NON LINEAR DYNAMIC ANALYSIS OF STADIUM ROOF

Arti Pakhare[1], N. L. Shelke[2] Manoj Deosarkar[3]

[1]M.E Structural Research Scholar Dept. of Civil Engineering, Dr. D. Y. Patil School of Engineering and Technology , Charoli (BK), Pune -412105, India
[2]Associate Professor, Dept. of Civil Engineering, Dr. D. Y. Patil School of Engineering and Technology , Charoli (BK), Pune -412105, India
[3]Assistant Professor, Dept. of Civil Engineering, Dr. D. Y. Patil School of Engineering and Technology, Charoli (BK), Pune -412105, India

---***---

Abstract - *In this study, the main structural elements of the football stadium are presented, with particular emphasis on the steel roof and its interaction with the underlying reinforced concrete structures. The proposed scheme comprised a Type-1 Flat Stadium Roof, Type-2 Curved Stadium Roof and Type-3 Inclined Roof by using finite element software STAAD-PRO. 1. In This Paper Stadium Roof Is Analyzed For Wind Load And For Time History Analysis. For Wind Load Zone III Is Considered and for Time History Analysis EL-Centro Data Is Used and results shows Max. Displacement in both X and Y direction and Normal Stresses.*

Key Words: Nonlinear analysis, Staad-pro, Time history

1. INTRODUCTION

A stadium roof is a roof system designed to roll back the roof on tracks so that the interior of the facility is open to the outdoors. Retractable roofs are sometimes referred to as operable roofs or retractable skylights. The term operable skylight, while quite similar, refers to a skylight that opens on a hinge, rather than on a track. Stadium roofs are used in residences, restaurants and bars, swim centers, and other facilities wishing to provide an open-air experience at the push of a button.

A. Aim

Nonlinear dynamic analysis of stadium roof for el-centro earthquake / for different ground motion.

B. Objective

1 To design a stadium roof as a tubular structure in accordance with IS801:2005.

3 To check post dynamic behaviour subjected to specified ground motion of stadium roof for the Max. Displacement in both X and Y direction and Normal Stresses.

2. LITERATURE REVIEW

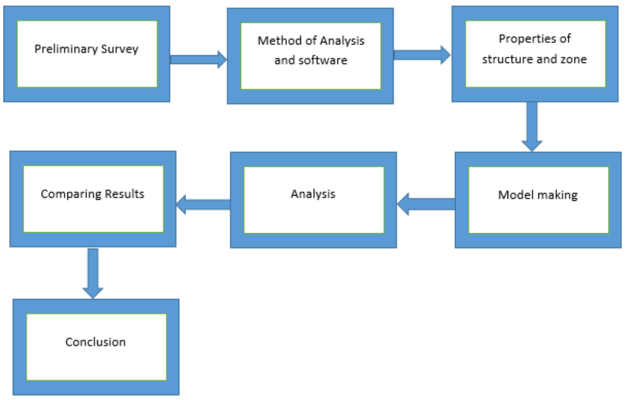
Nonlinear F.E. Analysis of Montreal Olympic Stadium Roof under Natural Loading Conditions Massimiliano Lazzari [1] the roof over the Montreal Stadium is composed of a pre-tensioned membrane combined with an eccentric cable-stayed system, i.e. the structure is non-symmetric, which leads to a non-uniform structural response under variable static loads. The Montreal Stadium roof is modeled by finite element method as a three-dimensional structure, accounting for geometrically nonlinear behavior.

F.E. Analysis of Montreal Stadium Roof Under Variable Loading Conditions. Renato VITALIANI [2] The roof over the Montreal Stadium is composed of a pre-tensioned membrane combined with an eccentric cable-stayed system. Due to the eccentricity of the cable system, the structure is non-symmetric, which leads to a non-uniform structural response under variable static loads. This paper begins by analysing the free vibrations and the frequencies of the structure, then goes on to consider the effects of wind and snow on the Montreal Stadium roof using the geometrically non- linear finite element procedure ("Loki") developed according to the total Lagrangian formulation. The loads induced by wind are simulated as deformation-dependent forces, i.e. follower loads.

Finite Element Analysis Of Dome Of A Home Subjected To Hurricane HabibSadid[3]Dome of a Home is a monolithic concrete dome structure specially designed to resist forces induced by wind and storm surge. This structure has survived several strong hurricanes since 2004 including Ivan, Dennis, and Katrina. Monolithic Domes are thin-wall reinforced concrete shell structures, capable of providing safe shelters for people in the areas with hurricanes and earthquakes. A solid model of the Dome of a Home is developed in CAD environment then, imported to FLUENT, a Computational Fluid Dynamic (CFD) software. The structure is exposed to wind load in different directions and the pressure coefficients are evaluated.

Finite Element Analysis of Seismic Responses of A Large-Cantilever Stadium Structure Zeyu Sun et. al.[4] In this paper, based on the Midas/gen platform, a three-dimensional finite element model(FEM) for a transfinite stadium with a large-span and large-cantilever roof , located in Shenyang, was used to study its potential responses to seismic activities. In the numerical analysis, an earthquake spectrum stipulated by the Chinese Seismic Code (GB50011-2010) was adopted to calculate the bidirectional horizontal displacements by the Complete Quadratic Combination (CQC) method on the basis of the response spectrum analysis.

3. METHODOLOGY



A. Design Considerations of a Stadium Roof

For this class discussion divide the class into the three groups representing the Spectators, the Owners/Operators and the Participants

Spectators

- Shading from the sun
- Shelter from the wind and rain
- Unobstructed viewing
- Sense of Identity
- Safety
- Aesthetically pleasing
- Cool and well ventilated

Owners/Operators

- Flexible
- Easy to maintain
- Durable
- Good broadcasting facilities
- Energy Efficient
- Cost Effective

Participants

- Good quality of playing surface
- Good atmosphere
- Floodlighting
- Ventilation

B. Problem statement

Three Models Are Compared In This Project Subjected To El-Centro Data

Type-1 Flat Stadium Roof

Type-2 Curved Stadium Roof

Type-3 Inclined Roof

C. Material Properties

Shows the concrete and steel bar properties, which are used for modeling of the reinforced concrete buildings in STAAD Pro. Concrete and steel bar properties as per IS 456

Table No1.Material Properties

Concrete Properties		Steel Bar Properties	
Unit weight (γcc)	25 (kN/m3)	Unit weight (γss)	76.9729 (kN/m3)
Modulus of elasticity (EECC)	22360.68 (MPa)	Modulus of elasticity (ESS	2x105 (MPa)
Poisson ratio (νcc)	0.2	Poisson ratio (νss)	0.3
Thermal coefficient (aacc)	5.5x10-6	Thermal coefficient (aass)	1.170x10-6
Shear modulus (GGcc)	9316.95 (MPa)	Shear modulus (GGss)	76923.08 (MPa)
Damping ratio (ςcc)	5 (%)	Yield strength (FFyy)	415 (MPa)
Compressive strength (FFcc)	30 (MPa)	Tensile strength (FFuu)	485 (MPa)

4. PROBLEM STATEMENT

A. Preparation for design calculation

- Material- Steel
- Section Size- 0.05m
- Location- Pune
- Basic Wind Speed- 39m/s
- Zone – ш
- Soil- Clay
- Size- 51.4m × 20m
- Height-20m
- µ- 0.3
- E- 2.5×105 MPa

Table No 2. Permissible Axial Stress In Compression Σac (Kg/Cm2)

Slenderness Ratio λ = L/R	GRADE (Yst 210)	I.S. 1161 GRADE (Yst 240)	GRADE (Yst 310)
0	1250	1500	1900
10	1217	1448	1821
20	1175	1400	1750
30	1131	1352	1679
40	1088	1303	1610
50	1046	1255	1539
60	1002	1207	1468

Table No 3. Permissible Stress For Steel Tubes As Per Is 806:1968

Grade (IS: 1161-1979)	Axial Stress In Tension (kg/cm2)	Bending Stress (kg/cm2)	Minimum Shear Stress (kg/cm2)	Minimum Shear Bearing (kg/cm2)
Yst210	1250	1400	900	1700
Yst240	1500	1650	1100	1900
Yst310	1900	2050	1350	2500

5. RESULTS AND DISCUSSION

A. Finite Element Analysis of Flat Roof

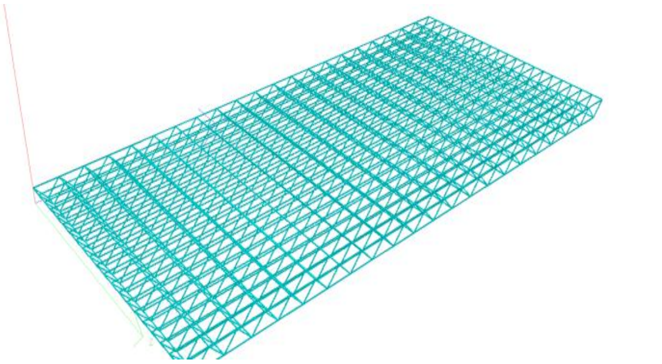


Fig 1. 3D View of Finite Element Analysis Of Flat Roof

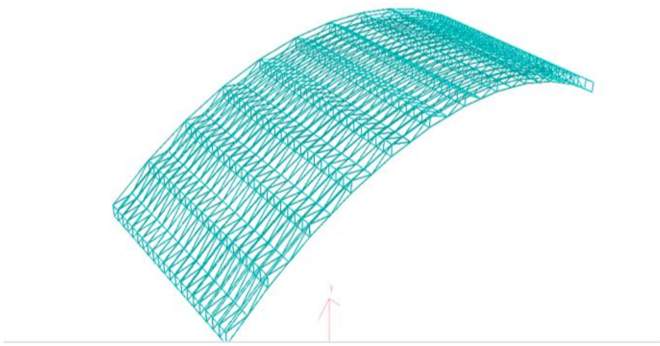


Fig 2. 3D View of Finite Element Analysis Of Curved Roof

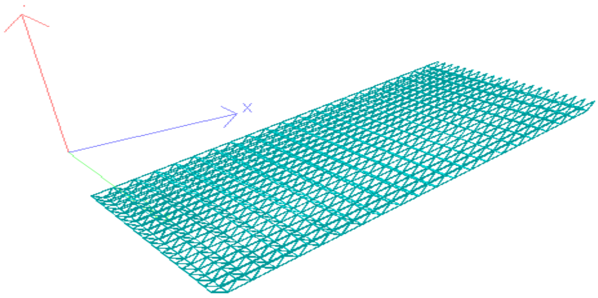


Fig.3. 3D View of Finite Element Analysis of Inclined Roof

B. MAX. DISPLACEMENT

Max. Displacement in X-Direction

MAX DISPLACEMENT +X		
FLAT	**CURVED**	**INCLINED**
18.159	9.29	18.159

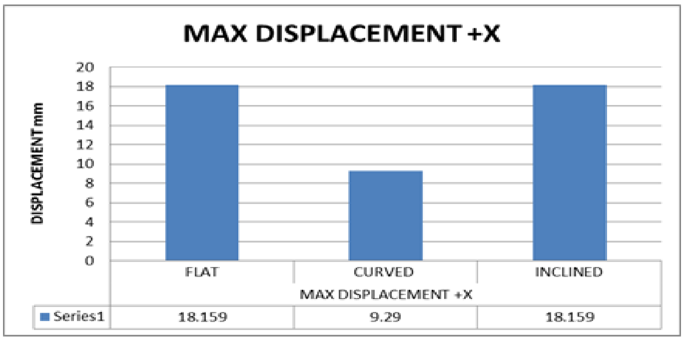


Fig 4. Max. Displacement in X-Direction

Above graph shows the maximum displacement of Flat, Curved & Inclined roof in X direction.

Max. Displacement in Y-Direction

MAX DISPLACEMENT +Y		
FLAT	CURVED	INCLINED
28.69	20.659	28.69

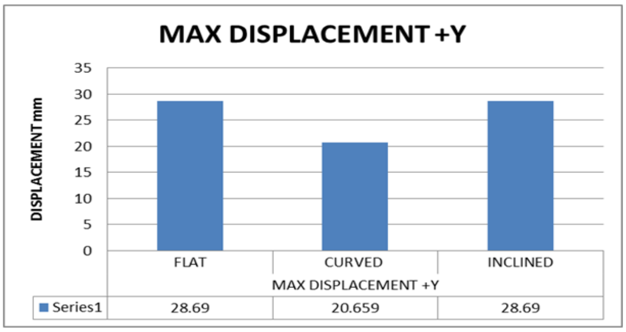


Fig 5 Max. Displacement in Y-Direction

Above graph shows the maximum displacement of Flat, Curved & Inclined roof in Y direction.

C. NORMAL STRESSES

NORMAL STRESS		
FLAT	CURVED	INCLINED
40.7	51.331	40.7

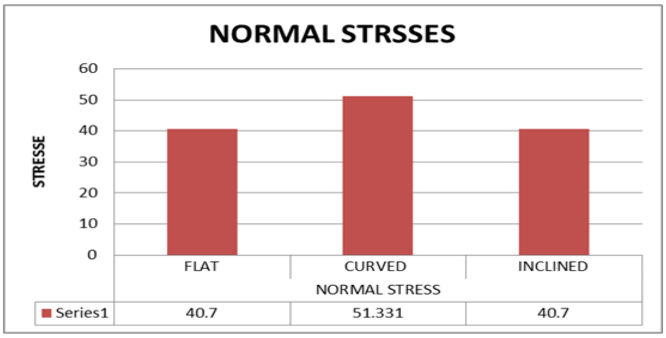


Fig 6 Normal Stresses

Above graph shows the Normal stress of Flat, Curved & Inclined roof.

D. DISCUSSION

From the results its conclude that Max. Displacement And Normal Stresses is economic for curve roof than flat roof and inclined roof.

6. CONCLUSIONS

[1] In This Paper Stadium Roof Is Analyzed For Wind Load And For Time History Analysis. For Wind Load Zone III Is Considered And For Time History Analysis EL-Centro Data Is Used.

[2] For Validation Axial Forces And Support Reaction For Each Type Of Roof Is Analyzed By Joint Method And Compare With Stadd-Pro Values. It Is Observed That The Values Of Stadd Ana Analytical Values Are Nearly Same.

[3] From the results its conclude that Max. Displacement And Normal Stresses is economic for curve roof than flat roof and inclined roof.

REFERENCES

[1]. MELCHERS R.E., “Structural reliability” Elley Horwood ltd., 1987

[2]. MAJOWIECKI M., “Snow and wind experimental analysis in the design of long-span

[3]. Horizontal structures”, Journal of Wind Engineering and Industrial Aerodynamics, Vol. 74 -76, 1998, 795-807.

[4]. LAZZARI M., SAETTA A., VITALIANI R., “Non-linear dynamic analysis of cable-suspended structures subjected to wind actions”, Journal of Computers and Structures, Vol. 79, N. 9, 2001, 953 - 969, March.

[5]. LAZZARI M., MAJOWIECKI M., SAETTA A., VITALIANI R., “Analyze dynamic nonlinear di system structurally legerity sub - horizontal suggest all zone del Vento: Lo studio di La Plata”, Proc. of the 5th National Congress of Wind Engineering, Perugia – 13-15 September 1998.

[6]. LAZZARI M., “Geometrically Non-Linear Structures Subjected To Wind Actions”, Ph.D. Thesis, University of Padua, 2002.

[7]. Schweizerh of K, Ramm E. Displacement dependent pressure loads in nonlinear finite element analyses. Computer Structure 1984;18(6):1099–114.

[8]. Anonymous: Football Stadiums, Technical Recommendation and requirements, FIFA, Federation International Football Association, 4th Edition, Switzerland, 2007.