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DESIGN OF UPVC WINDOWS FOR LATERAL WIND LOADS SANDWICH WITH HURRICANE BARS FOR MULTISTOREY STRUCTURES

S. Vallabhy[1], M. Arun Kumar[2], V. Bharath[2], E. Dhakshina Moorthy[2], Hitesh Kumar Jain[2]

[1]Assistant Professor: Civil Engineering Department, Prathyusha Engineering College, Thiruvallur, Tamil Nadu
[2]UG Student: : Civil Engineering Department, Prathyusha Engineering College, Thiruvallur, Tamil Nadu

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Abstract – *In olden days the windows of multistorey structures built were not to face high velocity winds. These windows are just not strong enough to resist these high velocity winds. That's why the old windows deflect or bend. When the bending or deformation happens narrow air gaps are formed between the frames and walls of the buildings which leads to the allowance of air that creates whistling and rattling sounds in the buildings. Part of these innovations include the formation of fusion welded UPVC frames which consists of galvanized iron reinforcement and toughened glass which lends to exceptional strength of windows. In coastal areas or high rise structures where the velocity of winds are greater, we use the windows consist of Hurricane Bars as a additional support to give further rigidity to frames which reduces the bending or deformation. This project deals with the provision of hurricane bars in UPVC window frame and comparing the values of required and available flexural rigidity under axial load.*

***Key Words*: UPVC frames, galvanized iron, toughened glass, hurricane bars, flexural rigidity.**

1. INTRODUCTION

Generally windows in building are provided to give light ventilation and improve aesthetics of the interior parts of building. The size of window depends upon the direction of wind, speed of wind and dimensions of room. The various window materials that are used in the construction are wood, aluminium and UPVC. Wood and aluminium had been the predominant material in the past has now given way to a new age material called UPVC (Un-plasticized Poly Vinyl Chloride). Earlier, structures were not constructed keeping in mind in erosion during the monsoons, expansion in the size of windows during summer, exposure to UV radiations, aesthetics. Now UPVC have changed all that and minimised these unwelcome intrusions. Wood has become difficult now a days to get access and aluminium is not so good enough and requires more maintenance so UPVC windows are becoming popular because of high energy efficient, excellent appearance and smooth surface finish, soft contoured profiles, and variety of designs to meet the needs of demanding architects, designers and users. The UPVC windows are the best fit for all weather conditions prevalent across India from salty humid corrosive air in coastal areas to suitable temperatures. UPVC windows in residential and commercial construction is used as both new and replacement windows.

1.1 UPVC

Un-plasticized Poly Vinyl Chloride is relatively new to the building industry as a material for windows and doors. UPVC is based on poly vinyl chloride(PVC), one of the most versatile polymers found.

UPVC is prepared with a special formulation in which different stabilizers and modifiers are added to poly vinyl chloride to make rigid and suitable for use as window frames. UPVC contains poly vinyl chloride(PVC), calcium carbonate($CaCo_3$) and titanium dioxide (TiO_2). PVC forms the major constituent of blend composition. Unlike other polymer PVC is heat sensitive and requires additives during processing. Hence the properties of PVC can be increased through additives like light and UV stabilizer, fillers, pigments and lubricants can be added during the blending process. Titanium dioxide is an expensive pigment used for imparting natural white color to the UPVC profile and provide necessary UV stability for the product. Calcium carbonate are fillers which are inorganic minerals as fine particles homogenized in PVC blend. Usage of filler has effect on mechanical property like tensile strength, elongation, impact strength, shrinkage and cost. Production of UPVC involves a complex extrusion process. Extrusion is a manufacturing process where material is drawn through a die of required cross section. The main advantage of extrusion process is that it can create very complex sections and also can be used for brittle objects. Additionally this process provide excellent surface finishes. UPVC extrusion process can be recycled. UPVC has excellent insulation properties resulting in high energy efficiency.

1.2 Hurricane Bars

Hurricane bars are the reinforcement provided in the chambers of UPVC window frames. These bars act as a mullion stiffener to withstand high velocity winds. Hurricane bars made of galvanized iron blended in different forms like U, C, etc,. Galvanized reinforcement are the normal reinforcement which are coated with a protective layer of a zinc metal. Zinc coating usually carried by hot dip galvanizing process which serve as a barrier to corrosive environment. Hurricane bar is provided in the hollow portion of the window frame which provides an additional power to bear the wind speeds up

to 250 km/h. The minimum thickness of hurricane bar is 1.2 mm. The thickness of hurricane bars shall be such that the windows meet the design wind pressure in accordance with IS 875 (part 3).

Fig -1: Hurricane Bar

2. REVIEW OF LITERATURE

A.L. Kelly[1], on his paper described about recycling of UPVC window profile waste. The quality of untreated granular waste was compared to that of waste treated by a range of contaminant removal processes including melt filtration and dissolution. Product quality measurements such as mechanical properties and surface defects are made on extruded strip and the nature of stabilizers present were determined. The mechanical properties of recyclates were found to be comparable to better or than those of virgin material in all cases and conformed to industry standards for window profile.

Peng Yonghong[2], proposed about the contrast study of composite stabilizers of UPVC profiles for windows. The influence of lead package composite stabilizer, calcium-zinc package composite stabilizer on the heat stability and weathering performance of Unplasticised poly vinyl chloride were studied based on congo red test, gear oven ageing test and accelerated weathering test. The results indicated that the lead package composite stabilizer was the best composite stabilizer in the heat stability of UPVC, the calcium-zinc package composite stabilizer was the best in the weathering performance of UPVC.

Vera Fernandes-Hachih[3], has described about influence of composition of UPVC on mechanical properties of window profiles exposed weathering. The durability of Unplasticised poly vinyl chloride components used in the building industry is a function of the interaction of the several factors. Results of Charpy impact tests were used to assess the influence of three factors on the durability of the profiles and they are additivation levels of titanium dioxide, nature of the impact modifier and the nature of the thermal stabilizer. The influence of composition of UPVC on mechanical properties of window profiles is demonstrated by means of study of the modulus of elasticity. Results indicated the need for several addition experiments in order to check changes in molecular mass and color.

Navid Eskandari[4], has determined about the thermal, mechanical and acoustic properties of silica-aerogel/UPVC composites. The properties of silica-aerogel/UPVC composites has been investigated with emphasis on sound and heat insulation. Hydrophobic silica aerogels were synthesized using silicate sodium precursor through a two-step sol-gel process. Then, the synthesized aerogels were mixed with UPVC compound at five different weight ratios in an internal mixer to find out the effects of silica aerogels on the thermal, mechanical and acoustical characteristics. The results revealed that adding silica aerogel into the matrix of UPVC increases its hardness and softening temperature while decreases impact strength. The sound absorption property of UPVC was increased up to three times by using silica aerogels due to its high porosity.

Satish Kumar. R[5],has made the comparison of windows with different types of materials. UPVC windows are good in aesthetics, durability, noise proofness, best air and water tightness. UPVC windows come with a very high quality surface finish and soft contoured profiles. Due to their ability to conserve energy through out their life time, UPVC windows are recognized as green windows there by scoring over traditional timber and metal windows. They best fit for all weather conditions prevalent across the India.

3. METHODOLOGY

The following flowchart illustrates the methodology adopted to determine the flexural rigidity of UPVC window frames with hurricane bars.

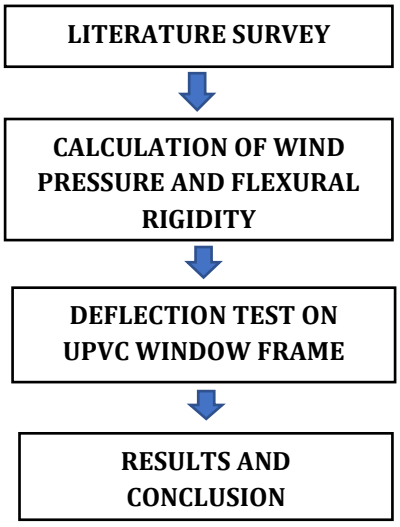

Chart – 1 : Methodology

The flexural rigidity of the UPVC window frame with hurricane bar is calculated manually and is compared with the results obtained from the deflection test. The deflection test is carried under simply supported conditions.

4. DESIGN CALCULATION

4.1 Calculation Of Wind Pressure Using IS 875 (Part3)

The wind pressure is calculated at the type-III building constructed at the central revenue quarters, Ranganathan garden, Anna Nagar west, Chennai.

The dimensions of the given building are
Height of the building = 60 m
Length of the building = 55.15 m
Width of the building = 19.95 m

The wind pressure on the building as per IS 875 (part3)
Basic wind speed (V_b) = 50 m/s
Risk factor (k_1) = 1
Terrain category (k_2) = 1.184
Topography factor (k_3) = 1
Design wind speed V_Z = V_b x k_1x k_2 x k_3
V_Z = 59.2 m/s
Design wind pressure P_Z = 0.6 V_Z^2
P_Z = 2103 pa
External pressure coefficient(C_{pe}) = 0.8
Internal pressure coefficient (C_{pi}) = 0.5
Maximum wind pressure = 1.3 x 2103
= 2734 pa

4.2 Calculation Of Manual Flexural Rigidity

Flexural rigidity is generally defined as product of young's modulus (E) and moment of inertia (I).

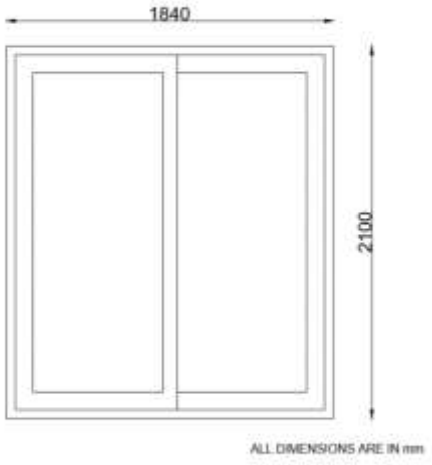

Fig -2: Typical Sliding Window

In this typical sliding window the wind load acting on the frame is transferred to wall since they are fixed. Therefore, the wind load calculation is considered for the centre mullion of the window. The EI value required for the section can be calculated as per the below formulae

$$EI = \frac{5WL^4}{384\Delta}$$

Where,
EI = Rigidity of UPVC frame member
W = Wind load (N/mm)
L = Load span (mm)
Δ = Maximum deflection (mm)

Now considering the values,
W = 273 x10^{-3} N/mm
L = 2016 mm
Δ = L/500 (from IS 800:2007 table no.6 for brittle cladding)
= 2016/500 mm
The required EI value as per the equation is

$$EI = \frac{5 \times 273 \times 10^{-3} \times 2016^4}{384 \times 11.2}$$

$EI_{required}$ = 14.56 x 10^9 N-mm^2

4.3 Laboratory Test And Calculation Of Flexural Rigidity

The deflection test is carried out in the laboratory to calculate the flexural rigidity for window provided with the hurricane bar.
The following are the various test apparatus required

- Knife edge supports
- UPVC frame
- Hurricane bar of 2 mm thickness
- Dial gauge with magnetic stand
- Loading pan
- Weights

Fig -3: Knife Edge Supports

Fig -4: Dial Gauge

Fig -5: Weights

Fig -6: UPVC Frame With Hurricane Bar

The test carried out by the following procedure

- Choose the section of the frame and provide the frame with hurricane bar of 2 mm thickness.
- Set the knife supports at determined positions and mount the frame to be tested.
- Measure the span of frame in between the supports.
- Place the dial gauge on the center of the simply supported frame to read the down-ward moment and set zero to measure the actual maximum deflection.
- Hang the loading pan at the mid point of the frame span.
- Load the frame gradually increasing 500 g and note the dial gauge readings for each gauge after every loading.

Fig -7: Deflection Test

Therefore the available EI value of the section can be calculated as per the below formulae.
Formula based on point load:

$$EI = \frac{PL^3}{48\Delta}$$

Where,
EI = Rigidity of UPVC frame member
P = load (N)
L = Load span (mm)
Δ = Maximum deflection (mm)

Table -1: Result Of Average EI From Deflection Test

Load (kg	Deflection (mm)(δ)	Load (N) (P)	K = P/δ	L³/48	EI = PL3/48δ	Avg EI
6.0	0.74	58.9	79.54	1.71E+08	1.36E+10	
6.5	0.87	63.8	73.29	1.71E+08	1.25E+10	
7.0	0.99	68.7	69.36	1.71E+08	1.18E+10	
7.5	1.13	73.6	65.11	1.71E+08	1.11E+10	
8.0	1.26	78.5	62.29	1.71E+08	1.06E+10	
8.5	1.37	83.4	60.86	1.71E+08	1.04E+10	
9.0	1.45	88.3	60.89	1.71E+08	1.04E+10	1.08E+10
9.5	1.56	93.2	59.74	1.71E+08	1.02E+10	
10.0	1.65	98.1	59.45	1.71E+08	1.01E+10	
10.5	1.76	103.0	58.53	1.71E+08	9.99E+09	
11.0	1.85	107.9	58.33	1.71E+08	9.96E+09	
11.5	1.92	112.8	58.76	1.71E+08	1.00E+10	
12.0	2.02	117.7	58.28	1.71E+08	9.95E+09	

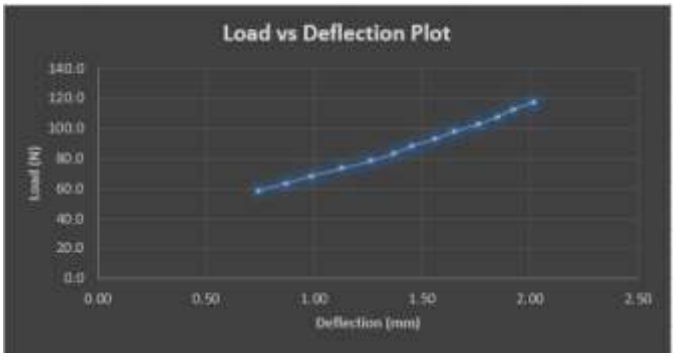

Chart -2: Load Vs Deflection Graph

5. RESULT

The safety factor of the flexural rigidity

$$= EI_{available} / EI_{required}$$
$$= 10.8 \times 10^9 / 14.56 \times 10^9$$
$$= 0.74$$

6. CONCLUSION

The UPVC window is most economic and efficient window when compared to the other windows like timber and aluminum windows. The use of hurricane bar in windows prevents excessive deflection due to wind loads and stiffens the frame. The result is an unappreciable as the safety factor should be greater than 1.0. therefore the rigidity value of available EI can be increased if the thickness of hurricane bar is increased.

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