Research & Analysis of Semi-Unitized Curtain-Wall System

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Abstract: Façade gives the building an exquisite design (i.e. unique design), which distinguish the buildings from each other. The materials used in the construction of the unitized panels are aluminum, glass etc, which can be recycled later and will be used again. The distinctive appearance is often the subject of controversial debate. Nowadays, unitized curtain wall system is mainly used for high rise buildings, it becomes the major investment in both the construction industry and long term durability of a building. Compared to the RCC structure and steel structure the unitized curtain wall system is new in the construction industry. This report will mainly focus on the design and analysis of unitized curtain wall system using stiffness matrix method and structural analysis programme (i.e. Staad pro). Nowadays the unitized curtain wall system, even the simpler type, are far more sophisticated than the earlier glazing system, though the many earlier glazing systems still performing admirably. More than fifty years of experience in the glazing field enable us to overcome the difficulties of the pioneering design, which results in better products. Beginning with the relatively simple, but innovative concept in the early 1950’s, a series of window and glazing panel units are supported by the simple framing member. Curtain wall system has been developed over the years, in to an innovation of a highly engineered design. The main objective of this paper is to analyze ad design the unitized curtain wall system for the high rise building.

Index Terms: Façade, glass, aluminum unitized profiles, MS brackets, Load bearing structure, anchors.

1. Introduction

Façade is a French origin, which means the front face. Facades are the first aesthetical features of a building that distinguish one from another. They determine its distinctive appearance and are often the subject of controversial debate. As a visible and representative element, it combines design with important everyday functions such as protection against wind and weather, as well as noise protection, the storage of heat and the generation of energy. The use of glass in exterior façade provides more light and good ambiance to the inhabitants of the building, which gave rise to the more use of glass. From the architectural point of view, the use of glass gives the aesthetic view to the building. A structure which is made up of aluminum frame work and the glass is pasted on it is called as curtain wall system. The vertical aluminum structure is called as mullion which acts like a column and the horizontal aluminum profile is called as transom which acts as beam in particular.

2. Literature Review

Pallavi Taywade, Santosh Shejwal (March 2015)- Structural design of a glass façade, In this paper author introduced the curtain wall system, then analyzed and designed the system to withstand the system under adversary loading conditions. Glass has become a major element while designing the modern commercial or public buildings. The use of steel structure improves the load bearing capacity of the structure and improve the transparency of facades.

Ladifa Barau Muhammad et al. [February 1010], The author research will explore the use of glass material as a curtain wall system in relation to investigating the types of curtain wall systems with a system detail of each type of curtain wall discussing and evaluating the most suitable type to be used on buildings in terms of constructional material view, anchorage view and tolerance view, and through basic factors such safety, economy and environmental factor Glass curtain walling is one effective material providing an interface between the exterior and interior of a building, as Ching and Adam stated that “a curtain wall is an exterior wall supported wholly by the steel or concrete structural frame of a building and carrying no loads other than its own weight and wind loads”.
Karol Kazmierczak. This paper presents curtain walls, their fundamental classification, challenges associated with their design and construction. A balanced, holistic approach to the curtain wall construction is emphasized. The paper presents a fundamental classification of curtain walls by function, materials, place of assembly, mullion type, glass type, attachment, access, and configuration. Primary façade design principles are classified and demonstrated on curtain wall components, with emphasis on a structural safety and a holistic approach. Both classifications were developed by the author for purposes of curtain wall specification and education of parties involved in their design, manufacturing, and construction. The paper is straightforward in nature to optimally address the average professional audience. Both a curtain wall and a sloped glazing are typically associated with a high-rise, high-end residential or commercial construction.

3. Types of Curtain wall Glazing

Based on the method of installation, the curtain wall is categorized in to three types.

A. Stick Wall System
   This is the earlier design of curtain wall technology. The wall is installed piece by piece. Usually, the mullion members (which is vertical member) are installed first, followed in turn by the transom members (which is horizontal rail member), and finally the glazing or window units. However, in designs accenting the horizontal lines the process may be altered to first install the larger transoms. In either case, the transom and mullion members are often long sections designed to either be interrupted or extended through at their intersections. The stick wall system was used extensively in the early years of metal curtain wall development, and is still widely used in greatly improved versions. Some contractors consider it to be superior to other systems.

B. Semi-unitized system (hybrid system)
   After a period of time, semi-unitized design was occurring in curtain wall technology. In this system, the mullion members are separately installed first, then pre-assembled framing units are placed between them. These units may be full story height, or they may be divided into a spandrel unit and a vision glass unit. Hybrid system is advantageous to use when for long span of two floors, which can be reinforced by steel.

   This system need large amount of labor for field jointing work and the erection time is comparatively greater.

C. Unitized System
   For modern technology, unitized curtain wall system was invented. This system is composed entirely of large frame units pre-assembled at the factory. The mullion member joins to the top and bottom transom member, and with a vision glazed glass panel. The production of whole panel is under controlled at the factory, where the process can be carefully inspected, and facilitates rapid enclosure of the building with a minimum of field labor and relatively few joints. While the unitized system offers many advantages with respect to quality assembly and speed up the site construction time, there is one design concern with respect to installed performance and durability. In a unitized system, there are three joints along every mullion and transom. These include the two glasses to Aluminium joints and a third joint at the junction between the half Mullions and half rails. Should an air or water leak develop at the third joint, there is usually no practical method of accessing the in-between panel joint of repair unless the manufacturer has provided a serviceable joint system design.

   In a unitized system, the manufacturer must rely on qualified installers to ensure that the air seals are properly installed between the split Mullions. Nevertheless, the unitized system is the most popular façade system according to one manufacturer and it has performed satisfactorily when installed correctly.

From the above three categorized curtain wall system, both unitize and semiunitized system is used for glazing. So for today research paper, we are going to study the design of semiunitized glazing with the help of Staad Pro.
4. Structural Design

The curtain wall system is designed to resist and handle all the loads as well as keep air and water from penetrating in the building. The imposed loads on the curtain wall is transferred to the building structure through structural interface (i.e. brackets) which attaches the mullions to the building. The Semiunitized is designed for the following loads.

1. Dead Load
2. Wind Load

Applicable Standard Codes:-

- IS 800-1984 Indian Standard Code of Practice for General Construction of Steel
- IS 875-1987 (Part-1 dead Loads) Indian Standard Code of Practice for Design
- IS 875-1987 (Part-3 Wind Loads) Indian Standard Code of Practice for Design

Software Used For Analysis & Design

- STAAD PRO V8i
- ANSYS

A) Building Parameters (G+10)

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<th>Parameter</th>
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<table>
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<tr>
<td>L/W</td>
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for Computation of Wind load as per IS 875 1987-(Part 3)
Typical Mullion Analysis

Max Span Length = 4.1 m
Max Bracketing span = 4.1 m
Number of Transom per Unit = 2 no’s
Max Deflection ($\delta_{\text{actual}}$) = 7.337 mm
Permissible Deflection ($\delta_{\text{perm}}$) = Min (Span/175 or 20 mm) (AS per AAMA)
Therefore = 10.28 mm
$\delta_{\text{actual}} < \delta_{\text{perm}}$ (Provided section is ok)

Design of Glass as Per ASTM E 1300:
Max: -0.970 kNm
Max: 2.155 kN
Max: -0.811 kN
Max: 7.337 mm

Figure 5. Max. Bending Moment, Shear Force & Axial Force

Figure 6. Max. Deflection
Glass Size = 1050 mm x 1400 mm
Type of Glass = 6 mm Hs + 16 mm AG + 5 mm HS
    (Double Glass Unit)
Wind Load = 1.71 kPa
Max Deflection at Centre = 5.63 mm
Allowable Deflection of Glass = B/60 OR 19 mm
    = 17.5 mm OR 19 mm

Figure 7. MS Bracket

Base Plate Design:
Width (B) = 220 mm
Depth (D) = 200 mm
Thickness (t) = 8 mm
Max BM = 0.492 kN-m

Check for Through Bolt
Nos. of Bolt = 1.0 Nos.
No. Of Interface = 2.0 Nos.
Max. Vertical Shear Force = 1.19 KN (V) (2.0 Times Factored)
Max. Horizontal Shear Force = 3.05 KN (H) (1.5 Times Factored)
Dia of Bolt = 10 mm
Shear Stress Induced in Bolt = 47.98 N/mm²

Bearing Check for Mullion at bolting point
Max Vertical Shear Force = 3.27 KN
Thk. Of Mullion at Bolting Point = 2.0 mm
Nominal Dia. Of Bolt = 10.0 mm
No. Of Bolts = 1.0 Nos.
Bearing Area of Mullion = 40 mm²
Bearing Stress In mullion = 81.73 N/mm²

5. Conclusion
1. In the design consideration of Semi-unitized curtain wall system, there are some major items which will affect the structural integrity of the system, are the provision of movement and weather tightness are the chief concern.
2. The result of analysis on glass indicated that the size and wind pressure governed the deflection and stress behavior of glass, so it becomes a major issue while designing glass.
3. The use of steel in load bearing structure improves the transparency of façade because it has been possible to keep the unitized panel member slender as much as possible.
4. In this study, the Semi-unitized curtain wall system is introduced and the system is being analyzed using the finite element and structural analysis software (i.e. STAAD-PRO)

5. References
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