Analysis of Laminated Glass Beam with different Core Thickness

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Abstract- **Glass beams are used on various non-vertical structural glass items to give lateral structural support to the glass installation. They are produced from various layers of toughened glass panels which are then laminated together. Depth and thickness of the glass beam is dependent on the load it will be supporting. It is composed of glass panels or laminated glass (LG) panels. Glass is as strong as aluminium when used as a beam in either a vertical or horizontal situation. Glass beams are generally composed of glass panels or laminated glass (LG) panels. Each LG panel in turn is composed of two or more glass panels connected by a flexible interlayer [polyvinyl butyral(PVB)or Sentry Guard Plus(SPG)]. In this thesis, laminated glass beam of different thickness and material properties are considered for the analysis. The interlayer materials such as SGP, PVB and also different glass types such as annealed, heat strengthened and fully tempered are used. The laminated glass beams under different loading conditions are analyzed in ANSYS software.**

Keywords- Laminated Glass Beam, Glass types and interlayers, ANSYS, Analysis

I. INTRODUCTION

Glass is one of a few materials which can be present and non present at the same time. Glass is transparent so one could look right through it, but it can still form a barrier from wind or rain for instance. It can serve other functions like bearing loads. Glass is one of the world's most recycled material: it can re-melted over and over again without any change in properties or loss of quality. Furthermore it is non-reactive with most elements and chemicals so it does not need protection from corrosion for instance. It is easily cleanable make it a material which results in low maintenance cost for the glass building component. The theoretical compressive stress of glass make it a very promising material: the generally accepted value is 1000N/mm^2, which is more than four times the capacity of normal steel.

Glass beams are used on various non-vertical structural glass items to give lateral structural support to the glass installation. They are produced from various layers of toughened glass panels which are then laminated together. Depth and thickness of the glass beam is dependent on the load it will be supporting. It is composed of glass panels or laminated glass (LG) panels. Glass is as strong as aluminium when used as a beam in either a vertical or horizontal situation. The number of layers and thickness of glass will be dependent on the span needed. For stability it is necessary for either end of the beam to be secured and this is most usually done with a stainless steel shoe, into which the beam is structurally loaded.

Fig.1 Glass beam

Like concrete, glass is strong in compression, but weak in tension. Although glass has a theoretical strength in the range of 1-100 GPa, the actual (tensile bending) strength of annealed float glass is limited to 20-110 MPa due to small defects at the glass surface. The strength at the edge of a glass pane is at the low end of this range, because of defects caused by the cutting and grinding process. A common method to increase the strength of glass is pre-stressing the glass through thermal treatments. A residual surface compressive stress is introduced by heating the glass followed by a rapid cooling of the glass. Depending on the level of pre-stress, these glass types can be divided into heat-strengthened or fully tempered glass. Although the application of stronger glass may seem advantageous, it is has a negative effect on the structural behaviour of a reinforced glass beam. Due to the increased energy release upon glass failure these glass types show more extensive crack branching than annealed float glass (without internal pre-stress)

II. OBJECTIVES

1. To validate ANSYS software
2. To perform static analysis on laminated glass with different material properties
3. To determine the effective core thickness of laminated glass beam with different material properties on the basis of buckling load

III. METHODOLOGY

This chapter describes the methodology of the thesis work. The methodology includes study of laminated glass beam and ANSYS software.

A. Modeling

The models are created using ANSYS software. 18 models are created with three different cases of thickness and different material properties. A base model with a thickness of 25.04mm (6+1.52+10+1.52+6) was modeled firstly, then two other models with lower core thickness (8+1.52+6+1.52+8mm) and higher core thickness (5+1.52+12+1.52+5mm) than the base model are created. The different glass types such as annealed, heat strengthened and fully tempered and also two different interlayers such as Sentry Glass Plus (SGP) and PolyVinyl Butryl (PVB) are used.

B. Dimensional details

A laminated glass beam is modeled using ANSYS software with the reference journal[3]. Finite element analysis results were used to develop static analysis of beams with different core thickness under simply support condition is studied**.** The dimensions for different cases of beams are as shown in table.

Table 1
Dimension details of beam

Type of glass	Young's Modulus E (MPA)	Tensile Strength (MPa)	Density ρ in Kg/m3	Poisson's Ratio υ
Annealed	70000	45	2500	0.23
Heat Strengthened	70000	70	2500	0.23
Fully Tempered	70000	120	2500	0.23

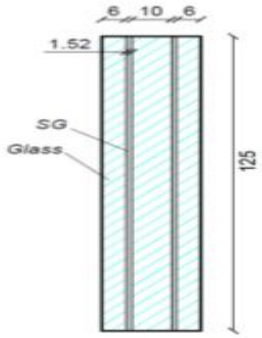

Fig.2 Cross section of base model

C. Material Properties

Laminated glass beam are made up of different materials. The material properties of are given below

Table 2
Material properties of interlayers

Interlayer material	Poisson's Ratio υ	Young's Modulus E (MPA)	Tensile Strength (MPa)	Density ρ in g/cm3
SGP	0.49	300	34.5	0.95
PVB	0.49	300	20	1.07

Table 3
Material Properties of different glass types

Thickness cases	Length of beam (mm)	Depth of beam(mm)	Exterior glass layer thickness (mm)	Inner glass core thickness (mm)	Interlayer material thickness (mm)
Case 1	1500	125	6	10	1.52
Case 2	1500	125	8	6	1.52
Case 3	1500	125	5	12	1.52

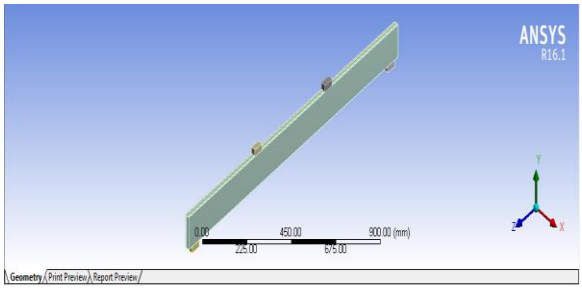

Fig.3 Laminated Glass Beam model

D. Meshing and Loading

The beam is modeled using a rectangular mesh which is a 4-node mesh. Two point loading is provided on the top area with simply supported end.

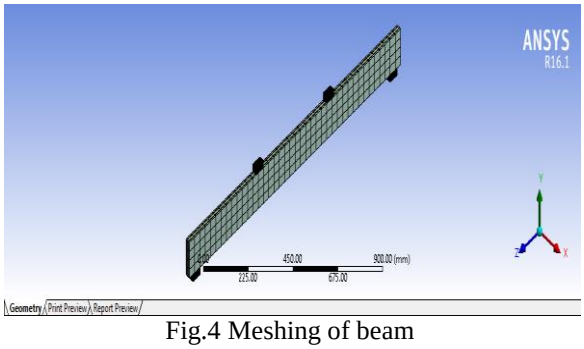

Fig.4 Meshing of beam

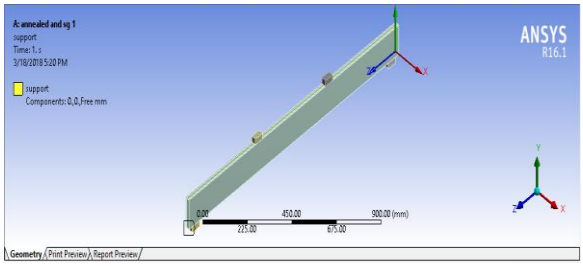

Fig.5 Support condition of beam

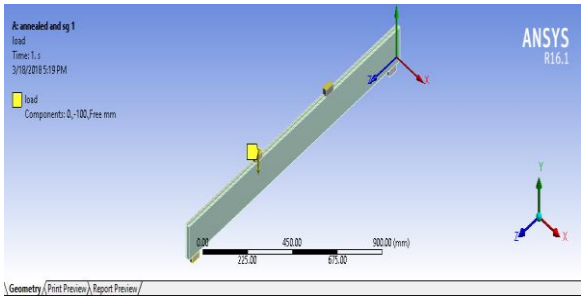

Fig.6 Loading of beam

E. Analysis of Laminated Glass Beam

Analysis was done using ANSYS software. Finite element analysis will provide in depth knowledge about the behavior of the member; it performed with proper boundary conditions and material properties. There are different analyses performed in this study.

IV. RESULTS AND DISCUSSION

A. Static Structural Analysis

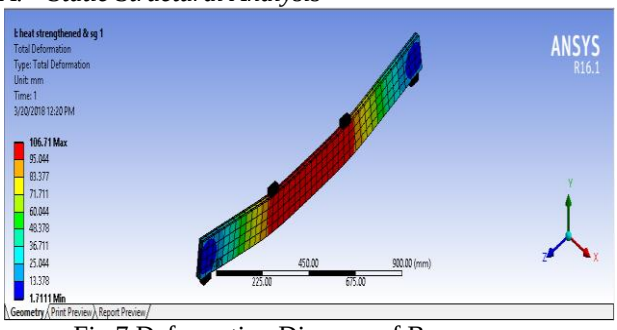

Fig.7 Deformation Diagram of Beam

Table 4
Maximum force and deformation on base beam with different material properties

Combinations	Force reaction (kN)	Deformation (mm)
Annealed glass & SGP	31.069	106.09
Heat strengthened & SGP	45.929	106.71
Fully tempered & SGP	72.353	108.59
Annealed glass & PVB	30.59	105.68
Heat strengthened & PVB	45.514	106.42
Fully tempered & PVB	72.156	108.51

B. Buckling Analysis

The buckling analysis was done on laminated glass beam with different material properties and layer thickness. The critical buckling load of beam are as shown in table.

Table 5
Critical buckling load in N for beams

Combinations	Case 1	Case 2	Case 3
Annealed glass & SGP	$3.120x10^5$	$2.90x10^5$	$3.24x10^5$
Heat strengthened & SGP	$3.120x10^5$	$2.90x10^5$	$3.24x10^5$
Fully tempered & SGP	$3.120x10^5$	$2.90x10^5$	$3.24x10^5$
Annealed glass & PVB	$3.120x10^5$	$2.90x10^5$	$3.24x10^5$
Heat strengthened & PVB	$3.120x10^5$	$2.90x10^5$	$3.24x10^5$
Fully tempered & PVB	$3.120x10^5$	$2.90x10^5$	$3.24x10^5$

V. CONCLUSIONS

Laminated Glass beam is analysed in ANSYS software and the results were compared. The following conclusions areobtained from the study;

- The laminated glass beam with combinations of fully tempered & SGP shows better performance than other combinations in case of maximum load
- The critical buckling load is maximum in case of beams with higher core thickness (5+1.52+12+1.52+5mm). Therefore the laminated glass beams with higher core thickness shows better performance.

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