Energy and Wind Analysis of Facade Design Building with Different Mullion Sections

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Abstract- *Nowadays, a new development in Façades has made it more dependable, enabling designers to build powerful economical solutions with flexibility that are stunningly stimulating, both inside and externally. Wind load detail analysis and calculated response to IS 875(1893) value utilising force deflection relationship in tall structures using aluminium composite material (ACM) Façade In this study, the state-of-the-art in terms of addressing the many kinds of aluminium composite in façades, their functional and strength requirements, as well as their applications and design for wind load in tall buildings is explored. The primary goal of this article is to discover material composites utilised in façades, as well as to design and assess a high-rise building's façade system for wind load. Furthermore, artificial lighting uses a substantial amount of energy; this study seeks to lower the quantity of energy used. When the building is outfitted with a façade system, increased outside wall insulation and the utilisation of daylight will enhance the effectiveness of mechanised cooling and heating.*

Keywords- Structural Façade, Wind Analysis, ACP Façade, Energy, Esthetic appearance

I. INTRODUCTION

Structural Facades play a significant role in the scientific and building industries. While the Façade is an outside envelope of glass, cladding, stone, etc. that is not cast long with bricks and mortar but does create the face of the structure. Glass is the most often utilised material in facade systems. Glass has been utilised in architecture for millennia and has been used for ages. It is currently employed as a structural component rather than as a see-through filler within a supporting frame assembly. The enhanced glass quality permitted a change in attitude toward glass usage, as well as the creation of float glass and the thermal fortification (tempering) technique, as well as the availability of research methodologies. The desire for architectural lightness, clarity, and accessibility has driven the use of glass in the production of large transparent windows, floors, and roofs. Glass is a brittle construction material that is unstable under stress due to its non-crystalline molecular structure, which enables it to be employed in a number of applications. Glass has functional characteristics such as solar power, thermal insulation, acoustic insulation, fire prevention, safety, and defence. Despite the fact that the material composition is weak, civil engineers are getting adept at designing the design within the acceptable safety constraints. The use of glass as a façade material has a constraint in terms of its capacity to make structural connections. There are several tried-and-true options on the market today. In addition, ACP, or aluminium composite cladding system, is increasingly widely used as a component of curtain wall systems. Aluminium Composite Panel ACP is designed to be lightweight while yet providing robust insulation. In India, façade system design is often carried out using the ASTM / Euro Codes, since Indian Codes do not provide such extensive concept data. As a consequence, more structural performance study is required for the design of aluminium composite panels for Indian circumstances. In the anticipated learning of aluminium panels via different end situations, the results will be analysed for various loadings and aspect ratios to assist designers. This study investigates the state-of-the-art that investigates the many kinds of windows in facades, aluminium composite cladding with their applications in practise, as well as their strength and functionality standards in tall structures.

As a result of the researchers' assessment of the façade, the few worrying elements for the structural design of the façade are as follows: [1] T.N Brinda's effort with the goal of designing the double glazing structural façade by written codes of Indian Standards contributed to performance evaluation by simulation in CosmolMultiphysics Simulation, which demonstrated that total building energy usage may be improved by Double-Skin Façades. [2] AgnieszkaLesniak's Structural Analysis of Factors Influencing the Cost of a Façade System has performed structural analysis using the MICMAC approach (refers to the French acronym for Cross-Impact Matrix Multiplication Applied to classification). In this section, the factors that influence the cost of the façade systems are identified, which includes factors for regulatory purposes, which have a minor impact on the cost level but have a direct relationship with other factors; determinants that have a significant effect on the cost, and a group of external aspects that have the least impact on the calculation of the faced cost. [7] Rao G.S. K. Rajasekhar's Structural design of toughened glass provides an overview of various available analytical procedures for evaluating the strength of the glass façade by summarization of linear and non-linear analysis using various drafted rules from the Euro code and the Indian Draft code. [8] V N Alekhin's Facade Systems for Energy Efficient Buildings provides a comparative study for energy efficiency, operating and installation time for several façade structures. As a result of the analysis and research, a new form of façade panel was developed. [9] AjlaAksamija's High Performance Building Envelopes examines the aims and techniques for designing high-performance, sustainable façade systems and provides required solutions with an integrated design approach. As a result, in this research work, the utilisation of an aluminium composite panel ACP façade as a structural component of a building is studied using STAAD-Pro, and the behaviour when exposed to Wind Loading is analysed.

II. AIM AND OBJECTIVE

A. **Aim**

The goal of this study is to learn more about the research in Façade system for the purpose of Structural design of Façade for different kinds of curtain wall systems with smart products available on the market, the constituents are created on standard products reengineered and reassembled for the fewest number of component layers possible, to determine the viability of their applications, they each cover several roles and provide adaptable output.

B. **Objectives**

The goal is to study the behaviour of a high-rise building's façade system for wind load and carry out structural review and design in accordance with Indian standards, as well as compute its response to minimise energy used for artificial lighting by using an effective and multidisciplinary design methodology while retaining the façade system's adaptive features and efficiency.

III. METHODOLOGY

The Curtain wall system comprises of the different types of curtain wall is indeed acasing system, made up of contiguous elements, that wrap around the building frame like a curtain, dismissing all the wind and weather, welcomes the ventilated climate, but still resists no building loads. It usually consists of an aluminum frame structure with glass vision panels or other modern smart materials on the market, as well as spandrels made of any panel material, such as glass, metallic, stone, compressed cement or double-decker panels. Curtain wall systems must meet many performance criteria prior to structural analysis in order to work satisfactorily to have Structural checks for safe design of Façade, Stability, check for brackets, check for mullions and check for connections.

A. Codal Provision

The codal provisions are given by the Indian Standards (Third Revision) of IS:875 (Part 3) which is enacted by the Indian Standards Bureau on (Date), following that the drafting was completed by the Section of Structural Safety Committee further had been given approval by Civil Engineering Division Council.

- Dead Load: On the Basis of material specified for the construction of the facades system here the need is in establishing their unit weights by considering specified materials for calculation of Dead Load.
- Imposed Load: The weight produced from movable partitions of building, uniformly distributed and concentrated loads are considered as imposed loads. When structure is induced with live load in the form of impact and vibration the Imposed load is assumed in the accordance with IS 875 (Part-2)
- Wind load: When designing a building the Wind load is considered as per the IS 875 (Part-3) as well as for its structural components
- Basic Wind Speed (Vb): The Basic wind speed is given by IS 875 (Part-3) which provides a Basic Wind speed (Vb) ofIndia. As applicable for different time zones of the country to 10m height over the mean ground level.
- IS 8147-1976: For the use of aluminium alloys, it’s an Indian Standard Code of Practice.
- IS 800-1984: For general construction in Steel its an Indian Standard code of Practice.
- ASTM 1300: For the determination of the Load resistance in Glass.
- Software’s used for Analysis & Design: STAAD Pro V8i (For Structural Analysis)

B. Case Study: Platinum Square Viman Nagar

Platinum Square, is the marquee project of Vascon also the crown jewel and latest to develop in the area. Vascon has also developed the Weikfield IT City Park with a staggering an office space of 2 million square feet, which has been fully leased out to IT and ITes companies also two 5-star hotels. Now, with the provision for limited units the launch of Phase 2 Platinum Square, it's latest opportunity for those to become a part of Vascon's success story, who missed out on the chance earlier.

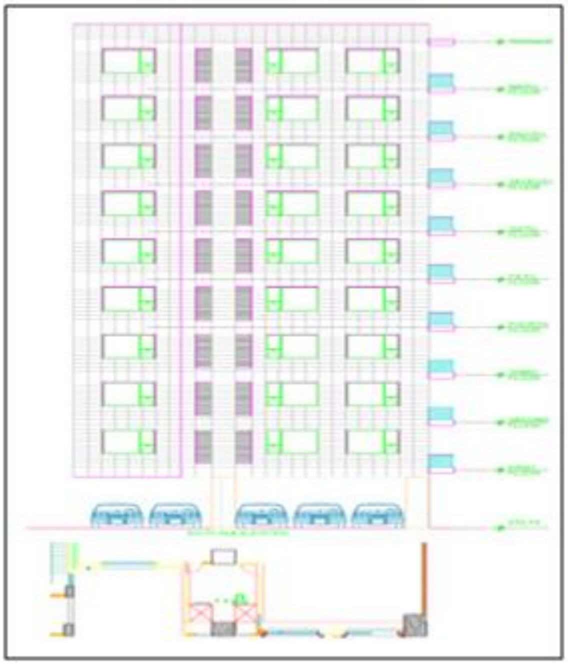

Fig.1 Elevation of Platinum Square Viman Nagar

IV. RESULT AND ANALYSIS IN STAAD

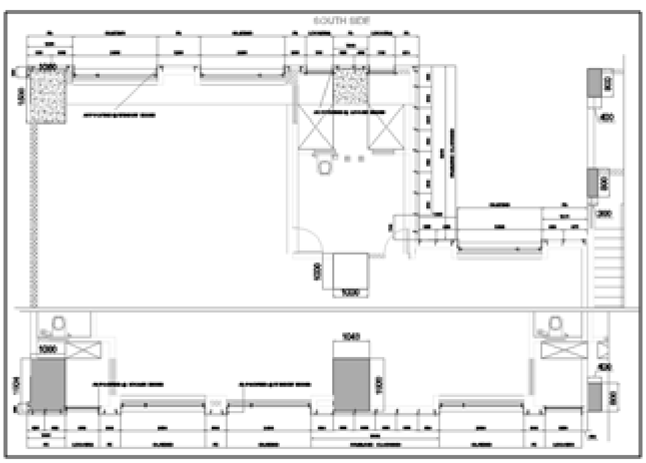

Fig.2 Floor Plan Platinum Square

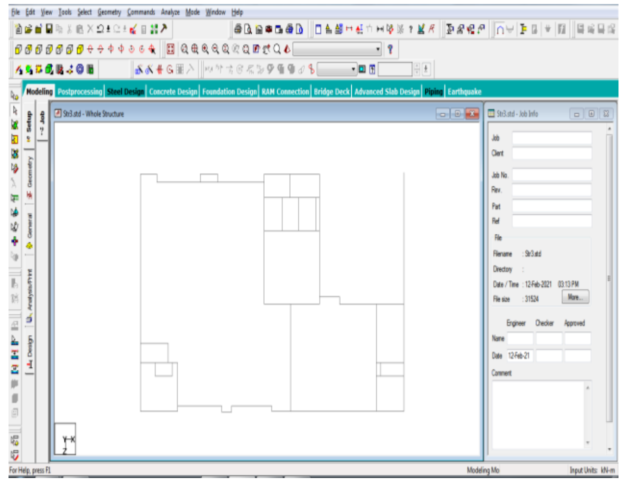

Fig.3 Floor Plan in STAAD

The provided floor plan in fig 2 are plotted beam layout plan in CAD and then plotted centreline and this centreline imported in Staad as seen in above fig 3

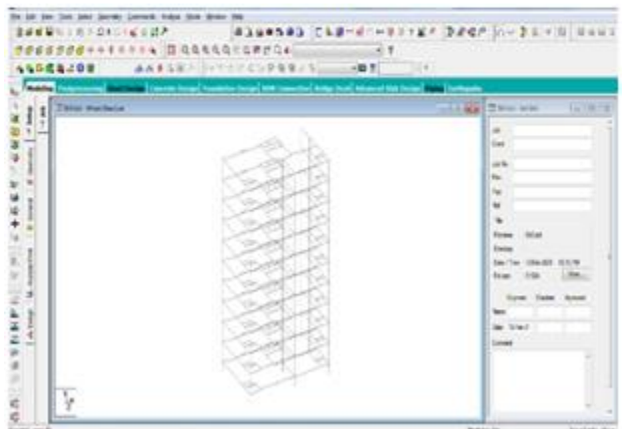

Fig.4 Modelling in STAAD

Create a model of a G+10 commercial building using the dimensions specified in the cad file for the beam column and slab.

Façade Calculation

I. General

To design adequate glass of spider pin supported curtain wall meeting required criteria. All the units are in the metric system.

II. Design calculation

- Design Code:

IS1949 1961: Design code in practicefor Structural Use of Aluminium in assemblies.

ASTM 1300 Min. Design Loads for the Buildings and other Structures.

- Material used:

16mm thick ACM (8+1.5+8)
Allowablestress, heat strengthened ACM Allowable stress, tempered ACM Allowable stress, structural sealant Modulus of Elasticity, E

- Loading:

Dead Load (DL) ACM weight wind Load

- Load Combination:

BasicWind Speed (V), Width of Building (W),Length of Building (L),Height of Building (H).
Top of spider wall:
1.0 Dead Load (Check for Serviceability)
1.0 Wind Load (Check for Serviceability)
1.2 Dead Load ± Wind Load

- Wind Load Calculation:

Reference from Wind Calculations for full details.
Max. Wind Pressure: KN/m^2
Analysis of ACM Panel
8 mm thk ACM
1.5 binder
8 mm thk ACM
Maximum aspect size on ACM panel
Height = 3522mm
Width = 1262mm
Horizontal loading act on ACM panel
wl = 1.25KPa
Note: Assume the ACM panel simply supported in 4 sides Check the bending stress of ACM panel Bending moment due to horizontal loading.

$$M = q \times \frac{L^2}{8}$$

Note: (consider 1000mm width)
q = 1.25 ×1 = 1.25 N/mm
L = 1262 mm
M = $1.25 \times 1262^2 / 8$ =248,851 N.mm

Due to wind loading – Bending Stress

$$\delta = M \times \frac{6}{(t^2 \times B)}$$

Note: B =1000 mm
5.83MPa< 49M ok
t = 16 mm (8+1.5+8)

Check the deflection of ACM panel Deflection due to horizontal loading.
Note: (consider 1000mm width)
q = 1.25 x 1 = 1.25N/mm
L = 1262 mm
E x I = 2.4576E+10
Deflection =1.68 mm<1262/ 60 = 21.0mm ok

Analysis of structural sealant of ACP panel
Area of ACM panel = 4.4 m^2
Design Wind Speed = 1.25 KPa

Required width of structural sealant
B = 1262 × 1.25 /(138) =11.4 mm
Take 12 mm thick ACM panel for the model in STAAD

V. MODELLING APPROACH IN STAAD

The modelling of the Façade System for Aluminium composite panel ACPsystem is performed in STAAD Pro V8iwhich is used for Structural Analysis and design.

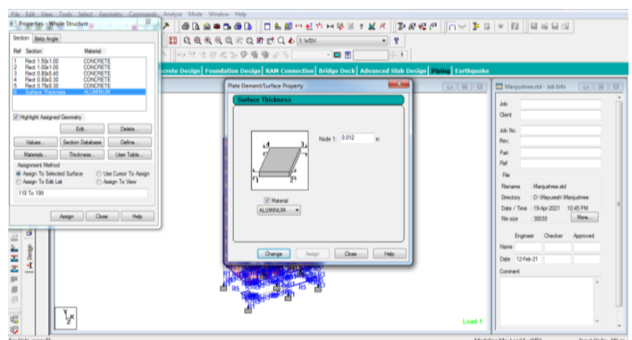

Fig.5 Defining ACP Panel in Staad

Based on the calculations above, the 12 mm thick ACP panel is specified in Staad pro with aluminum content.

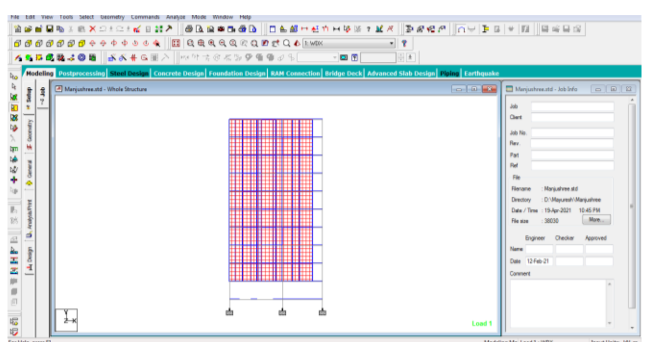

Fig.6 ACP Panel in Staad

Aluminium panels assign vertically in Staad models as given in AutoCAD

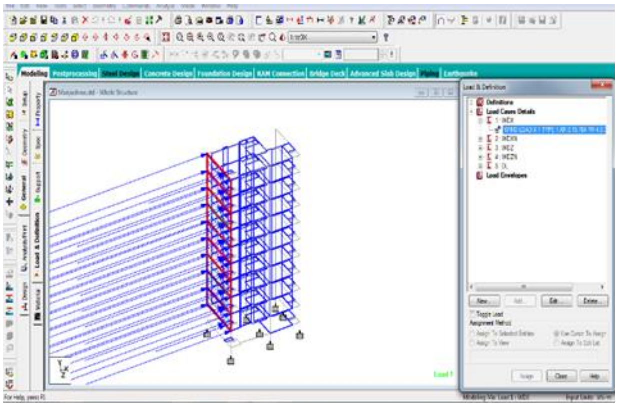

Fig.7 Wind Load Applied on Model

Apply wind loads in accordance with IS 875 to the model starting at floor 1. (Note: ground floor is parking space so it is not included in wind load)

V. RESULTS OF STAAD

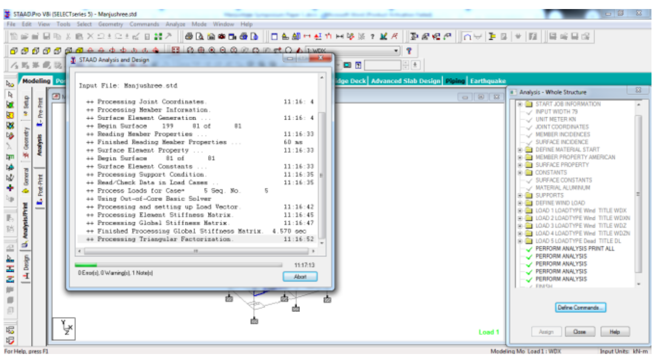

Fig.8 Analyze model in Staad

Analyze the model in Staad for the defined wind load to determine the stress on the aluminum plates.

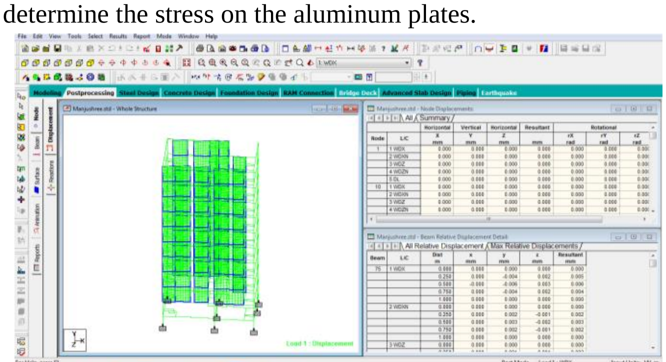

Fig.9 ACM Results in Staad

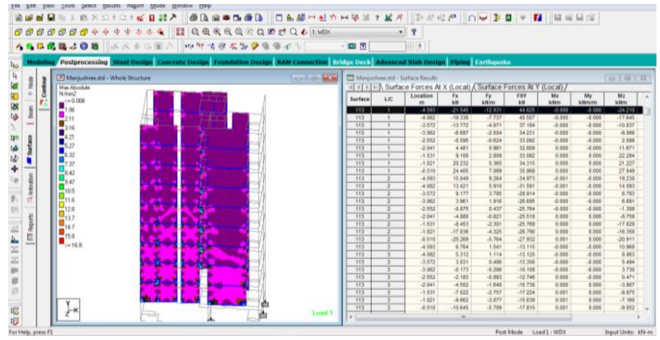

Fig.10Max. Stress on ACM

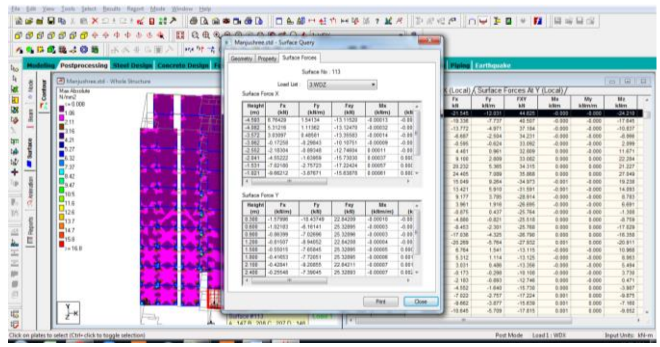

Fig.11Stress on ACM in tabular

According to the above data, the pressure for the ACM and the maximum stress on the ACM plate are 14.63 KN/m^2.

VI. REVIT MODELLING APPROACH

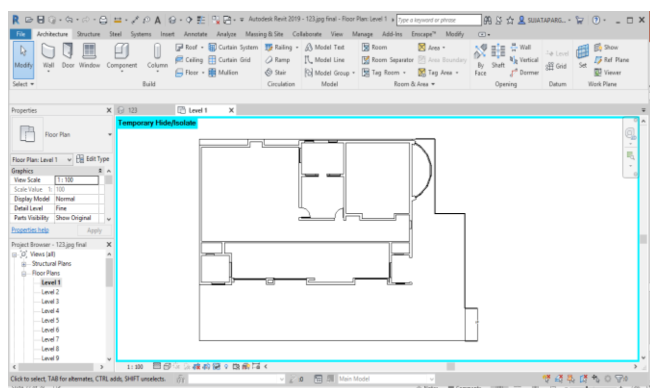

Fig.12 Floor Plan in Revit

After importing the cad model obtained in case study data in Revit & sketching out Floor plan of wall thickness 300mm.

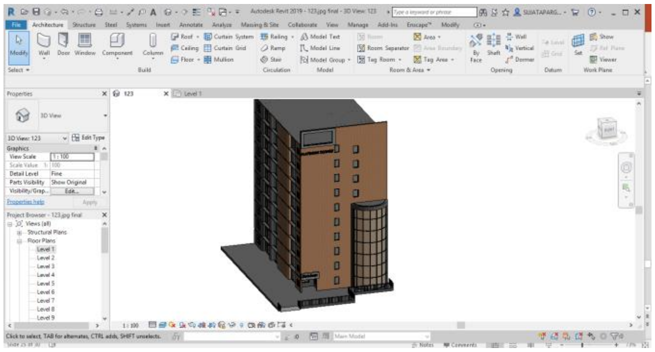

Fig.13 Modelling in Revit

Modelling out 3D plan for 12 floor levels and adding the material on exterior face as ACP of 12mm thickness.

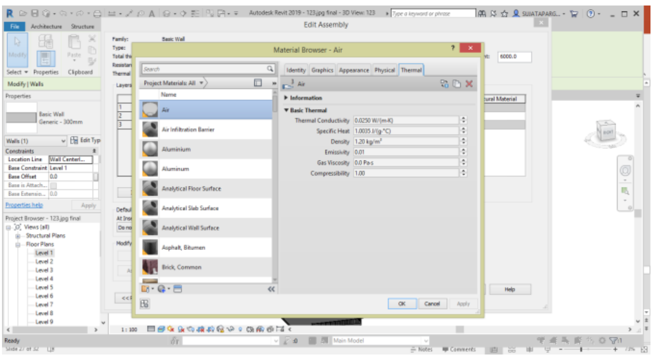

Fig.14 Material Details

Change in the material details was mainly of thermal Point for energy analysis set accordingly to manufacturing details.

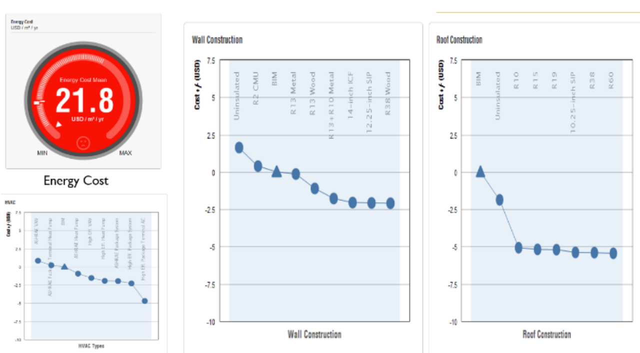

Fig.15 Energy Analysis Result

Energy optimization model of ACP Building resulted in consumption is 21.8USD/m²/yr.

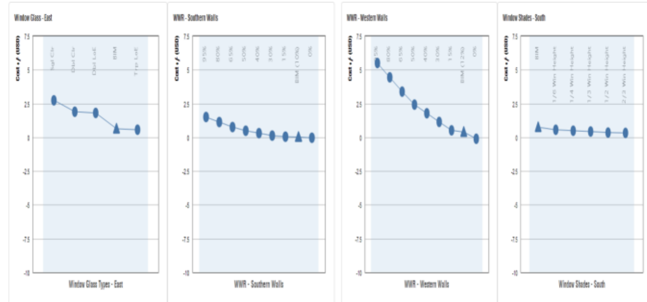

Fig.16 Energy analysis result on Revit

As compared to RCC Building with regular panels and without cladding here the energy consumption is reduced by 20% to 30% was observed after performing energy analysis.

VII. CONCLUSION

The investigation of numerous researchers' literatures on Structural Design of Façade System, its design, and integration of various aspects led to the adoption of efficient methodologies for Structural designing and analysis of an aluminium composite panel ACP façade system of a building in this article. This research is being carried out to test its stability using STAAD-Pro and to analyze its behavior when subjected to Wind Load. Following the wind study of the Façade system, conclusions were reached.

The wind load study discovered a maximum stress of 14.63KN/m2 on the Aluminium composite material ACP Façade and a maximum bending moment of 23.09KNm. The wind study resulted in the maximum stresses for the top floor, which may be constructed for a group of two or three stressors as high, medium, and low.

After doing an energy study, it was discovered that as compared to RCC buildings with normal panels and no cladding, here the energy consumption is lowered by 20% to 30%. According to the Revit energy optimization model, the consumption of an ACP building is 21.8 USD/m2/yr, which is less than that of an RCC structure without a facade.

VIII. FUTURE SCOPE

- According to the analytical results, the maximum stress on the ACM Plate is 14.63KN/m2, and this load, along with other factors, will be passed to the main supporting structure, and the mullion connection must be built for the main supporting structure, whether it is RCC, slab, steel, or beam. The design of the Facade for its connection may be done based on this tension.

- The element of energy efficiency in the Façade business must be taken into account in order to follow the trend of producing a balanced Façade. As a result, BIM-based simulations such as Revit will be employed to assure the energy analysis's flexibility and accuracy. We may further define whether the ACP Façade can be replaced or alternatively replaced with solar panels for higher energy efficiency using the findings of the energy analysis research; this method can be taken into account by the results of the energy analysis model.

IX. ACKNOWLEDGEMENT

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