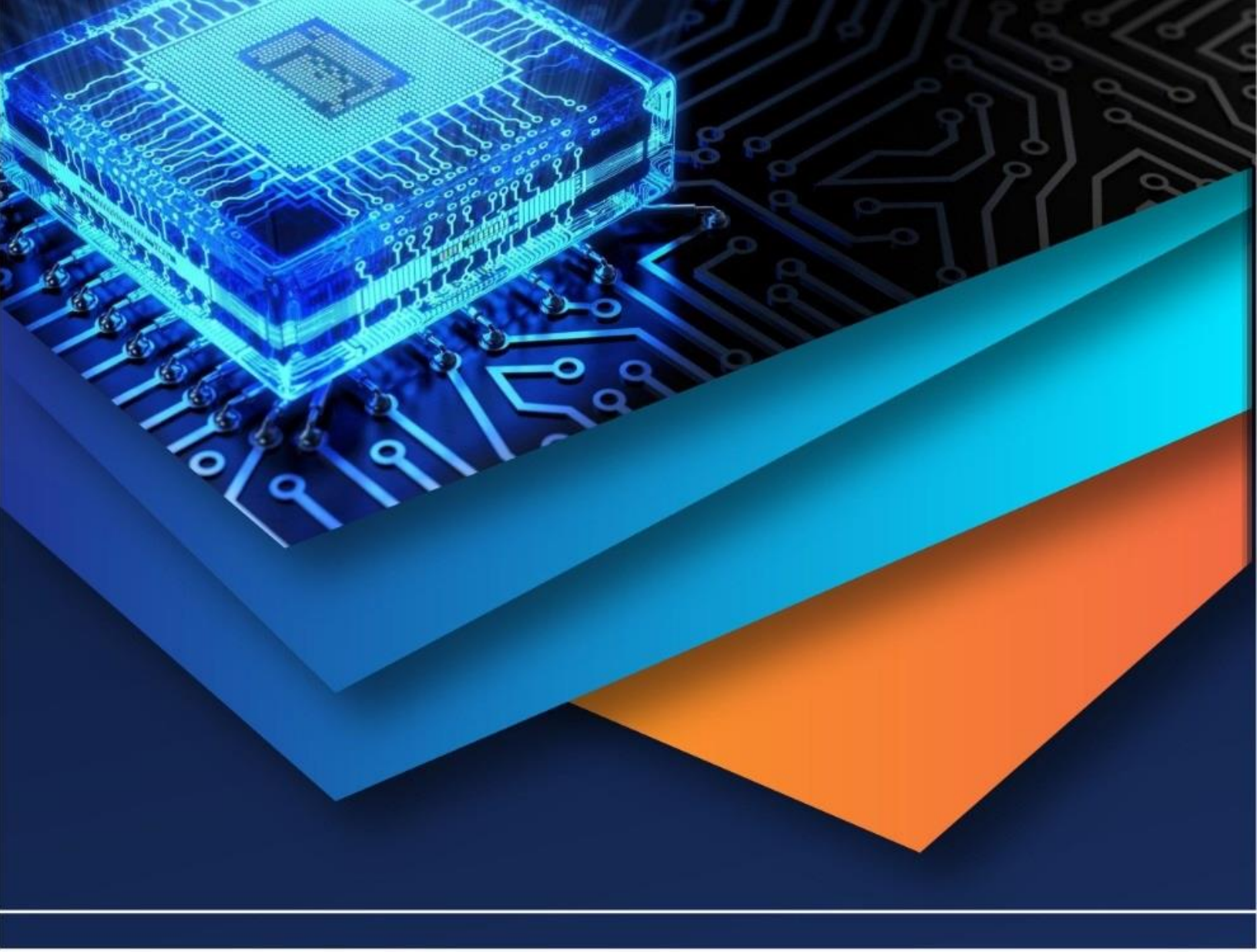
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