NATIONAL AWARD COMPETITION FOR STUDENTS 2021

Civil/Structural Engineering Students For Best Innovative Structural Steel Design

Competition Theme :

Iconic Steel Roof Structure over An Open-Air Theatre & Stage

insdag

Institute for Steel Development & Growth

BRIEF OF NACS (C) ----------2021

INTRODUCTION

Considering the safety regulation and social distancing norms of COVID-19, an outdoor theatre for different programs will be an option to give relaxation and enjoyment to the audiences. Especially in this year of pandemic where people got exhausted with lockdown stress and less movement and social gatherings, an open air theatre can bring good interaction and connection between the performers with audiences who can be ensured safety with reduced seating.

APPOINTMENT AS CONSULTANT

INSDAG wishes to provide most economical and aesthetically pleasing schemes and all relevant design and detail drawings thereof, to the Urban Authority.

Considering that you have been appointed as a structural consultant for this project and have been asked to furnish structural solution for "State-of-The-Art Steel Roof Structure over An Open-Air Theatre with Stage", and the task is to prepare a report that should have the following scope:

1. Development of an Economical and Aesthetic structural scheme within the specified requirement.
2. Structural design engineering and Detail drawings for the developed structural scheme.
3. Bill of materials.

FACILITIES

Client/ Architect has specified the following requirements for the proposed project:

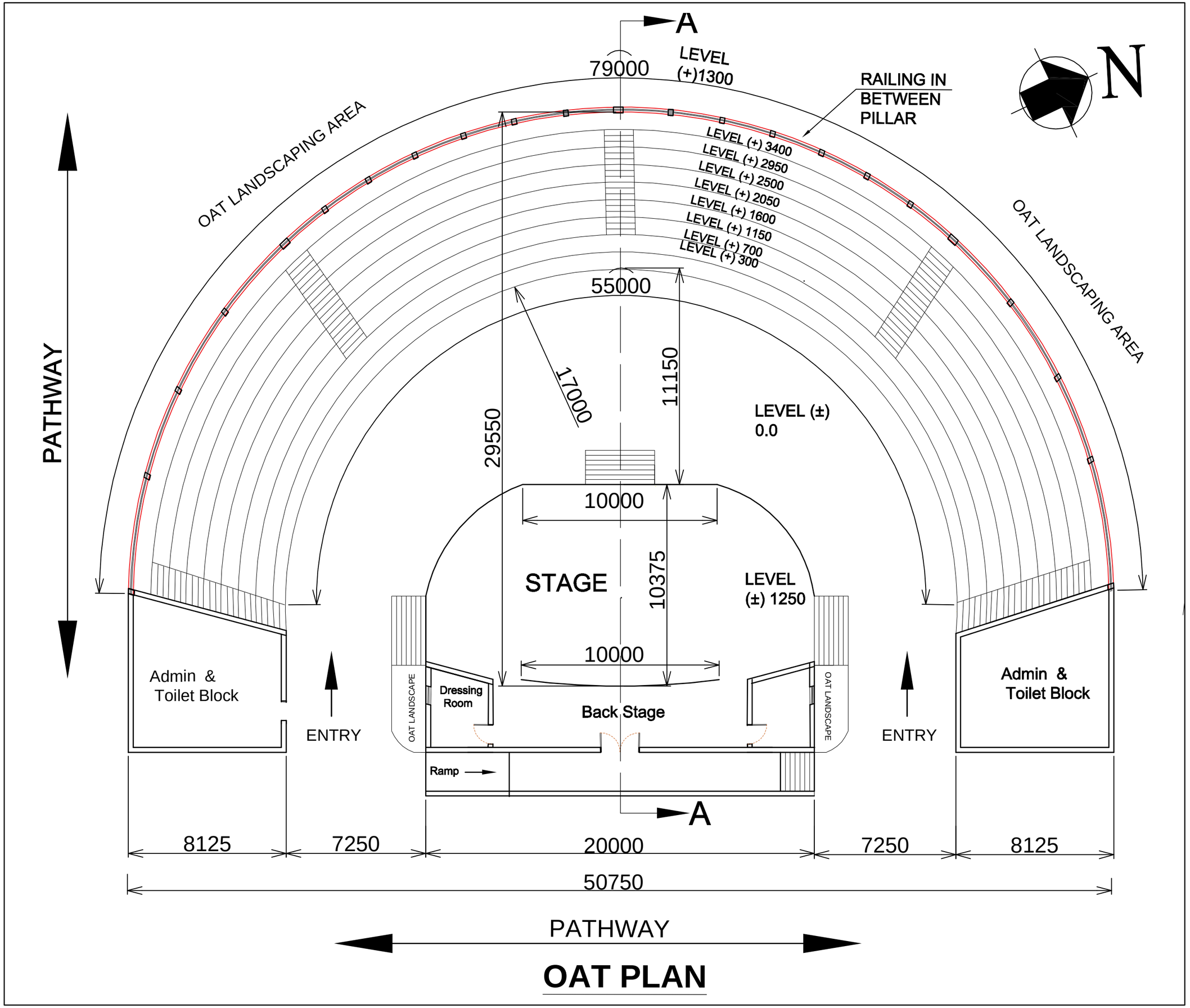
1.	Site Location	:	Kolkata, West Bengal
2.	Total length of the Open-Air Theater (Curved) with Stage	:	As shown in the Diagram.
3.	Column/ Trestle/ Any Support Structure Location	:	Outside / Backside of the theatre and Stage
4.	Column/ Trestle/ Any Support Structure Shape	:	As per Design. No Limitation
5.	Type of Roof Structure	:	Cantilever /Space Frame/Cable Supported/ any other
6.	Depth of Roof Structure	:	As per Design. No Limitation.
7.	Roofing	:	Colour Coated Steel Sheet/ Any Suitable Material
8.	Span of Roof Structure	:	Based on the Design. No Limitation

MATERIALS FOR CONSTRUCTION

1.	Foundation system	:	R.C.C. of minimum grade M25
2.	Structural members like columns, beams, members and bracing systems		Structural steel of mild steel (grade E250) or high tensile steel (grade E350 / E410)
3.	Roof & Cladding	:	Standard Colour Coated Steel Sheet (Galvalume)

STANDARD SHAPE OF THE STRUCTURE

While considering the shape and arrangement of the Structure, aesthetics, economy as well as structural integrity of the entire system has to be considered. The shape and orientation of the structure shall be such so as to attain maximum benefit out of all the natural resources available surrounding the structure.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79000
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OAT LANDSCAPING AREA
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LEVEL (+) 2500
LEVEL (+) 2050
LEVEL (+) 1600
LEVEL (+) 1150
LEVEL (+) 700
LEVEL (+) 300
55000
17000
11150
29550
LEVEL (±)
0.0
10000
STAGE
10375
LEVEL
(±) 1250
10000
Admin &
Toilet Block
ENTRY
OAT LANDSCAPE
Dressing
Room
Back Stage
OAT LANDSCAPE
Ramp
ENTRY
Admin &
Toilet Block
A
8125
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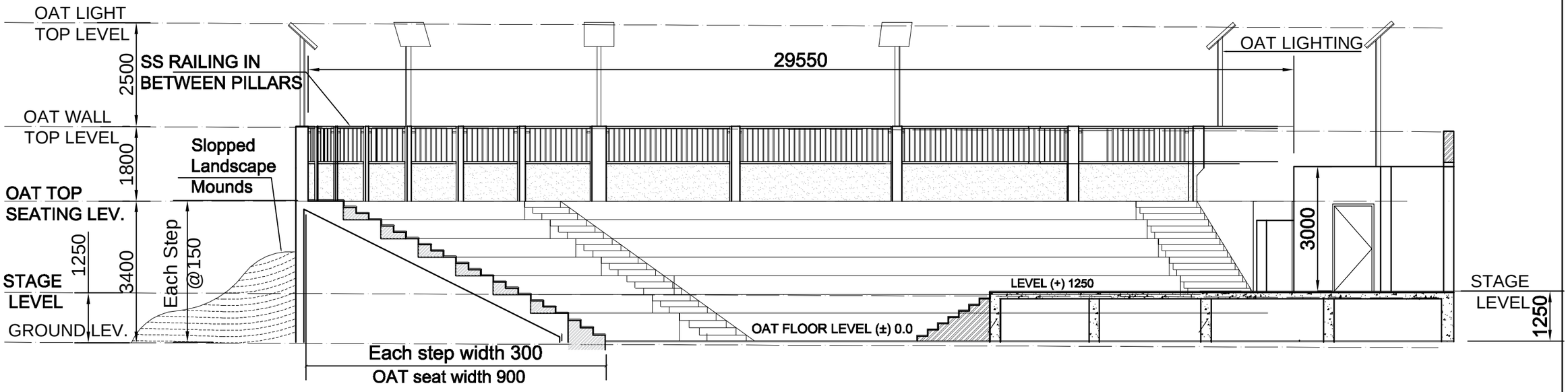
20000
7250
8125
50750
PATHWAY

OAT PLAN



SECTION AA
Not to Scale

YEAR – 2021

COMPETITION TOPIC:

ICONIC STEEL ROOF STRUCTURE OVER AN OPEN-AIR THEATRE WITH STAGE

DESIGN OPTION

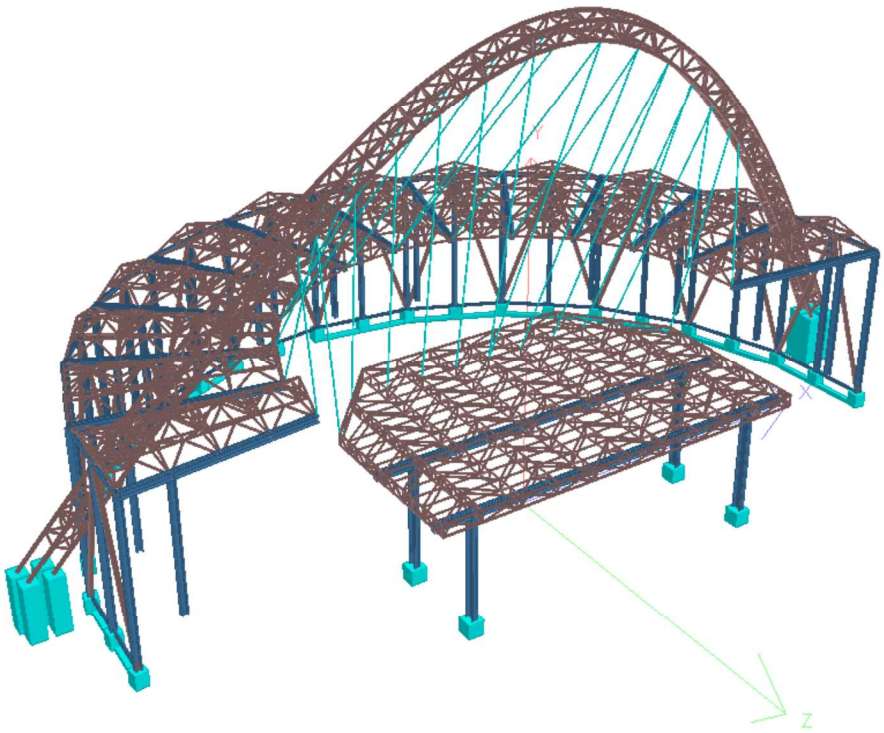
BY

1ST Prize Winner – Team E-01

from
IIEST, Shibpur, Howrah, West Bengal

IIEST, Shibpur
आई आई ई एस टि, शिवपुर
Erstwhile B E College (Estd 1856)

ICONIC STEEL ROOF STRUCTURE OVER AN OPEN-AIR THEATRE AND STAGE



Project Report

Submitted by:
Group No: E 01
Avishek Das
Swapnil Basu
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Department of Civil Engineering
Indian Institute of Engineering Science and Technology, Shibpur

Under the guidance of
Dr. Sujit Kumar Dalui
Assistant Professor, Department of Civil Engineering
Indian Institute of Engineering Science and Technology, Shibpur

1.0 Introduction

An Open Air Theatre is a beautiful recreational site for many people to enjoy their favourite Films, Programs, Plays, Shows along with the evening breeze. With this *iconic roof design* for the Amphitheatre, people are going to enjoy the place even more. As the construction will be completed by the end of the Pandemic, people can enjoy the new environment of the Open Air Theatre and interact with many others after their tiring days of Pandemic restrictions.

The concerned project is based on the scope of the efficient innovative structural design of a Steel roof structure over the Open Air Theatre, Stage and the *Arch* that supports the roof and the stage. The project is located in Kolkata, West Bengal, and is mainly aimed at reiterating the multiple advantages of steel construction such as flexible design, cost-effectiveness, economic benefits and speedy construction.

Steel is essentially a material of choice for design because it is inherently ductile and flexible. Structural steel's low cost, strength, durability, design flexibility, adaptability and recyclability continue to make it a material of choice in construction. Fast construction lowers the overhead expenses for construction management services.

The project has been done using the Limit State Design Method. Limit State Method makes use of partial safety factors applied to both load and strengths calibrated using reliability methods as specified by the code.

2.0 Client/Architect Requirements and specifications

Client Specified requirements for the Steel Roof Structure:

S.No.	Element	Details
1	Site Location	Kolkata, West Bengal.
2	Total Length of the Open Air Theatre (Curved) with Stage	As per problem statement.
3	Column/Trestle/Any Support Structure Location	Outside/Backside of the theatre and Stage (Enough open space around the OAT).
4	Column/Trestle/Any Support Structure Shape	As per design. No limitation.
5	Type of Roof Structure	Cantilever/Space Frame/Cable Supported/Tensile Membrane or any other Roof Structure. Roof over Seating area and Stage may be separated or overall one roof covering whole area.
6	Depth of Roof Structure	As per Design. No limitation.
7	Roofing	Colour Coated steel sheet/ Any suitable material.
8	Span of Roof Structure	Based on the design. No limitation.
9	Minimum Clear height below lowest roof member	Min. 6m above the stage floor level, Min. 8.5m from Top Seat level of OAT and Min. 10.5m from OAT floor.
10	Side walls	No side walls to be designed. There is railing around the OAT as shown in the sketch in the problem statement.
11	Overhang	Minimum 1.5 m if overhang is provided to cover the OAT and Stage without considering the inclination of rain and Sun rays.

3.0 Materials For construction

S.No.	Element	Materials
1	Foundation system	R.C.C. of minimum grade M25
2	Structural members like columns, beams, members and bracing systems	Structural steel of mild steel (grade E250BR) or high tensile steel (grade E350 / E410)
3	Roof and Cladding if any	Standard Colour Coated Steel Sheet/material for Tensile structure/ Any suitable material

4.0 Design Methodology

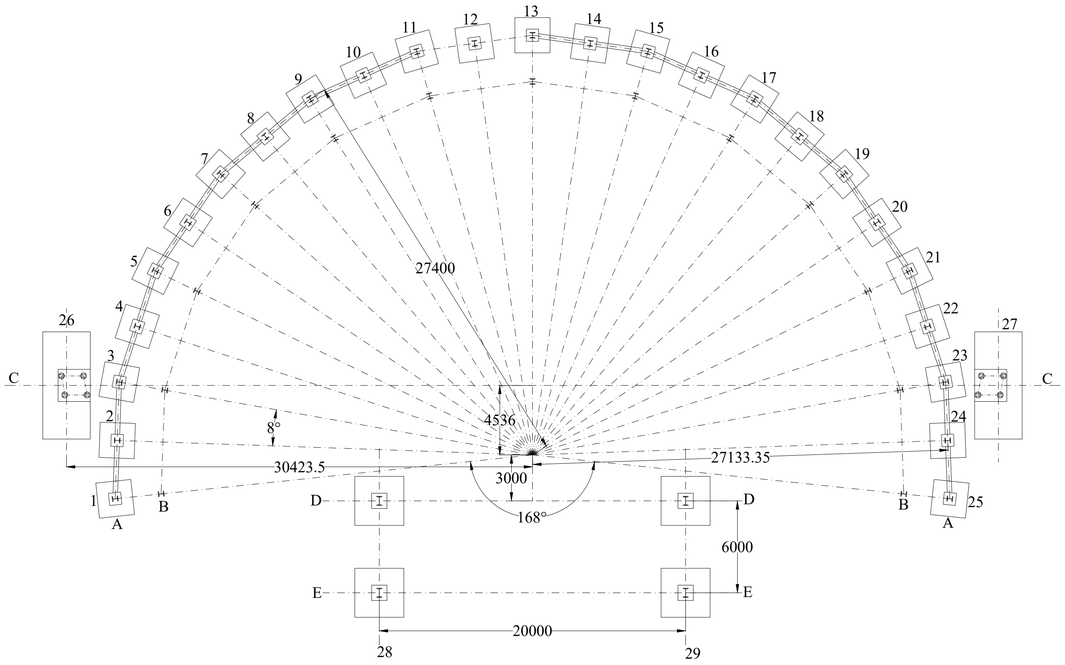
The design of this Roof Structure over the Open Air Theatre and Stage is done with the help of triangulated space truss elements. The design of the elements of this truss has been done using circular hollow steel sections to minimise the steel requirement of the structure. This use of triangular type roof trusses using triangulated space frames and *Arch* imparts aesthetic beauty to the structure.

Space frame (3D truss) is a rigid, lightweight, truss-like structure constructed from interlocking members in a geometric pattern. Space frames can be used to span large areas with few interior supports.

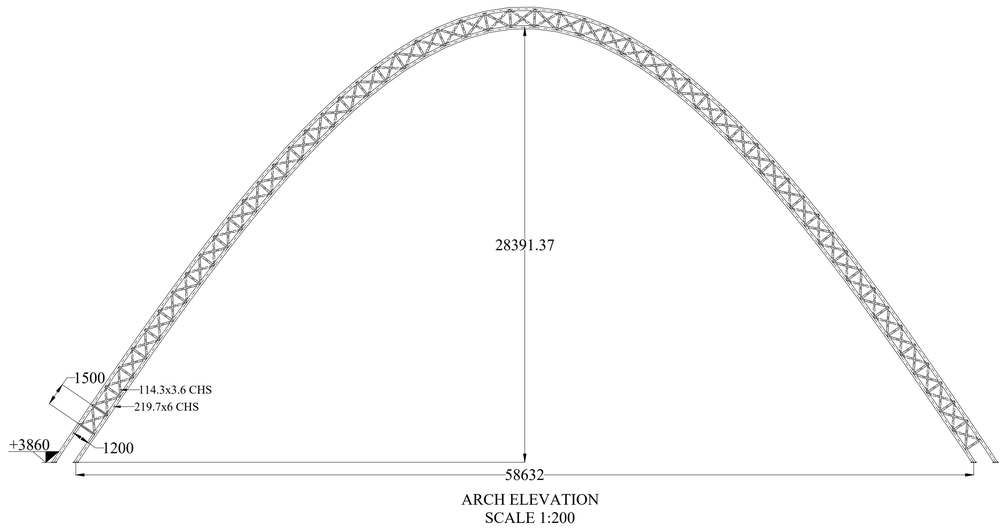
Like the truss, a space frame is strong because of the inherent rigidity of the triangle, flexing loads (bending moments) are transmitted as tension and compression loads along the length of each member. Theoretically, this assumption has been in practice since a very long time but in the actual case, because of rigidity of the joints between the end of the members, end moments are induced which give rise to the secondary stresses. Such joints enforce compatibility of translation as well as compatibility of rotation by members meeting at the joint. Consequently, these members are subjected to moments in addition to axial force, generating secondary stresses.

All the connections have been done using fillet welds. However, a suggestion of using ball and socket connections such as the commercial 3D joints manufactured by (Delta Structures Inc) is recommended, which have not been incorporated in the design because of availability problems.

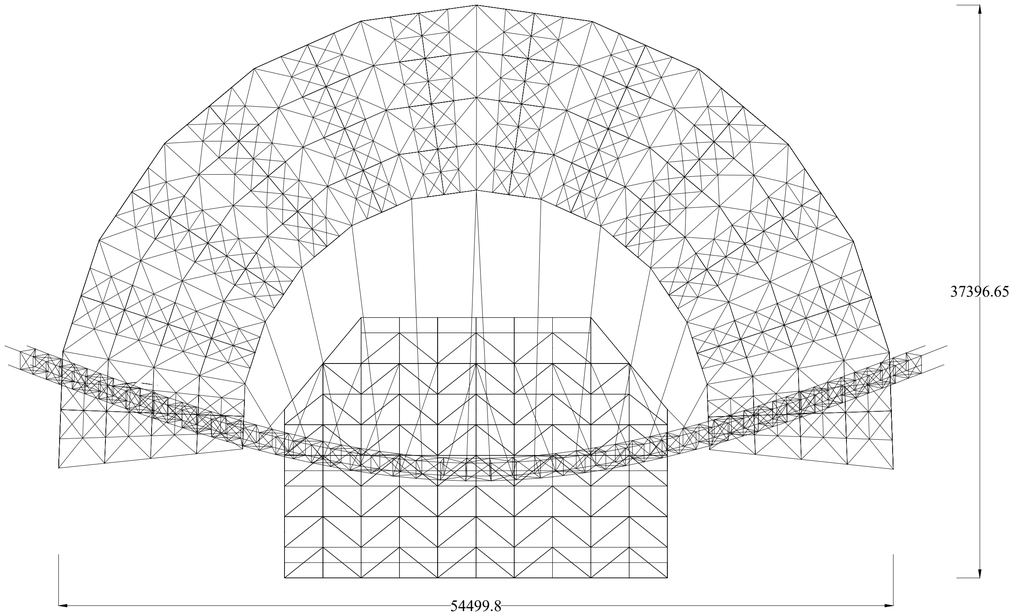
Design has been done in STAAD.Pro Connect Edition Software following IS 800:2007.



FOUNDATION GRID
SCALE 1:200



ARCH ELEVATION
SCALE 1:200



TOP VIEW OF O.A.T.
SCALE 1:200

NOTES:

1. ALL DIMENSIONS ARE IN MM UNLESS SPECIFIED.
2. ALL GUSSET PLATE THICKNESSES ARE SPECIFIED.
3. ALL DIMENSIONS TO BE CHECKED AND VERIFIED BY FULL SCALE SHOP LAYOUT.
4. ALL STRUCTURAL STEEL SHALL CONFORM TO IS:2062 (2011).
5. ELECTRODES FOR MILD STEEL SHALL CONFORM TO IS:814 AND IS:815(2004).
6. ALL M.S BOLTS AND NUTS SHALL GENERALLY CONFORM TO IS: 1363 (2002).
7. SCALE OF EACH DRAWING IS SPECIFIED BELOW EACH DRAWING.
8. FOOTING A1 TO A25 WILL BE OF F1 TYPE.
9. FOOTING D28, D29, E28 AND E29 WILL BE OF F2 TYPE.
10. FOOTING C26, C27 WILL BE OF F3 TYPE.
11. STRUCTURAL STEEL FOR ARCH WILL BE OF E350 AND OTHERS WILL BE OF E250.

REV.:	DATE	DETAIL OF REVISION	BY	CHD.	APP.	ACKD. BY	REF. DRAWING NO.	DETAILS OF REFERANCE DRG.

NOTES

DRG. DEVELOPED BY: E-01(KOLUGURI VARENYA)

TITLE:- GRID VIEW, TOP VIEW OF O.A.T. AND ELEVATION OF ARCH

VENDOR DRG. NUMBER | SE-FD-HMCPCL-0001 | REV.: 0

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Erstwhile B E College (Estd 1856)

INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR

NAME	SIGN	DATE
AVISHEK DAS		
SWAPNIL BASU		
SOMRAJ SEN		
K. VARENYA		

SCALE: GIVEN BELOW EACH DRAWING

AUTOCAD | SHEET SIZE: A1

SUBJECT:- OPEN AIR THEATRE

TITLE:- GRID VIEW, TOP VIEW OF O.A.T. AND ELEVATION OF ARCH

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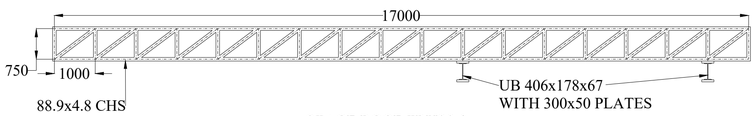

STAGE ROOF TRUSS 1
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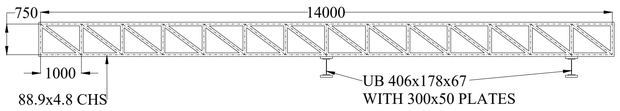
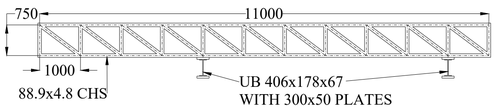
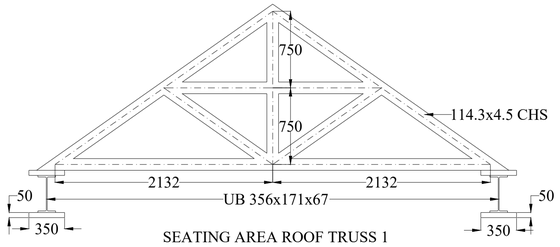


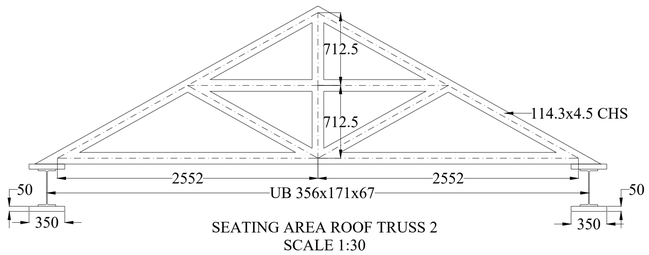
STAGE ROOF TRUSS 2
SCALE 1:75



STAGE ROOF TRUSS 3
SCALE 1:75



SEATING AREA ROOF TRUSS 1
SCALE 1:30



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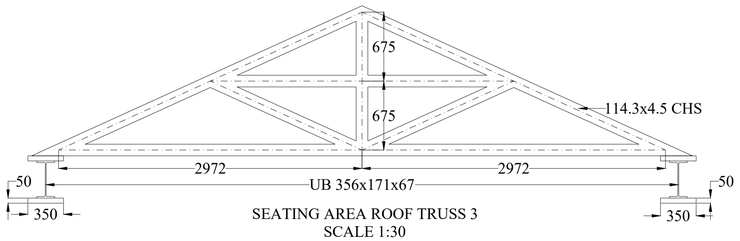
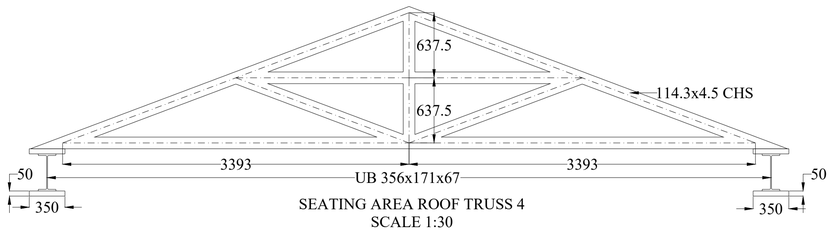


SEATING AREA ROOF TRUSS 3
SCALE 1:30



SEATING AREA ROOF TRUSS 4
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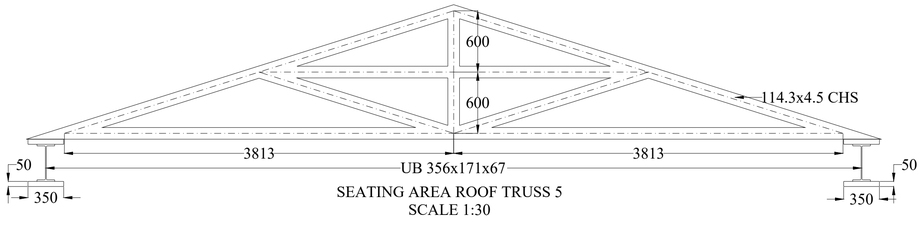

SEATING AREA ROOF TRUSS 5
SCALE 1:30

NOTES:

1. ALL DIMENSIONS ARE IN MM UNLESS SPECIFIED.
2. ALL GUSSET PLATE THICKNESSES ARE SPECIFIED.
3. ALL WELDS THICKNESSES ARE MENTIONED WITH THE DRAWINGS.
4. ALL DIMENSIONS TO BE CHECKED AND VERIFIED BY FULL SCALE SHOP LAYOUT.
5. ALL STRUCTURAL STEEL SHALL CONFORM TO IS 2062 (2011).
6. ALL WELDS SYMBOLS ARE AS PER IS813(1986).
7. ELECTRODES FOR MILD STEEL SHALL CONFORM TO IS:814 AND IS:815(2004).
8. ALL M.S BOLTS AND NUTS SHALL GENERALLY CONFORM TO IS 1363 (2002).
9. ALL THE STRUCTURAL STEEL WILL BE OFF FE410.

REV.:	DATE	DETAIL OF REVISION	BY	CHD.	APP.	ACKD. BY	REF. DRAWING NO.	DETAILS OF REFERANCE DRG.	NOTES

DRG. DEVELOPED BY: E-01(KOLUGURI VARENYA)

TITLE:- SEATING AREA AND STAGE ROOF TRUSS ELEVATIONS

VENDOR DRG. NUMBER: SE-FD-HMCPCL-0001 REV.: 0

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SCALE	GIVEN BELOW EACH DRAWING		
NAME		SIGN	DATE
AVISHEK DAS			
SWAPNIL BASU			
SOMRAJ SEN			
K. VARENYA			

AUTOCAD | SHEET SIZE A1

SUBJECT:- OPEN AIR THEATRE

TITLE:- SEATING AREA AND STAGE ROOF TRUSS ELEVATIONS

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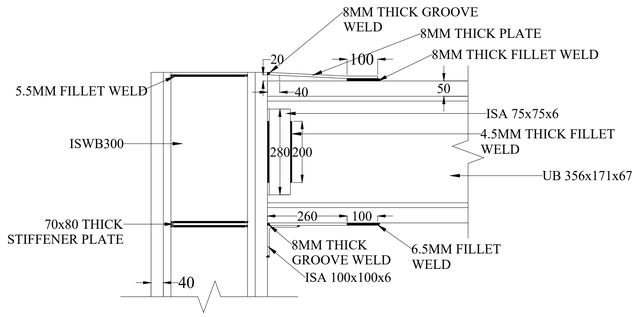
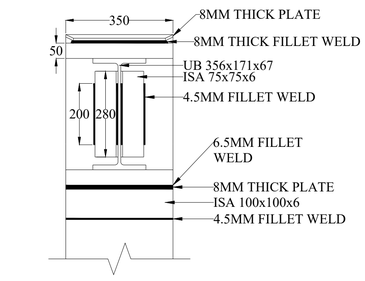
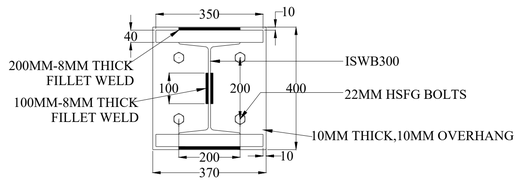


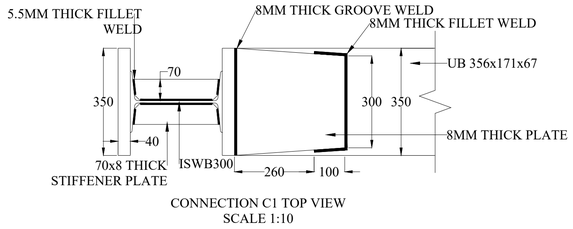
CONNECTION C1 SIDE ELEVATION
SCALE 1:10



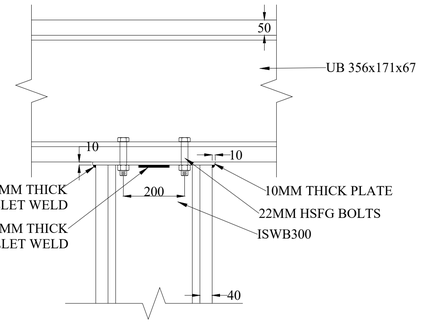
CONNECTION C1 FRONT ELEVATION
SCALE 1:10



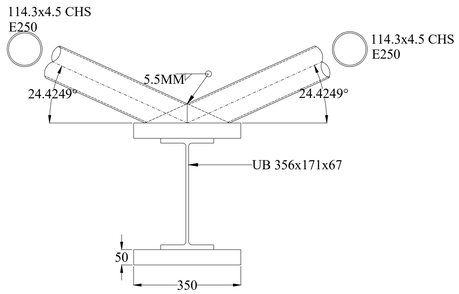
C2 COLUMN CAP CONNECTION TOP VIEW
SCALE 1:10



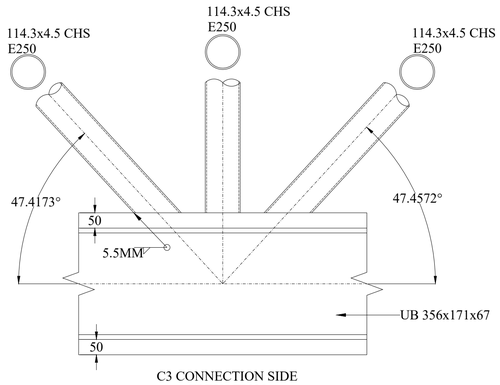
CONNECTION C1 TOP VIEW
SCALE 1:10



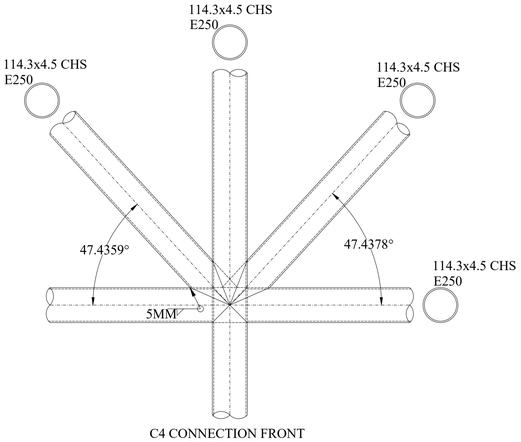
C2 COLUMN CAP SIDE VIEW
SCALE 1:10



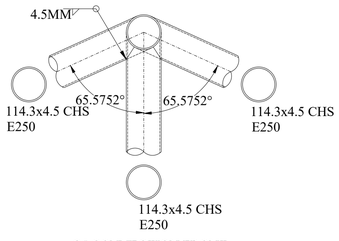
C3 CONNECTION FRONT ELEVATION
SCALE 1:10



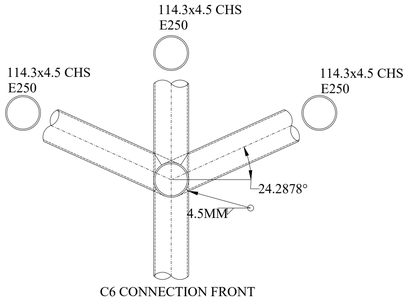
C3 CONNECTION SIDE ELEVATION
SCALE 1:10



C4 CONNECTION FRONT ELEVATION
SCALE 1:10



C5 CONNECTION FRONT ELEVATION
SCALE 1:10



C6 CONNECTION FRONT ELEVATION
SCALE 1:10

NOTES:

1. ALL DIMENSIONS ARE IN MM UNLESS SPECIFIED.
2. ALL GUSSET PLATE THICKNESSES ARE SPECIFIED.
3. ALL WELDS THICKNESSES ARE MENTIONED WITH THE DRAWINGS.
4. ALL DIMENSIONS TO BE CHECKED AND VERIFIED BY FULL SCALE SHOP LAYOUT.
5. ALL STRUCTURAL STEEL SHALL CONFORM TO IS:2062 (2011).
6. ALL WELDS SYMBOLS ARE AS PER IS:813(1986).
7. ELECTRODES FOR MILD STEEL SHALL CONFORM TO IS:814 AND IS:815(2004).
8. ALL M.S BOLTS AND NUTS SHALL GENERALLY CONFORM TO IS: 1363 (2002).
9. C1 COLUMN - VALLEY BEAM END CONNECTION.
10. C2 COLUMN - VALLEY BEAM CAP CONNECTION.
11. C3 NODE 260 K-T JOINT.
12. C4 NODE 305 K-X JOINT.
13. C5 NODE 298 V-V JOINT.
14. C6 NODE 774 V-I JOINT.
15. ALL STRUCTURAL STEEL WILL BE OF E250.

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REV.:	DATE	DETAIL OF REVISION	BY	CHD.	APP.	ACKD. BY	REF. DRAWING NO.	DETAILS OF REFERANCE DRG.

NOTES

DRG. DEVELOPED BY: E-01(KOLUGURI VARENYA)

TITLE:- BEAM-COLUMN AND TRUSS CONNECTION DETAILS

VENDOR DRG. NUMBER SE-FD-HMCPCL-0001 REV.: 0

SCALE	GIVEN BELOW EACH DRAWING	
NAME	SIGN	DATE
AVISHEK DAS		
SWAPNIL BASU		
SOMRAJ SEN		
K. VARENYA		

AUTOCAD SHEET SIZE A1

SUBJECT:- OPEN AIR THEATRE

TITLE:- BEAM-COLUMN AND TRUSS CONNECTION DETAILS

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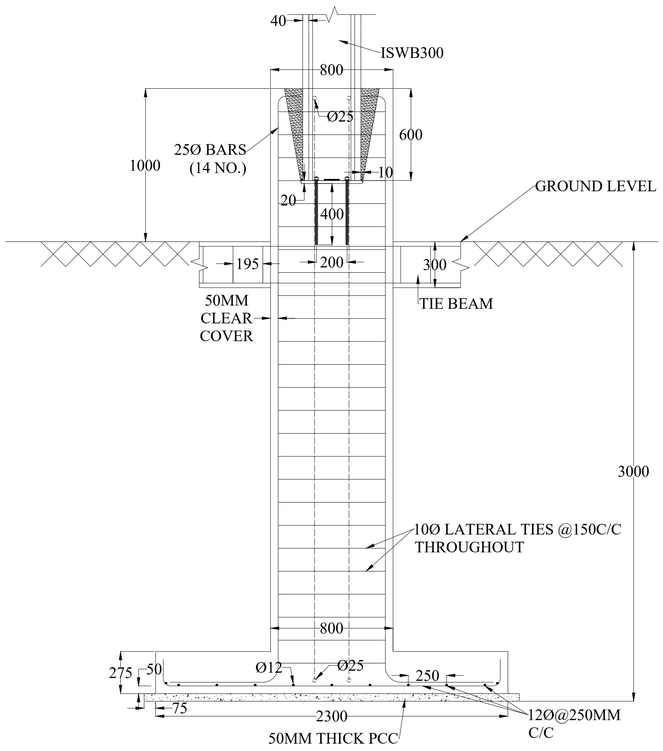
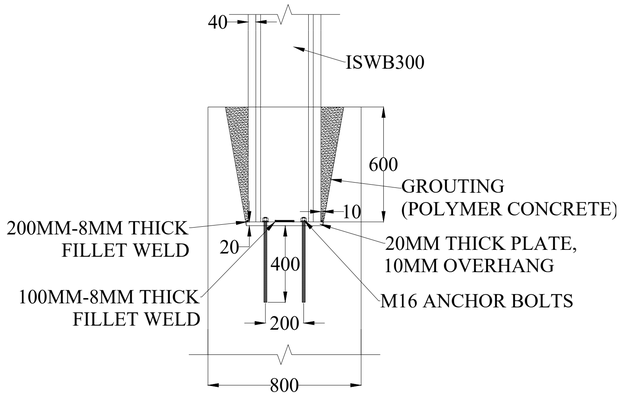
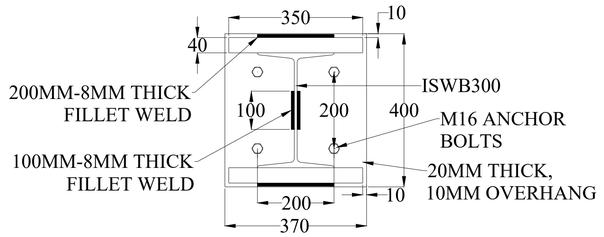


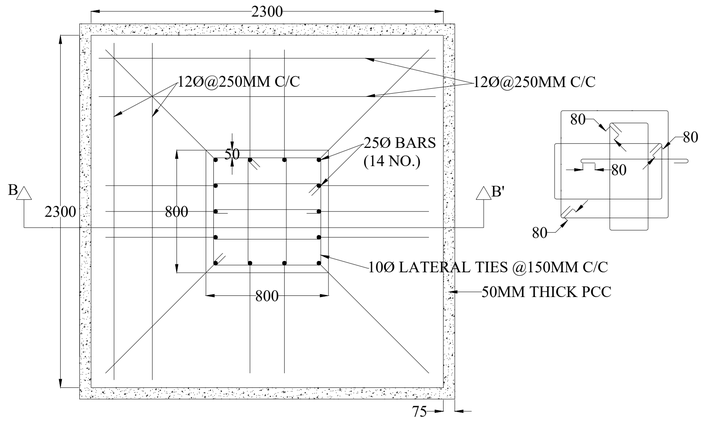
BB' SECTIONAL VIEW OF
FOOTING (F1)
SCALE 1:20



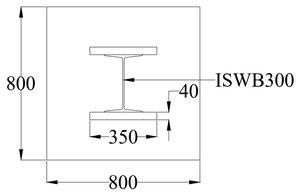
BASE PLATE DETAILS OF SEATING
AREA ROOF COLUMN (ELEVATION)
SCALE 1:16



BASE PLATE DETAILS OF
SEATING AREA ROOF COLUMN
(TOP VIEW)
SCALE 1:8



PLAN VIEW OF FOOTING (F1)
SCALE 1:20



TOP VIEW OF PEDESTAL OF SEATING
AREA ROOF COLUMN
SCALE 1:16

NOTES:

1. ALL DIMENSIONS ARE IN MM UNLESS SPECIFIED.
2. ALL GUSSET PLATE THICKNESSES ARE SPECIFIED.
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10. ALL THE REBARS SHOULD BE OF GRADE FE415.
11. DESIGN CONCRETE MIX TO BE DONE CONFORMING WITH IS 10262: 2019.

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Erstwhile B E College (Estd 1856)

INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR

REV.:	DATE	DETAIL OF REVISION	BY	CHD.	APP.	ACKD. BY	REF. DRAWING NO.	DETAILS OF REFERANCE DRG.

NOTES

DRG. DEVELOPED BY: E-01(KOLUGURI VARENYA)

TITLE:- SEATING AREA ROOF PEDESTAL, FOOTING(F1) AND BASE PLATE DETAILS

VENDOR DRG. NUMBER | SE-FD-HMCPCL-0001 | REV.: 0

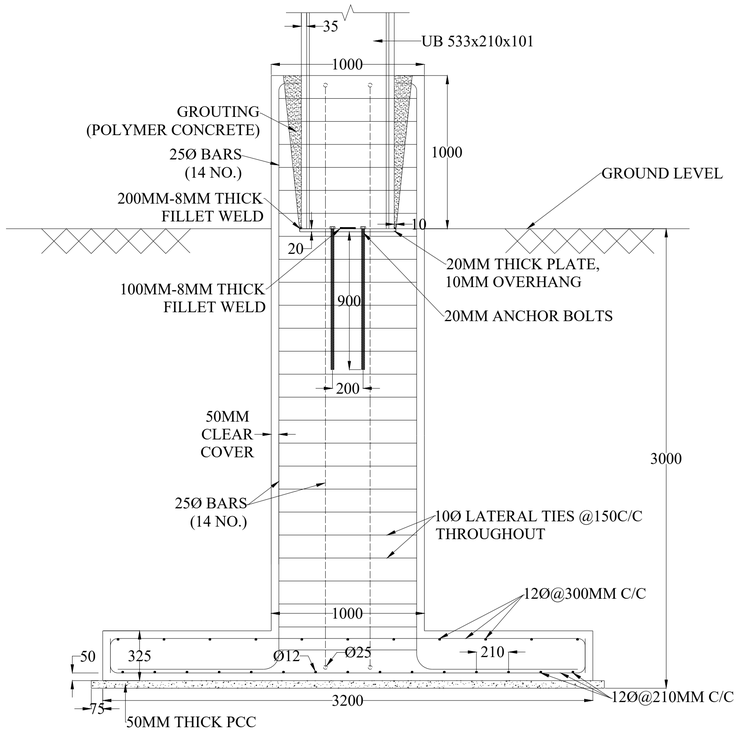
SCALE	GIVEN BELOW EACH DRAWING	
NAME	SIGN	DATE
AVISHEK DAS		
SWAPNIL BASU		
SOMRAJ SEN		
K. VARENYA		

AUTOCAD | SHEET SIZE | A1

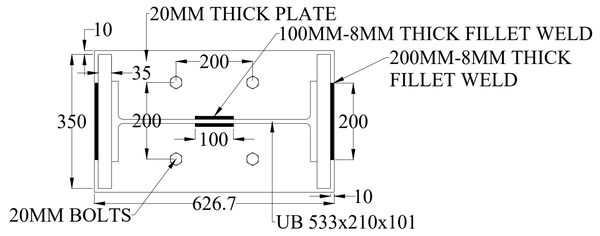
SUBJECT:- OPEN AIR THEATRE

TITLE:- SEATING AREA ROOF PEDESTAL, FOOTING(F1) AND BASE PLATE DETAILS

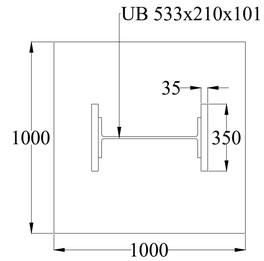
DWG NO.:- 4 (SHEET 4 OF 8) | REV.: 0



AA' SECTIONAL VIEW OF FOOTING (F2)
SCALE 1:20



BASE PLATE DETAILS OF
STAGE COLUMN
(TOP VIEW)
SCALE 1:8



TOP VIEW OF PEDESTAL
OF STAGE COLUMNS
SCALE 1:16

NOTES:
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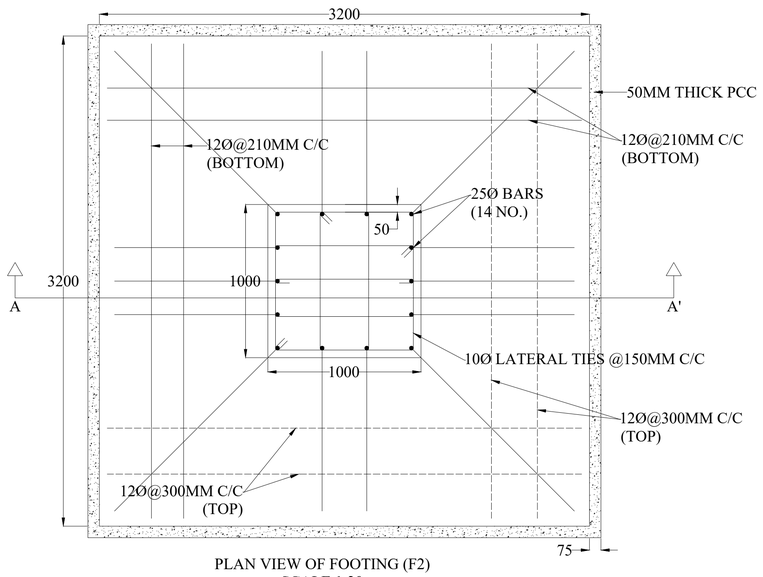
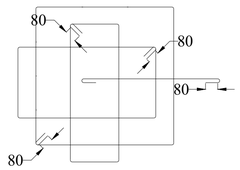


PLAN VIEW OF FOOTING (F2)
SCALE 1:20



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NOTES

DRG. DEVELOPED BY: E-01(KOLUGURI VARENYA)

TITLE:- STAGE PEDESTAL, FOOTING(F2) AND BASE PLATE DETAILS

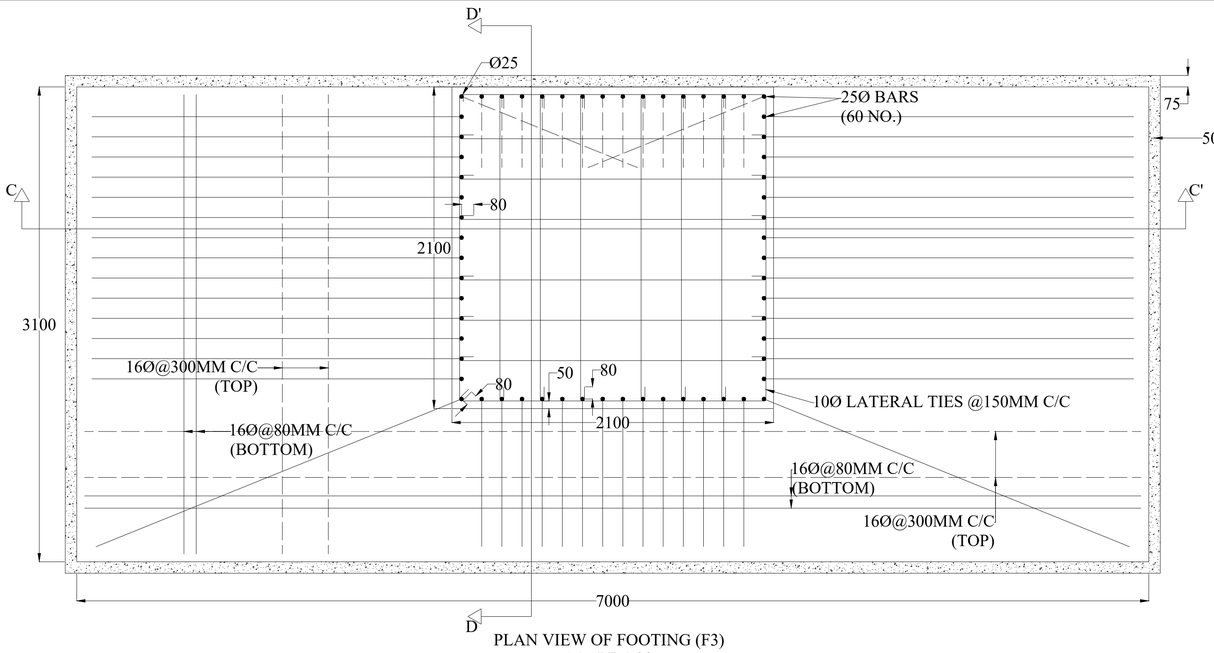
VENDOR DRG. NUMBER SE-FD-HMCPCL-0001 REV.: 0

SCALE	GIVEN BELOW EACH DRAWING	
NAME	SIGN	DATE
AVISHEK DAS		
SWAPNIL BASU		
SOMRAJ SEN		
K. VARENYA		

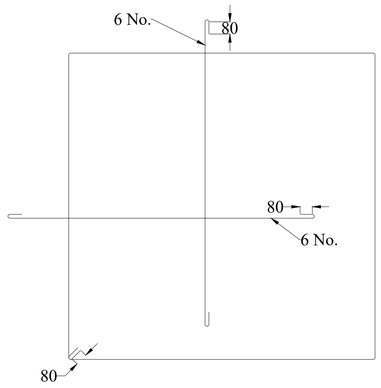
SUBJECT:- OPEN AIR THEATRE

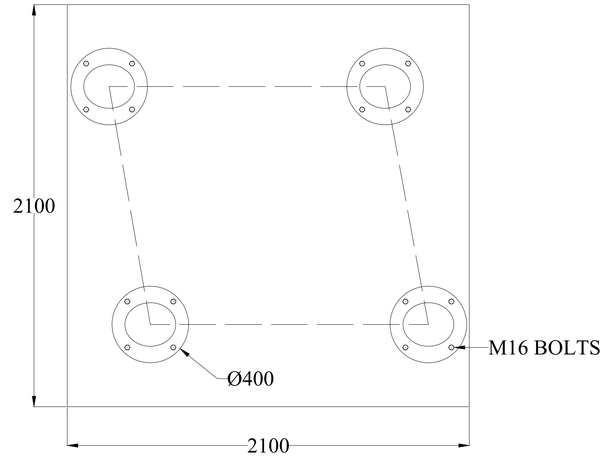
TITLE:- STAGE PEDESTAL, FOOTING(F2) AND BASE PLATE DETAILS

AUTOCAD | SHEET SIZE A1 | DWG NO.:- 4 (SHEET 5 OF 8) | REV.: 0

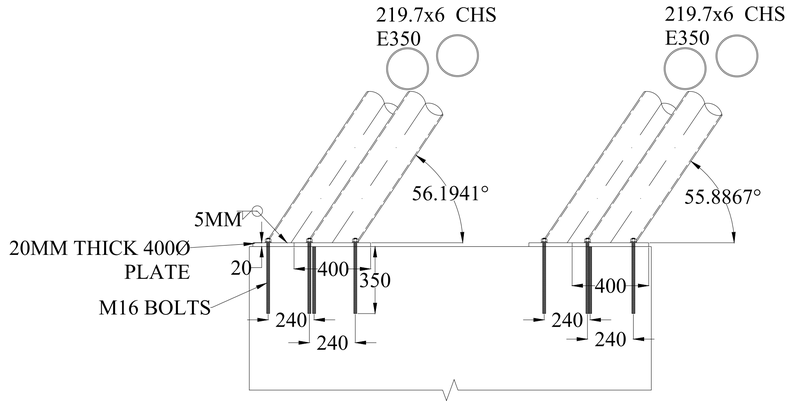


PLAN VIEW OF FOOTING (F3)
SCALE 1:20

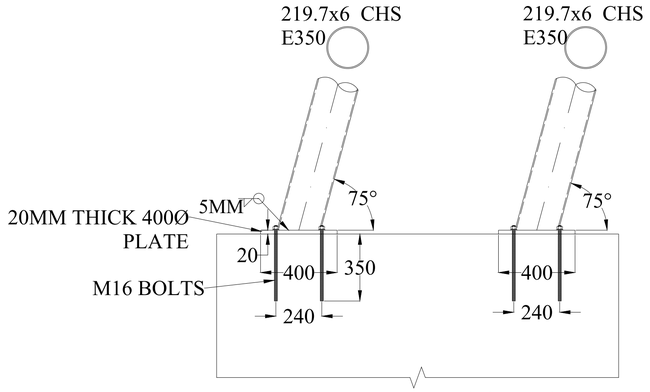




TOP VIEW OF PEDESTAL OF ARCH
SCALE 1:16



BASE PLATE DETAILS OF ARCH
(ALONG DD')
SCALE 1:16



BASE PLATE DETAILS OF ARCH
(ALONG CC')
SCALE 1:16

NOTES:
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NOTES

DRG. DEVELOPED BY: E-01(KOLUGURI VARENYA)

TITLE:- ARCH PEDESTAL, FOOTING(F3) AND BASE PLATE DETAILS

VENDOR DRG. NUMBER SE-FD-HMCPCL-0001 REV.: 0

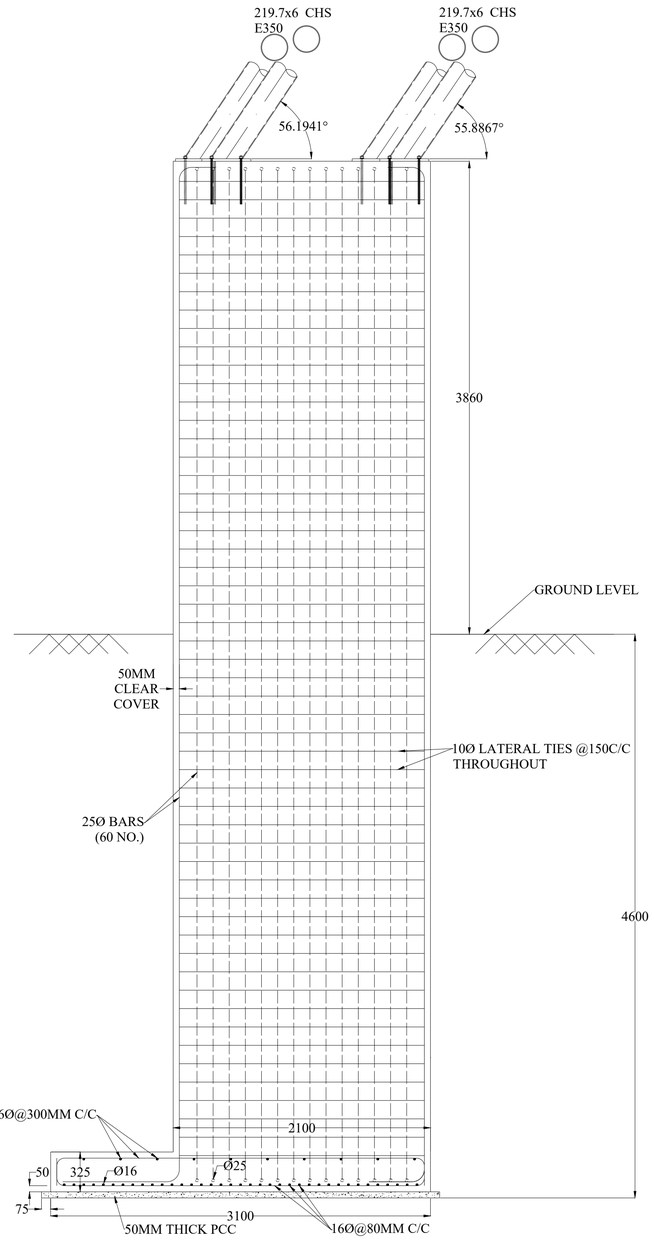
SCALE	GIVEN BELOW EACH DRAWING	
NAME	SIGN	DATE
AVISHEK DAS		
SWAPNIL BASU		
SOMRAJ SEN		
K. VARENYA		

AUTOCAD SHEET SIZE A1

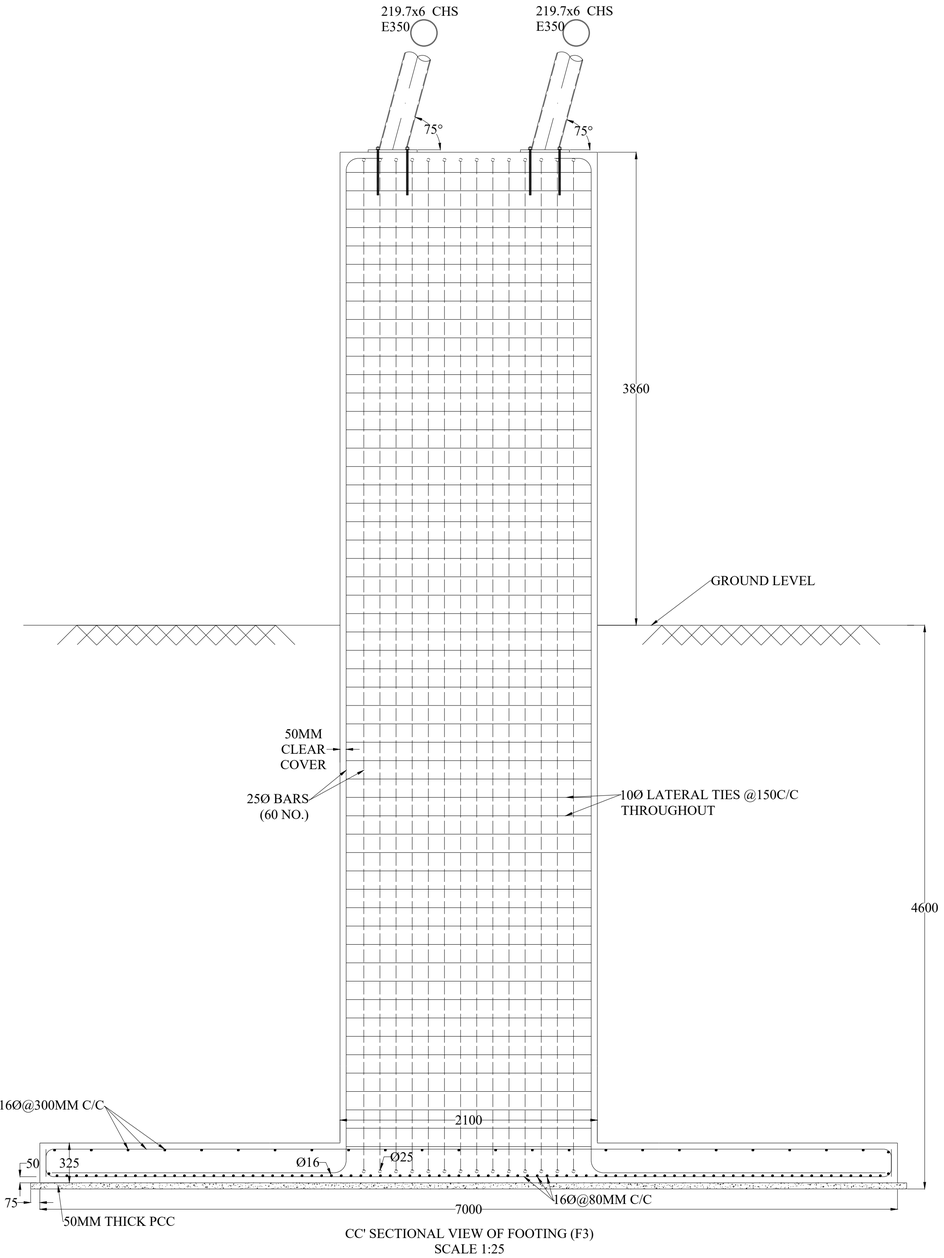
SUBJECT:- OPEN AIR THEATRE

TITLE:- ARCH PEDESTAL, FOOTING(F3) AND BASE PLATE DETAILS

DWG NO.:- 4 (SHEET 6 OF 8) REV.: 0



DD' SECTIONAL VIEW OF FOOTING (F3)
SCALE 1:25



CC' SECTIONAL VIEW OF FOOTING (F3)
SCALE 1:25

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DRG. DEVELOPED BY: E-01(KOLUGURI VARENYA)

TITLE:- ARCH PEDESTAL, FOOTING(F3) AND BASE PLATE DETAILS

VENDOR DRG. NUMBER SE-FD-HMCPCL-0001 REV.: 0

SCALE	GIVEN BELOW EACH DRAWING	
NAME	SIGN	DATE
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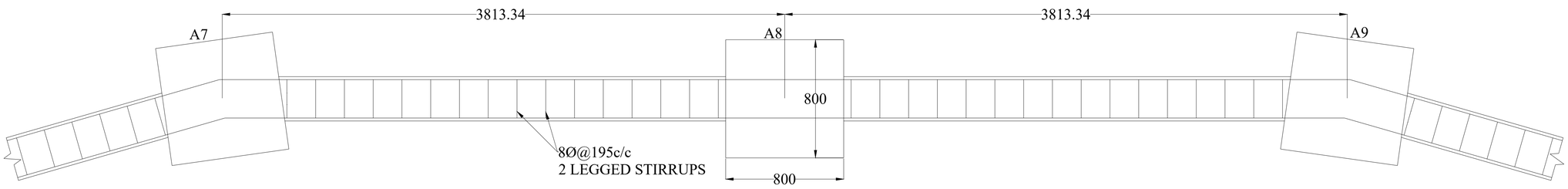
SWAPNIL BASU		
SOMRAJ SEN		
K. VARENYA		

AUTOCAD SHEET SIZE A1

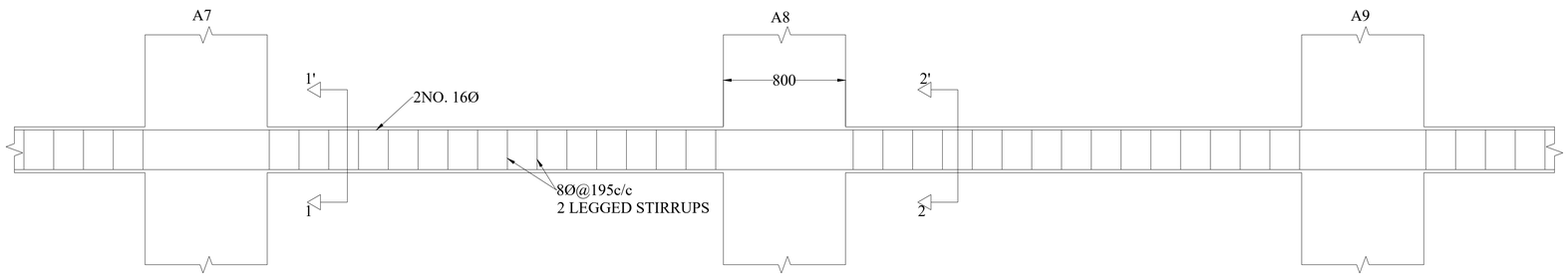
SUBJECT:- OPEN AIR THEATRE

TITLE:- ARCH PEDESTAL, FOOTING(F3) AND BASE PLATE DETAILS

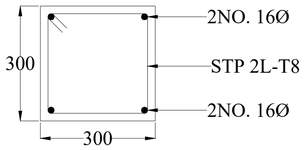
DWG NO.:- 4 (SHEET 7 OF 8) REV.: 0



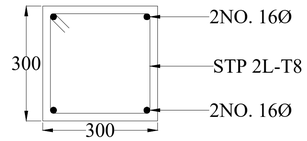
TOP VIEW OF SEATING AREA TIE BEAMS
SCALE 1:16



ELEVATION OF SEATING AREA TIE BEAMS
SCALE 1:20



1-1' SECTIONAL VIEW OF SEATING AREA TIE BEAM
SCALE 1:8



2-2' SECTIONAL VIEW OF SEATING AREA TIE BEAM
SCALE 1:8

NOTES:
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NOTES

DRG. DEVELOPED BY: E-01(KOLUGURI VARENYA)

TITLE:- TIE BEAM REINFORCEMENT DETAILS

VENDOR DRG. NUMBER SE-FD-HMCPCL-0001 REV.: 0

SCALE	GIVEN BELOW EACH DRAWING	
NAME	SIGN	DATE
AVISHEK DAS		
SWAPNIL BASU		
SOMRAJ SEN		
K. VARENYA		

AUTOCAD | SHEET SIZE A1

SUBJECT:- OPEN AIR THEATRE

TITLE:- TIE BEAM REINFORCEMENT DETAILS

DWG NO.:- 5 (SHEET 8 OF 8) REV.: 0

YEAR – 2021

COMPETITION TOPIC:

ICONIC STEEL ROOF STRUCTURE OVER AN OPEN-AIR THEATRE WITH STAGE

DESIGN OPTION

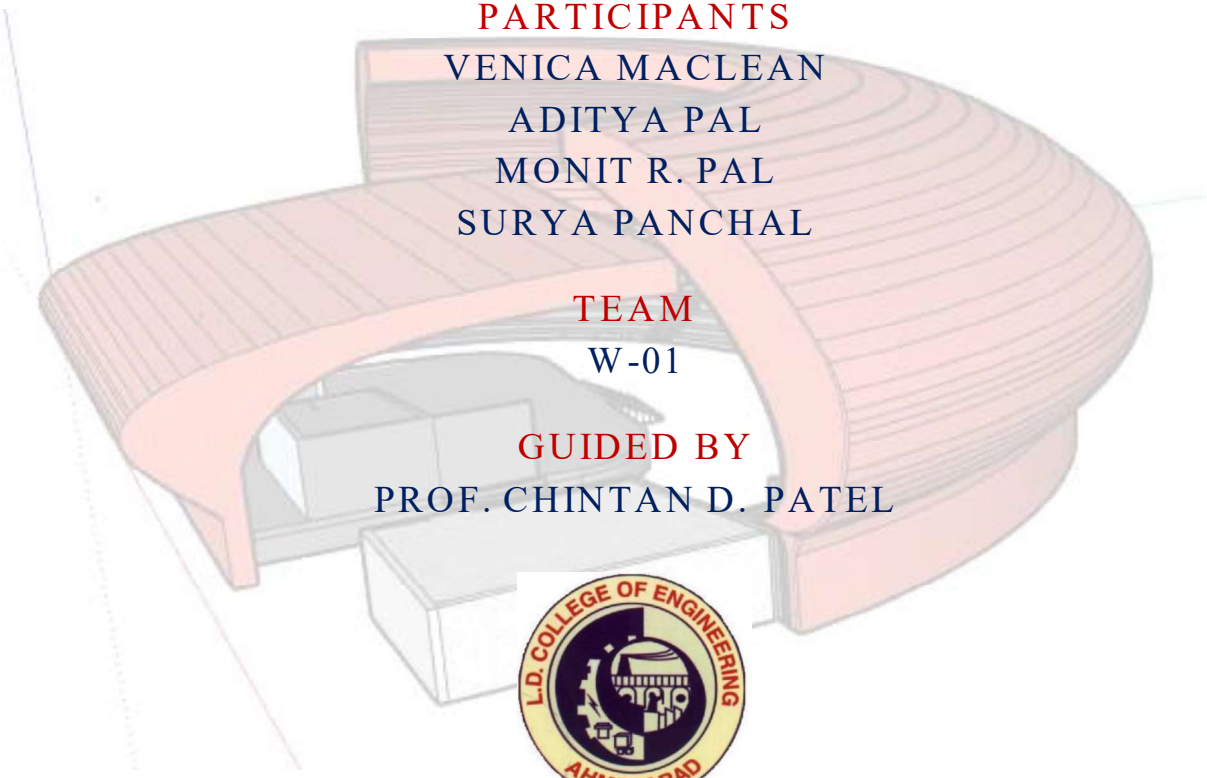
BY

3ND- A Prize Winner – Team E-06

from
L. D. College of Engineering and Technology, Ahmedabad, Gujarat

NATIONAL AWARD COMPETITION FOR STUDENTS 2021

ICONIC STEEL ROOF STRUCTURE OVER AN OPEN-AIR THEATRE & STAGE



PARTICIPANTS

VENICA MACLEAN

ADITYA PAL

MONIT R. PAL

SURYA PANCHAL

TEAM

W-01

GUIDED BY

PROF. CHINTAN D. PATEL

L. D. COLLEGE OF ENGINEERING
AHMEDABAD-380015
GUJARAT

2.0 PARAMETERS PROVIDED BY INSDAG

1	Site Location	Kolkata, West Bengal
2	Total length of the Open-Air Theatre (Curved) with Stage	Seating: 18.661 m Stage: 18.43 m
3	Column/ Trestle/ Any Support Structure Location	Outside / Backside of the theatre and Stage (Enough open space around the OAT)
4	Column/ Trestle/ Any Support Structure Shape	Rectangle columns
5	Type of Roof Structure	Cantilever /Space Frame/Cable Supported/Tensile Membrane or any other Roof Structure. Roof over Seating area and Stage may be separated or overall one roof covering whole area
6	Roofing	Colour Coated Steel Sheet/ Any Suitable Material
7	Span of Roof Structure	Seating: 10.5 m Stage: 17.12 m
8	Minimum Clear height below lowest roof member	Min 6 m above the stage floor level, Min 8.5 m Top seat level of OAT & Min 10.5 m from OAT floor. **Provided:** **Seating: 13.75 m** **Stage: 8.03 m**
9	Overhang	Minimum 1.5 m if overhang is provided to cover the OAT and Stage without considering the inclination of rain and sunrays
10	Foundation system	R.C.C. of minimum grade M25
11	Structural members like columns, beams, members and bracing systems	Structural steel of mild steel (grade E250BR) or high tensile steel (grade E350 / E410)
12	Roof & Cladding	Standard Colour Coated Steel Sheet/material for Tensile structure/ Any suitable material

2.0 PARAMETERS PROVIDED BY INSDAG

1	Foundation system	R.C.C. of minimum grade M25
2	Structural members like columns, beams, members and bracing systems	Structural steel of mild steel (grade E250BR) or high tensile steel (grade E350 / E410)
3	Temperature variation	15 Centigrade
4	Safe Bearing Capacity	150.0 kN/m2 at 3.0m from GL
5	Electrical and other allied loads from bottom of roof structure	20 kg per sq. meter

2.1 GENERAL GUIDELINES BY INSDAG:

- Items designed in accordance with design scope, should be checked for axial, bending, bearing stresses etc. as applicable. Equivalent stresses and any other stresses necessitated by the relevant codes should also be calculated.

- Deflection calculated should be within stipulations gives in relevant IS code.

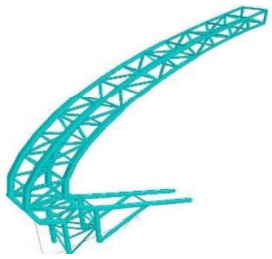
- For design of Base Plates and Foundation Bolts, grade of concrete to be considered as mentioned above.

- The shape and orientation of the structure shall be such so as to attain maximum benefit out of all the natural resources available surrounding the structure.

- All connections shall be either welded connection or bolted connection using mild steel or high tensile black bolts, turned bolts or HSFG bolts.

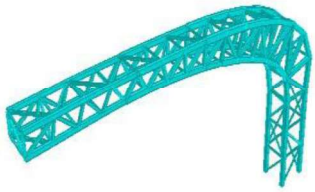
4.0 BIFURCATION OF SEATING AND STAGE ROOF DESIGN

SEATING ROOF



- Entire Seating roof structure geometry comprises of 16 Truss frame systems (as shown above) spaced at distance of **4m** at bottom in a semi-circular shape covering the angle of 179°.
- Each frame is of size **1.5m * 1.8m** with lower Purlin-Purlin spacing being **1.35m** and upper Purlin-Purlin spacing being **1.25m.**
- Four steel columns (of height **3.1m**), connected by Battens and Lacings have been erected from the pedestal above which the Truss roof assembly is supported.
- Square Hollow Sections (SHS) with larger sections at the base and reducing gradually while reaching the top, are utilized in these systems. This facilitates economical structure and also checks the deflection from the extreme end at the top.
- SHS connectors are used to connect the individual frame system and connection is made rigid by also providing bracings between the connectors. This mechanism imparts integrity to the Truss frames and results in an overall self-supporting geometry.
- Purlins of length **5.5m** is provided to connect the rafters of all the frames and loads have been applied per meter length on these purlins which is distributed to the members of the Truss frame. Partial moment release is applied at the connections in the frame which results into only axial forces being transferred to the Truss members.
- Inclined beams originating from the top of Trestles serve the purpose of being the reference for placing the concrete slab for seating and connecting the concrete slab for seating with the Roof frame.
- Truss System: Truss system adopted is **Warren type Truss** to take its advantage in evenly spreading the load across different members. The design obtained is fairly simple as compared to other truss systems.

STAGE ROOF



- Entire stage roof structure geometry comprises of 6 Truss frame systems (as shown above) spaced at distance of **3m** at bottom in a linear orientation.
- Each frame is of size **1.5m * 1.8m** with lower Purlin-Purlin spacing being **1.25m** and upper Purlin-Purlin spacing being **1.45m.**
- Four steel columns (of height **3.9m**), connected/stiffened by Battens and Lacings have been erected from the pedestal above which the Truss roof assembly is supported.
- Square Hollow Sections (SHS) with larger sections at the base and reducing gradually while reaching the top, are utilized in these systems. This facilitates economical structure and also checks the deflection from the extreme end at the top.
- SHS connectors are used to connect the individual frame system and connection is made rigid by also providing bracings between the connectors. This mechanism imparts integrity to the Truss frames and results in an overall self-supporting geometry.
- Purlins of length **4.5** is provided to connect the rafters of all the frames and loads have been applied per meter length on these purlins which is distributed to the members of the Truss frame. Partial moment release is applied at the connections in the frame which results into only axial forces being transferred to the Truss members.
- Truss System: Truss system adopted is **Warren type Truss** to take its advantage in evenly spreading the load across different members. The design obtained is fairly simple as compared to other truss systems.

5.0 DISTINCT FEATURES OF THE PROPOSED CONCEPT

1. The primary feature of design is the **GEOMETRY** of the proposed iconic steel roof structure. The roof over the audience seating is constructed in a mathematical shape of **ELLIPSE**. The property of ellipse is such that any line which passes through its one of the foci will pass mandatorily through its other foci only. The advantage of this property is adopted in the design of roof. The speakers are placed such that they lie on the foci of the gigantic elliptical roof and the sound originating from them, after interaction with roof surface will pass through the other foci which is kept such that it lies in the atmosphere outside the roof structure. Owing to this, only the pleasant sound will be audible to the audience and all the unnecessary echo and noise will be thrown out, making it a great acoustical arrangement.

2. The geometry of roof over the stage is also of curved design to maintain symmetry with that of roof over seating. This roof is also partially parabolic to utilize the **property of parabola** and the sound emerging from stage shoots up to maximum distance towards the audience.

3. The benefits procured due to aforementioned design is that such structure will drastically **reduce the additional expense to be done for acoustic arrangements** in structures like open-air theatre. This will also minimize the load of additional cladding which would have been provided to sound proof the structure.

4. Another fascinating fact regarding the structure is that owing to its geometrical design the entire assembly becomes **self-supporting** and the additional bracings and interconnections among the frames and members are avoided which assists in achieving overall economy of the structure.

5. The sheeting that has been used in the structure is **ACP (Aluminum Composite Panel)** which provides aesthetically pleasant appearance in the interior of roof. Moreover, this user- friendly material sheet can be bent, folded and turned easily into shapes that can't be achieved by any other material. It is its this bending property which will comply with the curved shape of the proposed roof and will prevent the punching of sheet which might have occurred if any other sheet would have been provided.

6. The inclination of both roofs is provided to keep the **drainage of rain water in check.** Sufficient care has been taken that entire fall of rain water is smoothly drained to the backside of both the roofs so that water accumulation does not deteriorate the sheeting material or the structural members.

7. Detailed drawings of structural members and connection of joints are prepared in CAD software and analysis have been done in STAAD PRO software to design the entire structure for its optimum safety and serviceability and keeping the scope of future extension as well.

6.0 APPROACH TO DESIGN STRUCTURAL SYSTEM

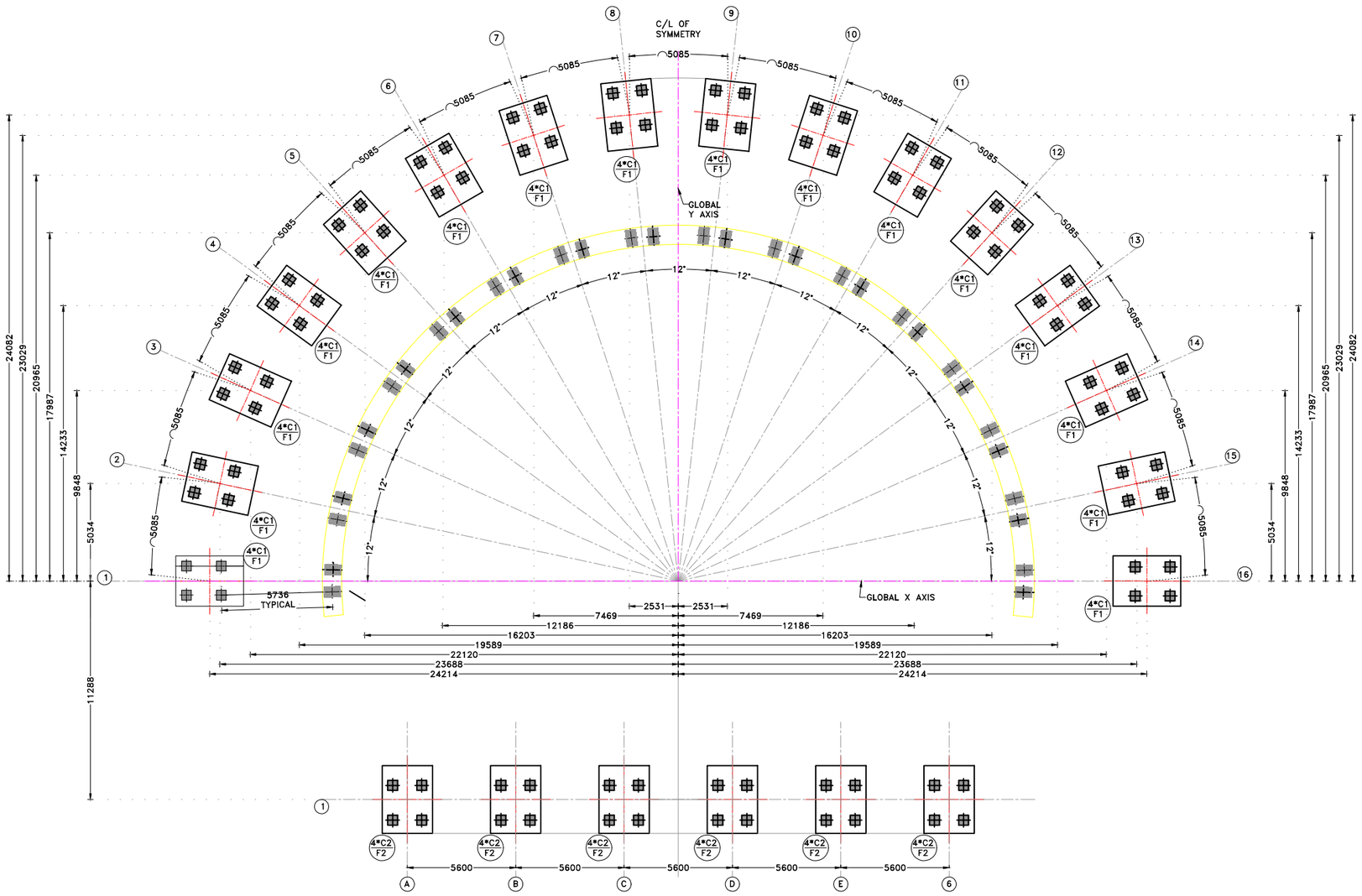
The initial phase of designing after finalizing the geometry began by importing the CAD drawing coordinates in STAAD PRO software and fixing the effective depth of roof by placing the I-sections of varying dimensions. Once the required depth satisfying the conditions of safety, serviceability and economy is obtained, I-sections are replaced by the Truss frame for developing the appropriate Load transfer mechanism.

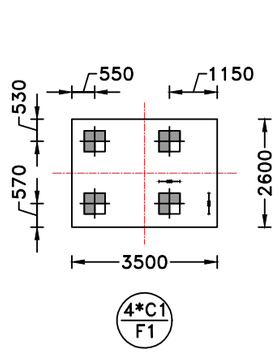
All the members of Roofing frame, Steel Trestle, inclined steel beam, Bracings, Purlins and Rafters are made up of steel Box sections manufactured by TATA steel. These Box sections are easy to bend, easy to weld, corrosion resistant and profile cutting for these sections is simpler as compared to other sections of steel, thus being beneficial for the circular geometry adopted for this very design. Moreover, all these hollow steel sections feature a high strength to weight ratio that results in savings in steel and costs.

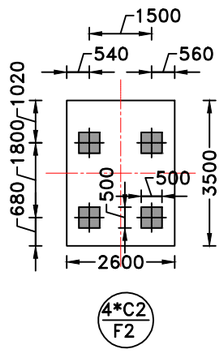
Trestles along with the Roofing frame members are given Truss specification by providing **partial moment Release** (5% restrain) to connections. The advantage obtained by doing this is that the roof which rests on the Trestle combinedly acts as a singular Truss frame. Due to this, dimensions of foundation can be reduced by providing slightly larger dimensions to the Trestle. The **structural system** consists of varying Box sections from SHS 220×220×8 mm to 60×60×4 that are self-sufficient and transfer dead loads, imposed loads, wind loads and seismic loads to the supports. In addition, **wind bracings** are provided in the longitudinal as well as transverse direction to give stability to the structure so that they behave integrally under wind load. Bracings are designed as compression members carrying axial load only. **Purlins** are designed for providing extra support to the rafters of Roof truss frame and these rectangular box shaped purlins are oriented (Designed accordingly by providing Beta angle in Staad pro model) such that loads act upon the major axis of Purlin. **Sag rods** are provided in seating roof to reduce the tendency of Purlins to bend laterally and twist. These rods prevent sag of purlin in direction parallel to a sloping roof due to vertically applied loads. Typical design for **Tension members** and **Compression members** of Truss frame and Trestle have been showcased and all the members are checked for safety as well as serviceability.

Concrete columns (Pedestal extended till foundation) are designed only for axial load as the values of shear forces at the top face of column is negligible. **Combined column footings** are provided, and frame base is assumed to be pinned. The combined footing is designed such that the centre of gravity of the foundation coincides with the resultant of four columns so that no moment is generated due to eccentric loading. **Strip foundation** is provided at the front part of Seating roof over which the audience seating arrangement threshold lies. The significance of strip footing is that, in case of imposed loads being increased the moment won't only affect any particular support but rather will be transferred to adjacent supports and foundation failure will not occur. **Inclined steel beams** are provided which emerge from the Trestle of every frame. These steel beams will serve as support to the concrete staircase slab which will be casted for seating purpose of Audience. **Plinth beams** are provided to distribute the load of the Steel structure over the foundation.

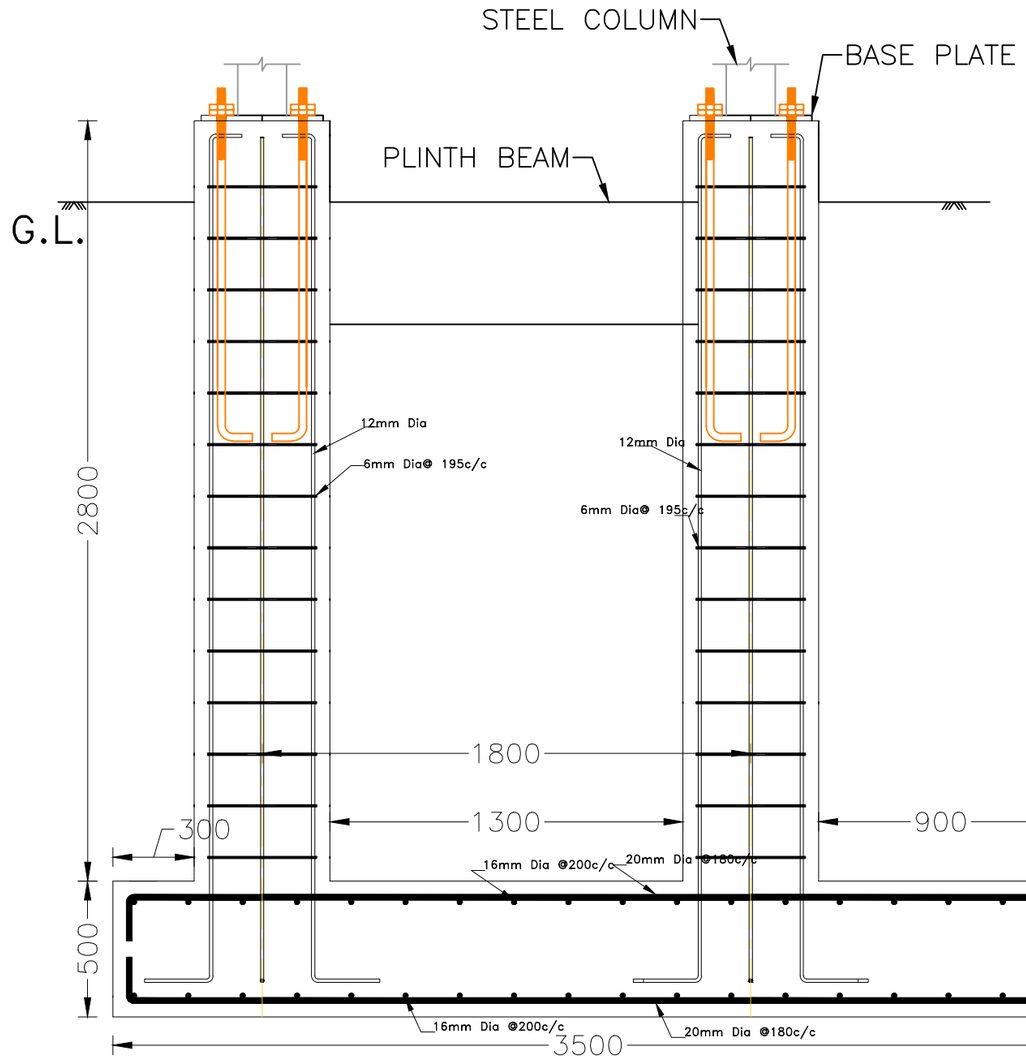
All members are welded members (Conforming to IS:816-1969) and have been used for all main-frame connections. For connections between secondary and primary members the Butt weld have been used along with gusset plates and packing plates wherever required. **Gusset plates** are designed for the nodes where multiple members are to be connected. Connection of concrete pedestal with **Base plate** has been done using Butt weld and anchor bolts. The main truss frame which rests on steel Trestle is connected with the Trestle by **Bearing plates** and these plates are connected by Bolted connection.

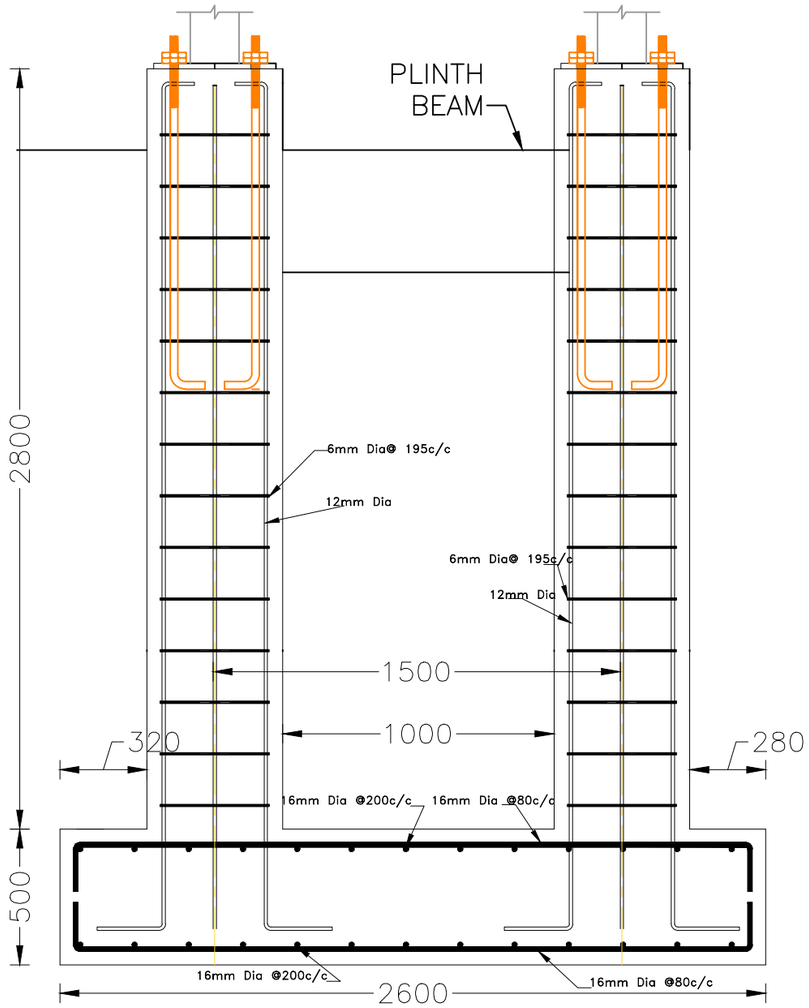


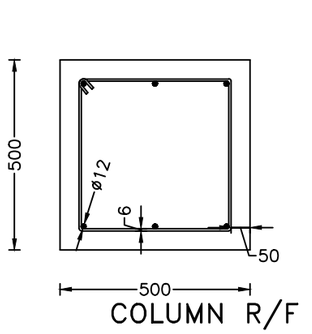


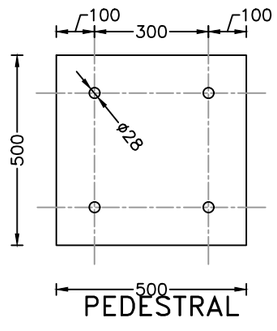


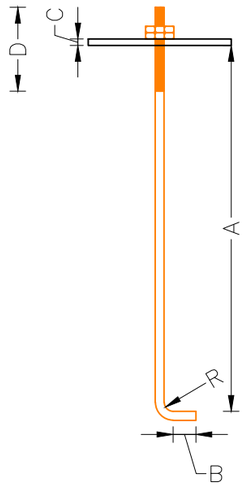
DWG NO:– 1	DATE:– 21/12/2021
TITILE:– FOUNDATION GRID	
PROJECT:– ICONIC STEEL ROOF STRUCTURE OVER AN OPEN AIR THEATRE	
TEAM NO:– W01	
CLIENT:– INSDAG, KOLKATA	
GUIDED BY:– PROF. C.D. PATEL	
PREPARED BY: VENICA MACLEAN ADITYA PAL MONIT PAL SURYA PANCHAL	INSTITUTE:– LD COLLEGE OF ENGINEERING







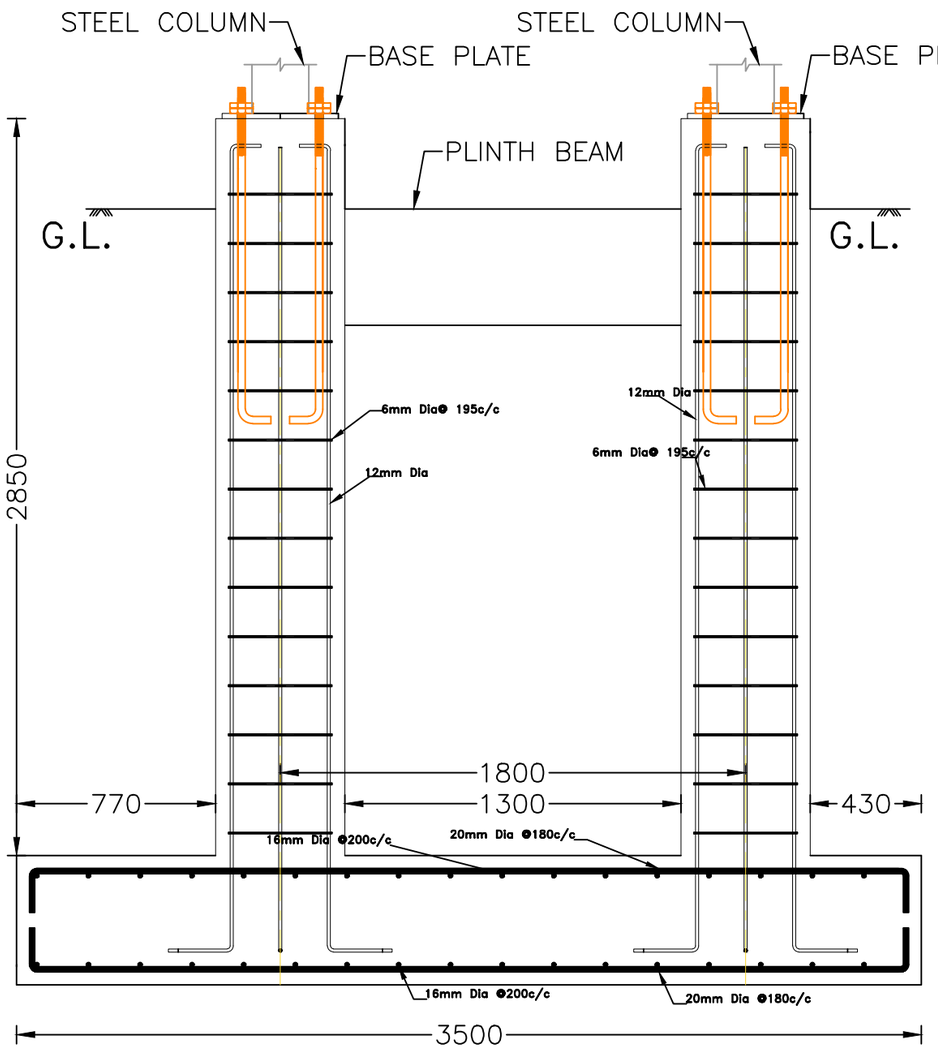


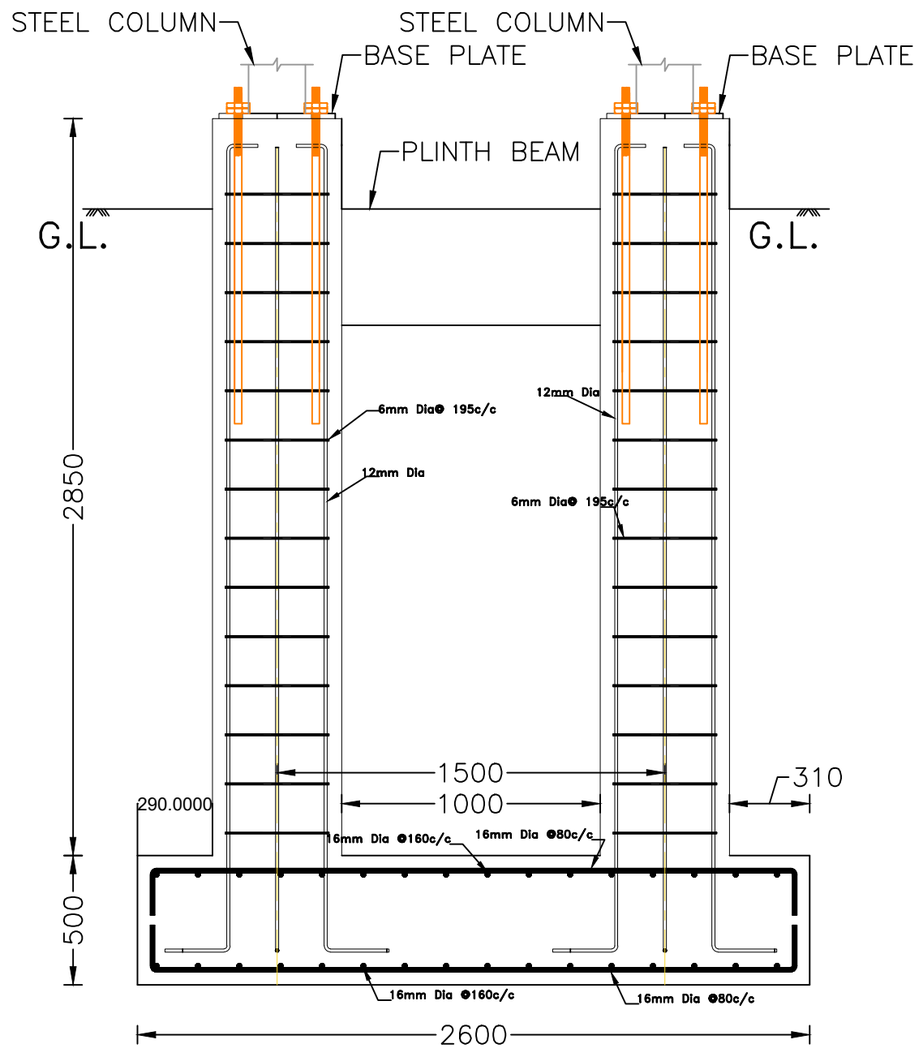


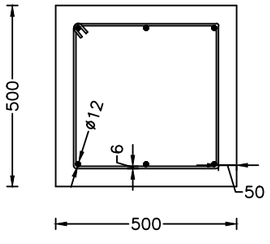
SCHEDULE OF DIMENSIONS
(ALL DIMENSIONS ARE IN MM)

A	EMBEDDED LENGTH	1152
B	BEND LENGTH	72
C	BASE PLATE	20
D	THREAD LENGTH	264
R	ROOT RADIUS	28

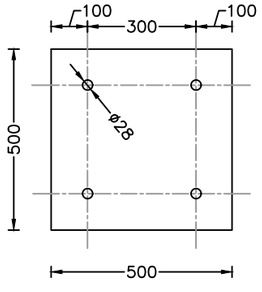
DWG NO:– 2	DATE:– 21/12/2021
TITILE:– FOUNDATION GRID	
PROJECT:– ICONIC STEEL ROOF STRUCTURE OVER AN OPEN AIR THEATRE	
TEAM NO:– W01	
CLIENT:– INSDAG, KOLKATA	
GUIDED BY:– PROF. C.D. PATEL	
PREPARED BY: VENICA MACLEAN ADITYA PAL MONIT PAL SURYA PANCHAL	INSTITUTE:– LD COLLEGE OF ENGINEERING



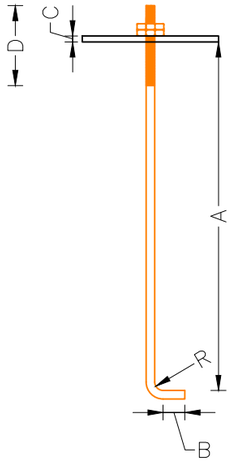




COLUMN R/F



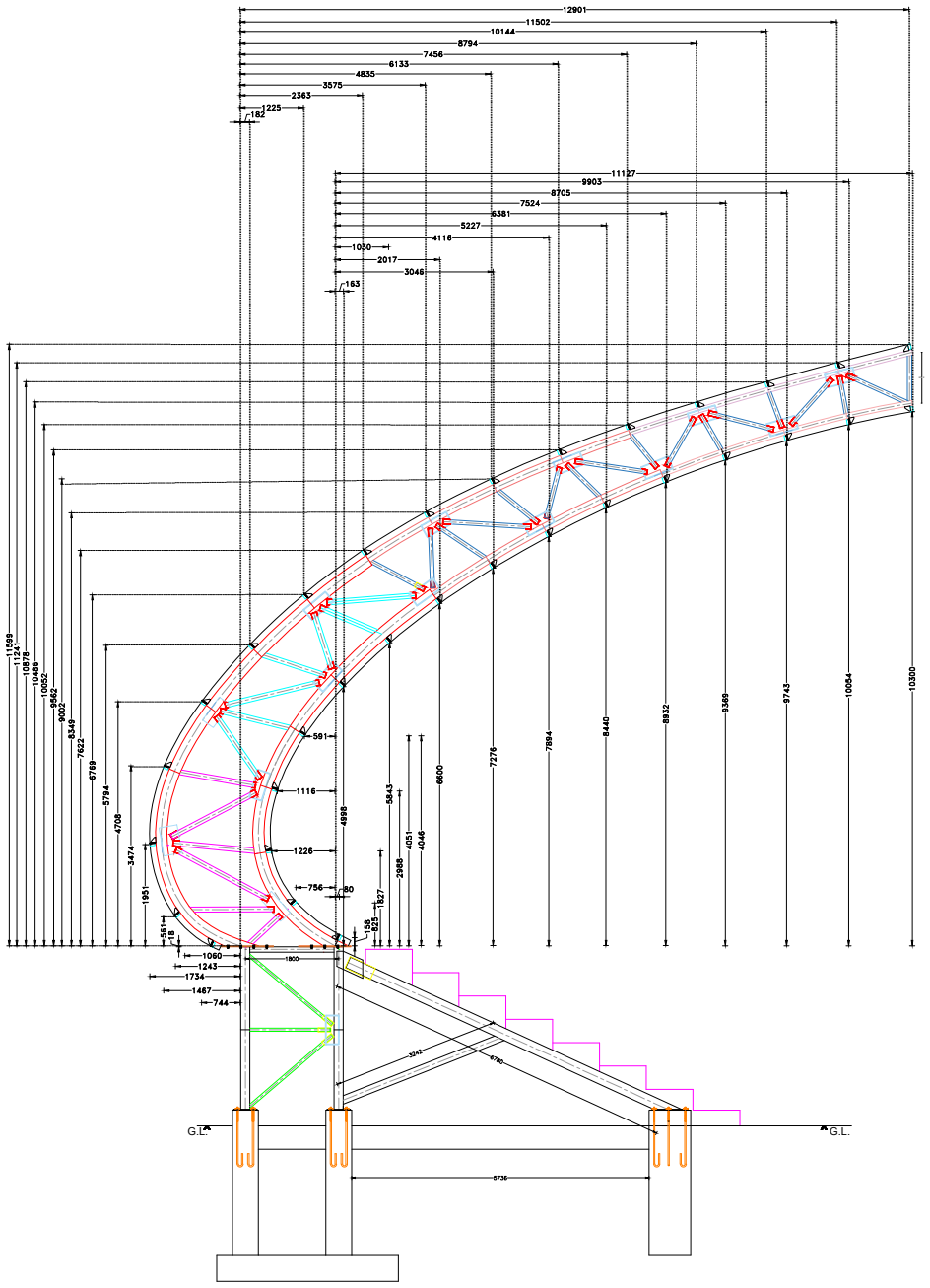
PEDESTRAL

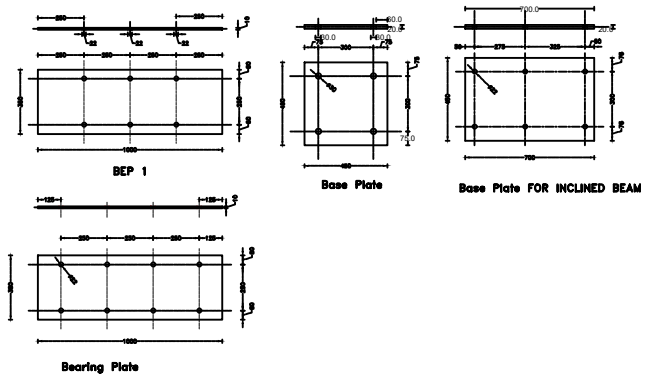


SCHEDULE OF DIMENSIONS
(ALL DIMENSIONS ARE IN MM)

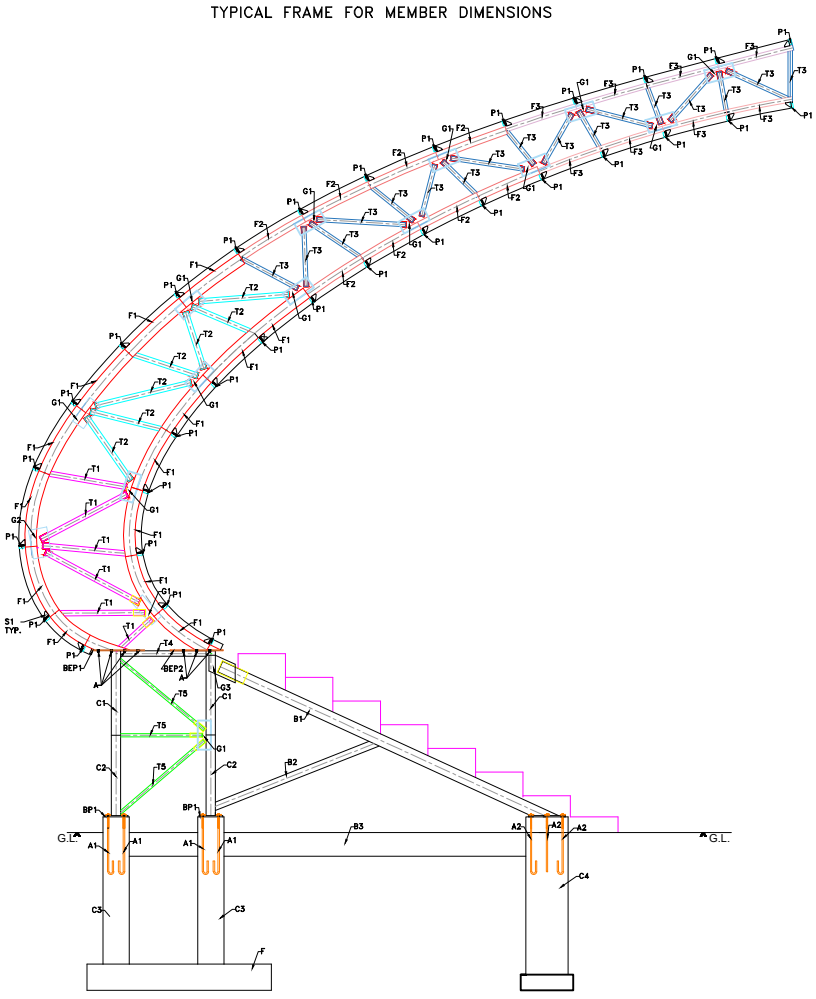
A	EMBEDDED LENGTH	1000
B	BEND LENGTH	72
C	BASE PLATE	20
D	THREAD LENGTH	264
R	ROOT RADIUS	22

DWG NO:– 3	DATE:– 21/12/2021
TITILE:– FOUNDATION GRID	
PROJECT:– ICONIC STEEL ROOF STRUCTURE OVER AN OPEN AIR THEATRE	
TEAM NO:– W01	
CLIENT:– INSDAG, KOLKATA	
GUIDED BY:– PROF. C.D. PATEL	
PREPARED BY: VENICA MACLEAN ADITYA PAL MONIT PAL SURYA PANCHAL	INSTITUTE:– LD COLLEGE OF ENGINEERING

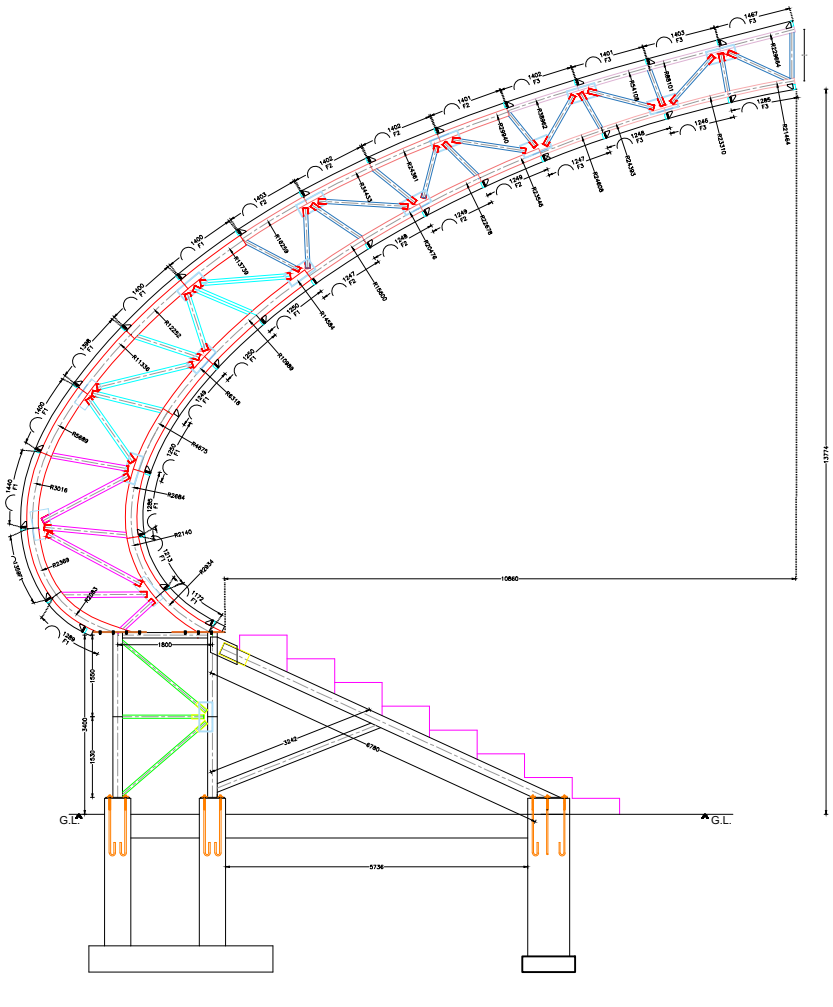




TYPICAL FRAME FOR MEMBER DIMENSIONS



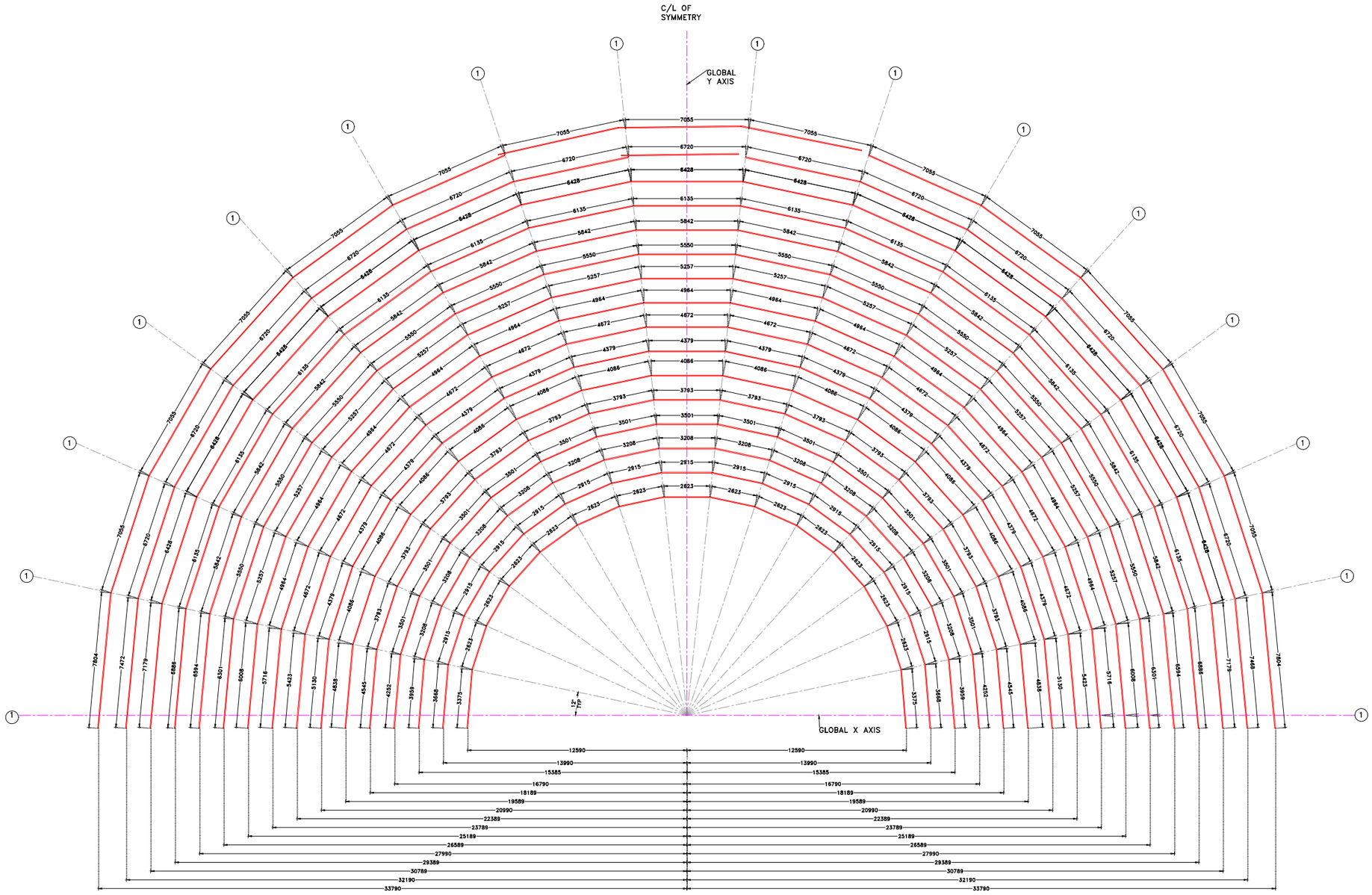
TYPICAL FRAME FOR MEMBER IDENTIFICATION



TYPICAL FRAME FOR MEMBER DIMENSIONS

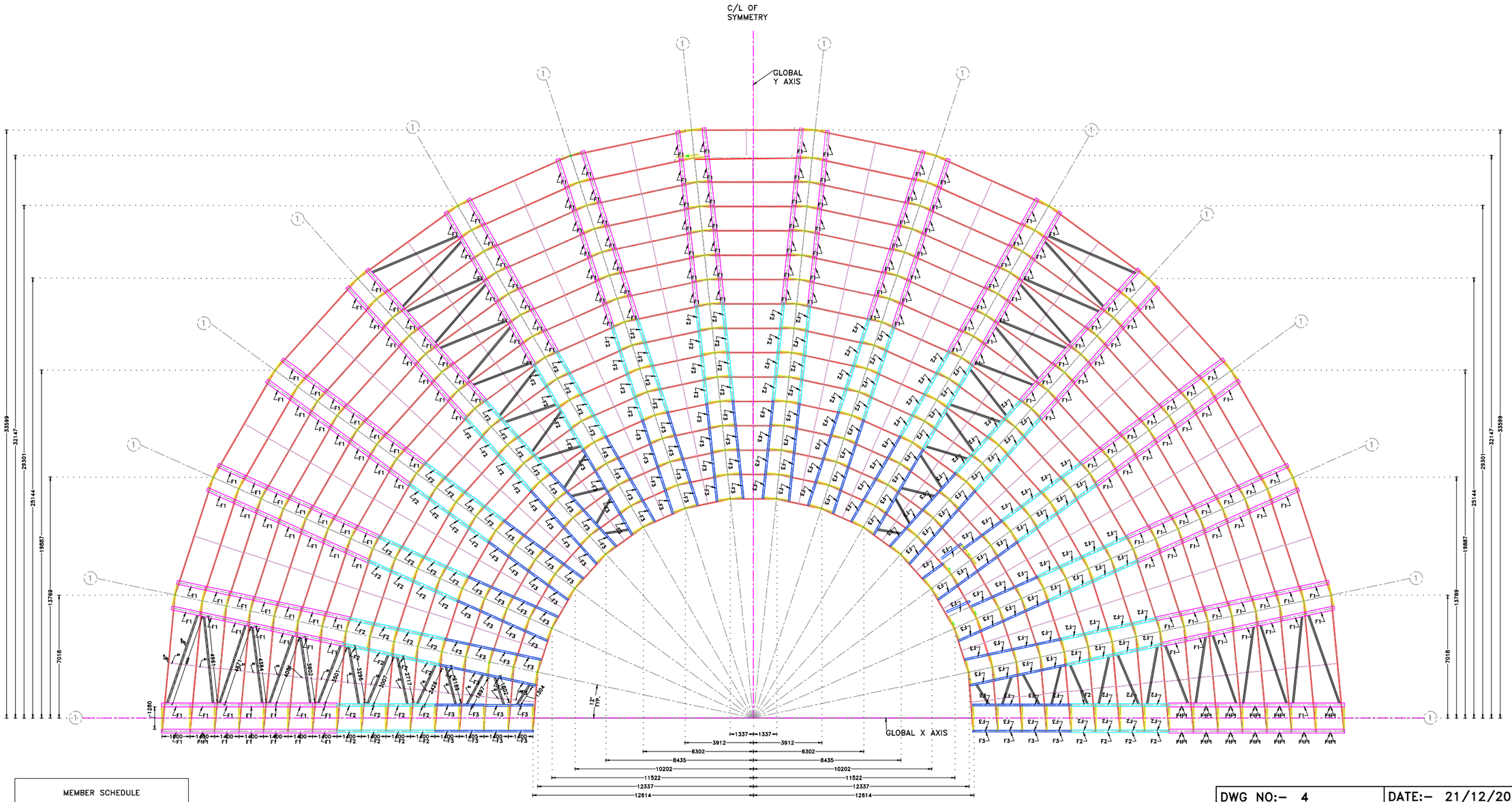
SEATING DETAILS			
MARK	DETAILS	SIZE	SPECIFICATION
P1	PURLIN	96*48*4.8	SHS
T1	TRUSS MEMBER	100*100*5.0	SHS
T2	TRUSS MEMBER	100*100*4.0	SHS
T3	TRUSS MEMBER	80*80*4.0	SHS
T4	TRUSS MEMBER	100*100*6.0	SHS
T5	TRUSS MEMBER	60*60*4.0	SHS
F1	FRAME MEMBER	220*220*6.0	SHS
F2	FRAME MEMBER	150*150*5.0	SHS
F3	FRAME MEMBER	100*100*5.0	SHS
G1	GUSSET PLATE	550*250*10	
G2	GUSSET PLATE	550*350*10	
G3	GUSSET PLATE		
BEP	BEARING PLATE	1000*330*10	
BEP	BEARING PLATE	1000*350*10	
A	BOLT	20 DIA.	
A1	J-ANCHOR BOLT	20 DIA.	ANCHOR LENGTH 1.4m
A2	J-ANCHOR BOLT	20 DIA.	ANCHOR LENGTH 1m
C1 TO C2	STEEL COLUMN	180*180*6.0	SHS
B1	INCLINED BEAM	220*220*6.0	SHS
B2	INCLINED BEAM	150*150*4.0	SHS
BP1	BASE PLATE	450*450*20	
C3 TO C4	PEDESTAL		RECT. CONCRETE, M25
B3	BEAM		RECT. CONCRETE, M25
C4	COLUMN		RECT. CONCRETE, M25
F	FOUNDATION		RECT. CONCRETE, M25
NOTE: 1) ALL DIMENSIONS ARE IN MM.			
2) SHS = SQUARE HOLLOW SECTION (TATA STRUCTURAL STEEL)			

DWG NO:– 2	
TITILE:– SEATING SEACTION	
PROJECT:– ICONIC STEEL ROOF STRUCTURE OVER AN OPEN AIR THEATRE	
TEAM NO:– W01	
CLIENT:– INSDAG, KOLKATA	
GUIDED BY:– PROF. C.D. PATEL	
PREPARED BY: VENICA MACLEAN ADITYA PAL MONIT PAL SURYA PANCHAL	INSTITUTE:– LD COLLEGE OF ENGINEERING



PURLIN LOCATION

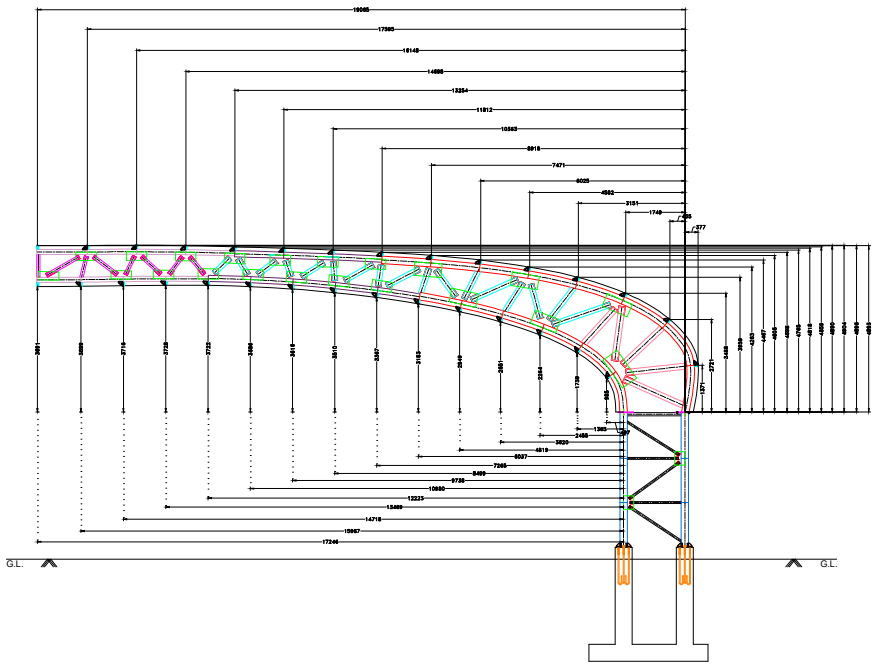
DWG NO:– 5	DATE:– 21/12/2021
TITILE:– PURLIN LOCATION	
PROJECT:– ICONIC STEEL ROOF STRUCTURE OVER AN OPEN AIR THEATRE	
TEAM NO:– W01	
CLIENT:– INSDAG, KOLKATA	
GUIDED BY:– PROF. C.D. PATEL	
PREPARED BY: VENICA MACLEAN ADITYA PAL MONIT PAL SURYA PANCHAL	INSTITUTE:– LD COLLEGE OF ENGINEERING



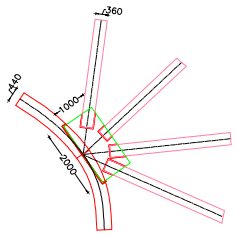
ROOF PLAN

MEMBER SCHEDULE	
F1	220*220*6
F2	150*150*5
F3	100*100*5
B	100*100*4
S	8mm dia
P	96*48*4.8

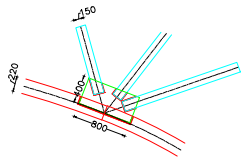
DWG NO:– 4	DATE:– 21/12/2021
TITILE:– STAGE ROOF PLANE	
PROJECT:– ICONIC STEEL ROOF STRUCTURE OVER AN OPEN AIR THEATRE	
TEAM NO:– W01	
CLIENT:– INSDAG, KOLKATA	
GUIDED BY:– PROF. C.D. PATEL	
PREPARED BY: VENICA MACLEAN ADITYA PAL MONIT PAL SURYA PANCHAL	INSTITUTE:– LD COLLEGE OF ENGINEERING



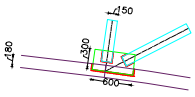
TYPICAL FRAME FOR MEMBER DIMENSIONS



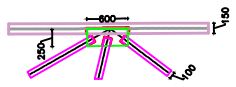
GUSSET PLATE–G1 CONNECTION



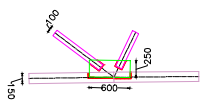
GUSSET PLATE–G2 CONNECTION



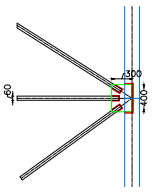
GUSSET PLATE–G3 CONNECTION



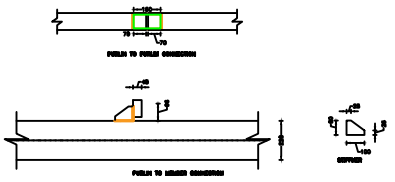
GUSSET PLATE–G4 CONNECTION



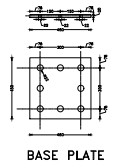
GUSSET PLATE–G4 CONNECTION



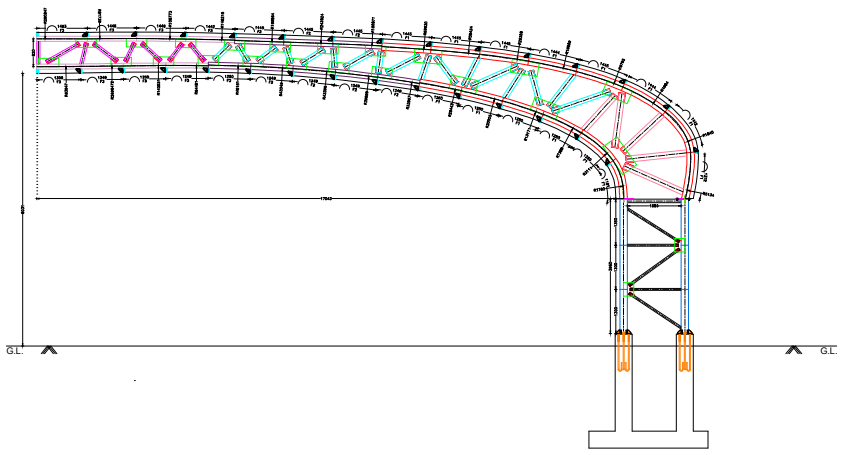
GUSSET PLATE–G5 CONNECTION



BEARING PLATE

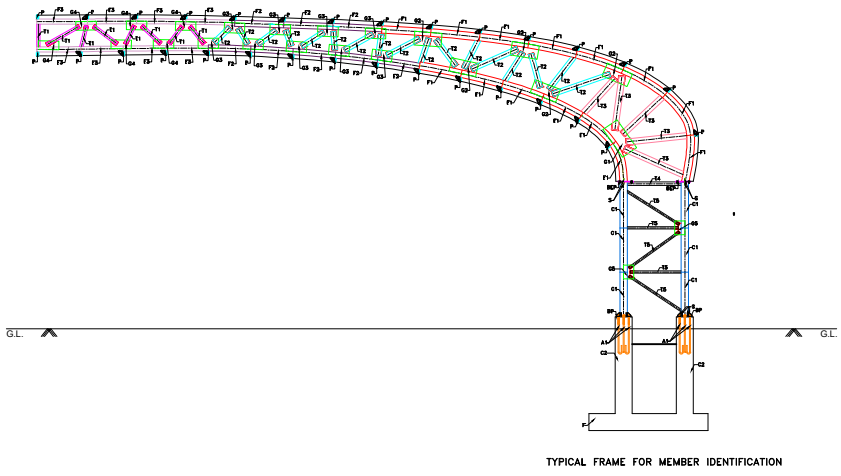


BASE PLATE



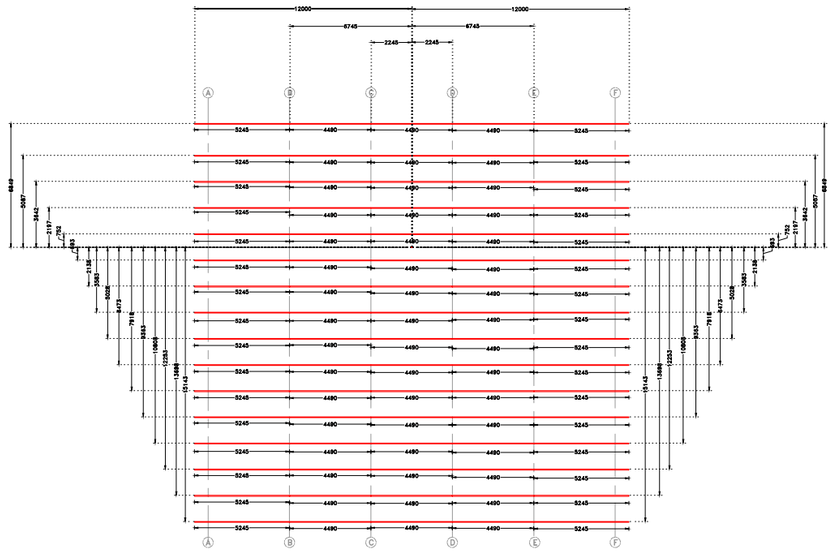
TYPICAL FRAME FOR MEMBER DIMENSIONS

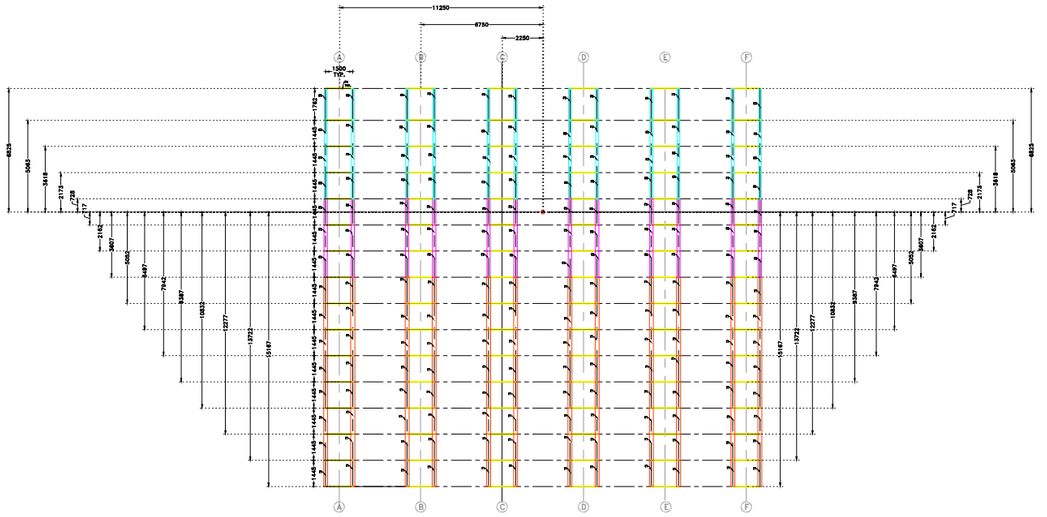
STAGE DETAILS			
MARK	DETAILS	SIZE	SPECIFICATION
P	PURLIN	96*48*4.8	SHS
T1	TRUSS MEMBER	100*100*5.0	SHS
T2	TRUSS MEMBER	150*150*6.0	SHS
T3	TRUSS MEMBER	180*180*6.0	SHS
T4	TRUSS MEMBER	100*100*4.0	SHS
T5	TRUSS MEMBER	60*60*4.0	SHS
F1	FRAME MEMBER	220*220*6.0	SHS
F2	FRAME MEMBER	180*180*6.0	SHS
F3	FRAME MEMBER	150*150*5.0	SHS
G1	GUSSET PLATE	1000*500*10	
G2	GUSSET PLATE	800*400*10	
G3	GUSSET PLATE	600*300*10	
G4	GUSSET PLATE	600*250*10	
G5	GUSSET PLATE	400*300*10	
BEP	BEARING PLATE	450*----*20	
S	STIFFNER	-- DIA.	
C1	STEEL COLUMN	220*220*6.0	SHS
BP	BASE PLATE	450*450*20	
A	BOLT		
A1	J-ANCHOR BOLT	22 DIA.	
C2	PEDESTAL		RECT. CONCRETE, M25
F	FOUNDATION		RECT. CONCRETE, M25
NOTE: 1) ALL DIMENSIONS ARE IN MM.			
2) SHS = SQUARE HOLLOW SECTION (TATA STRUCTURAL STEEL)			

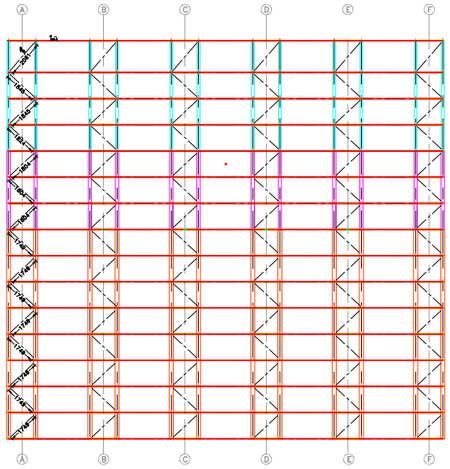


TYPICAL FRAME FOR MEMBER IDENTIFICATION

DWG NO:– 6	DATE:– 21/12/2021
TITILE:– STAGE SECTION	
PROJECT:– ICONIC STEEL ROOF STRUCTURE OVER AN OPEN AIR THEATRE	
TEAM NO:– W01	
CLIENT:– INSDAG, KOLKATA	
GUIDED BY:– PROF. C.D. PATEL	
PREPARED BY: VENICA MACLEAN ADITYA PAL MONIT PAL SURYA PANCHAL	INSTITUTE:– LD COLLEGE OF ENGINEERING







MEMBER SCHEDULE	
F1	220*220*6
F2	180*180*6
F3	150*150*5
F4	60*60*4
B	80*80*4
P	96*48*4
S	8 MM DIA

DWG NO:– 7	DATE:– 21/12/2021
TITILE:– STAGE PLAN	
PROJECT:– ICONIC STEEL ROOF STRUCTURE OVER AN OPEN AIR THEATRE	
TEAM NO:– W01	
CLIENT:– INSDAG, KOLKATA	
GUIDED BY:– PROF. C.D. PATEL	
PREPARED BY: VENICA MACLEAN ADITYA PAL MONIT PAL SURYA PANCHAL	INSTITUTE:– LD COLLEGE OF ENGINEERING

14.0 BILL OF QUANTITY(BOQ)

Detailed Bill of Materials have been prepared by measuring the quantities of steel, concrete and earthwork. These quantities are multiplied by their prevailing current market rates to obtain the final estimate of project. Additional 10% for contingencies, erection cost and contractor's profit have been added to the total cost to obtain a final cost of **₹ 1,90,11,726.00.** All the entities have been calculated separately for Seating and Stage roof.

BOQ has been showcased in detail and in a clear accessible format in an Excel file which has been attached along with the submission of proposed project.

BILL OF MATERIALS FOR SEATING ROOF

SR. NO.	DESCRIPTION/PARTICULARS	UNIT	Nos.	LENGTH (m)	WIDTH (m)	HEIGHT (m)	Unit Weight	MULTIPLIER	WEIGHT(kg)	Total Weight (Kg)	Rate	Total Cost
100	**STEEL MEMBERS IN SEATING ROOF**									*92,859.72*	75	₹ 69,64,479.00
							(kg/m)					
1	**TATA SHS : 220x220x8 mm**									*11,356.38*	75	8,51,728.50
	Inclined Beams For Sitting Arrangement		2	6.83	1	1	51.96	16	11356.3776			-
												-
2	**TATA SHS : 220x220x6 mm**									*23,310.59*	75	17,48,294.25
	Upper Rafters Of The Frame (At Bottom)		2	9.7	1	1	39.59	16	12288.736			-
	Lower Rafters Of The Frame (At Bottom)		2	8.7	1	1	39.59	16	11021.856			-
												-
3	**TATA SHS : 180x180x5 mm**									*16,742.98*	75	12,55,723.50
	Trestles		4	9.7	1	1	26.97	16	16742.976			-
												-
4	**TATA SHS : 150x150x5 mm**									*7,557.72*	75	5,66,829.00
	Upper Rafters Of The Frame (At Middle)		2	5.61	1	1	22.26	16	3996.1152			-
	Lower Rafters Of The Frame (At Middle)		2	5	1	1	22.26	16	3561.6			-
												-
5	**TATA SHS : 150x150x4 mm**									*1,867.28*	75	1,40,046.00
	Support Member Provided For Inclined Beam		2	3.24	1	1	18.01	16	1867.2768			-
												-
6	**TATA SHS : 100x100x6 mm**									*880.24*	75	66,018.00
	Beam Connecting Trestle		2	1.62	1	1	16.98	16	880.2432			-
												-
7	**TATA SHS : 100x100x5 mm**									*9,185.51*	75	6,88,913.25
	Upper Rafters Of The Frame (At Top)		2	5.7	1	1	14.41	16	2628.384			-
	Lower Rafters Of The Frame (At Top)		2	5.02	1	1	14.41	16	2314.8224			-
	Lower Truss Member In Frame		2	9.2	1	1	14.41	16	4242.304			-
												-
8	**TATA SHS : 100x100x4 mm**									*5,840.13*	75	4,38,009.75
	Middle Truss Member In Frame		2	9.91	1	1	11.73	16	3719.8176			-
	Bracing		1	45.19	1	1	11.73	4	2120.3148			-
												-
9	**TATA SHS : 80x80x4 mm**									*9,648.66*	75	7,23,649.50
	Upper Truss Members In Frame		2	18.341	1	1	9.22	16	5411.32864			-
	Front Ring Members : Top Layer		1	41	1	1	9.22	2	756.04			-
	Front Ring Members : Second Layer		1	45.43	1	1	9.22	2	837.7292			-
	Members Connecting The Frame From Outside		14	1.28	1	1	9.22	16	2643.5584			-
												-
10	**TATA SHS : 60x60x4 mm**									*5,453.03*	75	4,08,977.25
	Bracing Provided In The Upper Ring		1	4.597	1	1	6.71	16	493.53392			-
	Bracing Provided In The Lower Ring		1	4.175	1	1	6.71	16	448.228			-
	Members Connecting The Frame From Inside		14	1.28	1	1	6.71	16	1923.8912			-
	Trestle Bracing		1	22.82	1	1	6.71	16	2449.9552			-
	Members Joining Inclined Beam		1	1.28	1	1	6.71	16	137.4208			-
												-
11	**PURLINS**									*1,017.20*	75	76,290.00
	We've taken **TATA RHS** of											
	size **96x48x4.8 mm** for purlins.											
	Upper & Lower Purlins		1	1019.195	1	1	9.66	2	1017.195			
200	**CONNECTIONS & OTHER MATERIALS**											₹ 42,22,578.01
							kg/m³					
1	**GUSSET PLATE**		34	0.55	0.25	0.01	7850	16	5871.8	*5,871.80*	75	4,40,385.00
2	**BASE PLATE (STRAIGHT MEMBERS)**		4	0.45	0.45	0.02	7850	16	2034.72	*2,034.72*	75	1,52,604.00
3	**BASE PLATE (INCINED MEMBERS)**		2	0.7	0.45	0.02	7850	16	1582.56	*1,582.56*	75	1,18,692.00
4	**BEARING PLATE**		8	1	0.35	0.01	7850	16	3516.8	*3,516.80*	75	2,63,760.00
5	**STIFFNER**		64	0.006938	1	0.01	7850	16	557.7	*557.70*	75	41,827.81
6	**SHEETING**											
	ACP Sheets For Smooth And Reflecting Surface		1	1571.23	1	1	1	1			1500	2356845
	(Innerside of the frame)											
	TATA FLEXICLAD Sheets For Exterior Surface		1	1571.23	1	1	1	1			540	848464.2
300	**CONCRETE & EARTHWORK**									Total Quantity(m^3)	Rate(INR/m^3)	₹ 9,83,544.96
1	Excacation upto 1.5m	cu m	1	3.5	2.6	1.5		16		*218.40*	275	60,060.00
2	Excavation upto 3m	cu m	1	3.5	2.6	1.5		16		*218.40*	285	62,244.00
3	Excavationn for strip footing upto 1.5m	cu m	1	59.824	1	1.5		1		*89.74*	275	24,677.40
4	Excavationn for strip footing upto 3m	cu m	1	59.824	1	1.5		1		*89.74*	285	25,574.76
5	Concrete Pedestal	cu m	4	0.5	0.5	2.8		16		*44.80*	4000	1,79,200.00
6	Concrete Pedestal Under Inclined Member	cu m	2	0.5	0.8	3		16		*38.40*	4000	1,53,600.00
7	Combined Footing	cu m	1	3.5	2.6	0.5		16		*72.80*	4000	2,91,200.00
8	Strip Footing	cu m	1	59.824	1	0.3		1		*17.95*	4000	71,788.80
9	Plinth Beam In One Direction	cu m	2	7	0.25	0.45		16		*25.20*	4000	1,00,800.00
10	Plinth Beam In Other Direction	cu m	2	1	0.25	0.45		16		*3.60*	4000	14,400.00
	GRAND TOTAL											1,21,70,601.97
	Adding 10 % connection cost (inclusive of fabrication cost, erection cost, cost of enamel paint and wastage)											₹ 1,33,87,663.00

BILL OF MATERIALS FOR STAGE ROOF

SR. NO.	DESCRIPTION/PARTICULARS	UNIT	Nos.	LENGTH (m)	WIDTH(m)	HEIGHT(m)	Unit Weight	MULTIPLIER	Weight (Kg)	TOTAL WEIGHT (kg)	Rate(INR/KG)	Total Cost (INR)
100	**STEEL MEMBERS IN STAGE ROOF**									*44,106.80*	75	₹ 33,08,010.34
							(kg/m)					
1	**TATA SHS : 220x220x6 mm**									*12,691.29*	75	9,51,846.53
	Upper Rafters Of The Frame (At Bottom)		2	11.484	1	1	39.59	6	5455.81872			
	Lower Rafters Of The Frame (At Bottom)		2	7.43	1	1	39.59	6	3529.8444			
	Trestles		4	3.9	1	1	39.59	6	3705.624			
2	**TATA SHS : 180x180x6 mm**									*7,232.40*	75	5,42,430.23
	Upper Rafters Of The Frame (At Middle)		2	4.334	1	1	32.05	6	1666.8564			
	Lower Rafters Of The Frame (At Middle)		2	6.247	1	1	32.05	6	2402.5962			
	Lower Truss Members In Frame		2	8.224	1	1	32.05	6	3162.9504			
3	**TATA SHS : 150x150x6 mm**									*4,872.38*	75	3,65,428.80
	Middle Truss Members In Frame		2	15.38	1	1	26.4	6	4872.384			
4	**TATA SHS : 150x150x5 mm**									*2,906.00*	75	2,17,949.89
	Upper Rafters Of The Frame (At Top)		2	5.83	1	1	22.26	6	1557.3096			
	Lower Rafters Of The Frame (At Top)		2	5.049	1	1	22.26	6	1348.68888			
5	**TATA SHS : 100x100x5 mm**									*1,001.73*	75	75,129.75
	Upper Truss Members In Frame		2	5.793	1	1	14.41	6	1001.72556			
6	**TATA SHS : 100x100x4 mm**									*402.57*	75	30,192.75
	Members Connecting Roof & Trestle		1	5.72	1	1	11.73	6	402.5736			
7	**TATA SHS : 80x80x4 mm**									*1,491.43*	75	1,11,857.25
	Bracings In Frame		1	26.96	1	1	9.22	6	1491.4272			
8	**TATA SHS : 60x60x4 mm**									*5,402.33*	75	4,05,174.74
	Connecting Members In Frame		16	1.28	1	1	9.22	6	1132.9536			
	Laterally Supporting Members For Trestle		8	1.496	1	1	9.22	6	662.06976			
	Trestle Bracings		12	5.434	1	1	9.22	6	3607.30656			
9	**PURLIN**									*8,106.67*	75	6,08,000.40
	We've taken **TATA RHS** of											
	size **96x48x4.8 mm** for purlins.											
	Upper & Lower Purlins		1	419.6	1	1	9.66	2	8106.672			
200	**CONNECTIONS & OTHER MATERIALS**											₹ 15,63,921.45
							kg/m³					
1	**GUSSET PLATE**									*4,578.12*	75	3,43,359.00
	G1		2	1	0.5	0.01	7850	6	471			
	G2 to G6		10	0.8	0.4	0.01	7850	6	1507.2			
	G7 to G15		18	0.6	0.3	0.01	7850	6	1526.04			
	G16 to G21		12	0.6	0.25	0.01	7850	6	847.8			
	G22 to G23		4	0.4	0.3	0.01	7850	6	226.08			
2	**BASE PLATE**		4	0.45	0.45	0.02	7850	6	763.02	*763.02*	75	57,226.50
3	**BEARING PLATE**		8	0.45	0.45	0.01	7850	6	763.02	*763.02*	75	57,226.50
4	**STIFFNER**		76	0.006938	1	0.01	7850	6	248.352648	*248.35*	75	18,626.25
5	**SHEETING**											
	ACP Sheets For Smooth And Reflecting Surface			533.08							1500	799620
	(Innerside of the frame)											
	TATA FLEXICLAD Sheets For Exterior Surface			533.08							540	287863.2
300	**CONCRETE AND EARTH WORK**									Total Quantity (m³)	Rate (INR/m3)	₹ 2,40,852.00
1	Excacation upto 1.5m	cu m	1	3.5	2.6	1.5		6		81.90	275	22,522.50
2	Excavation upto 3m	cu m	1	3.5	2.6	1.5		6		81.90	285	23,341.50
3	Concrete Pedestal	cu m	4	0.5	0.5	2.85		6		17.10	4000	68,400.00
4	Combined Footing	cu m	1	3.5	2.6	0.5		6		27.30	4000	1,09,200.00
5	Plinth Beam in one direction	cu m	2	1.3	0.35	0.45		6		2.46	4000	9,828.00
6	Plinth Beam in other direction	cu m	2	1	0.35	0.45		6		1.89	4000	7,560.00
	GRAND TOTAL											51,12,783.79
	Adding 10 % connection cost (inclusive of fabrication cost, erection cost, cost of enamel paint and wastage)											₹ 56,24,063.00
	TOTAL COST OF STRUCTURE (INCLUDING SEATING AND STAGE)											₹ 1,90,11,726.00

BOQ Summary

Total cost (Including steel, concrete and earthwork) of Seating Roof = ₹ 1,21,70,601.97

Cost obtained after adding 10% connection cost

(inclusive of fabrication cost, erection cost etc.) = ₹ 1,33,87,663

Total cost (Including steel, concrete and earthwork) of Stage Roof = ₹ 51,12,783.79

Cost obtained after adding 10% connection cost

(inclusive of fabrication cost, erection cost etc.) = ₹ 56,24,063

FINAL ESTIMATED COST OF THE PROJECT = ₹ 1,90,11,726

YEAR – 2021

COMPETITION TOPIC:

ICONIC STEEL ROOF STRUCTURE OVER AN OPEN-AIR THEATRE WITH STAGE

DESIGN OPTION

BY

3RD- B Prize Winner – Team E-06

from
Meghnad Saha Institute of Technology, Kolkata, West Bengal

National Award Scheme for Civil/Structural Engineering Students for Best Innovative Structural Steel Design

Design of

Iconic Steel Roof Structure over An Open-Air Theatre & Stage

by

Group E-06

Arijit Bhattacharya

Archisha Bhar

Debu Addhya

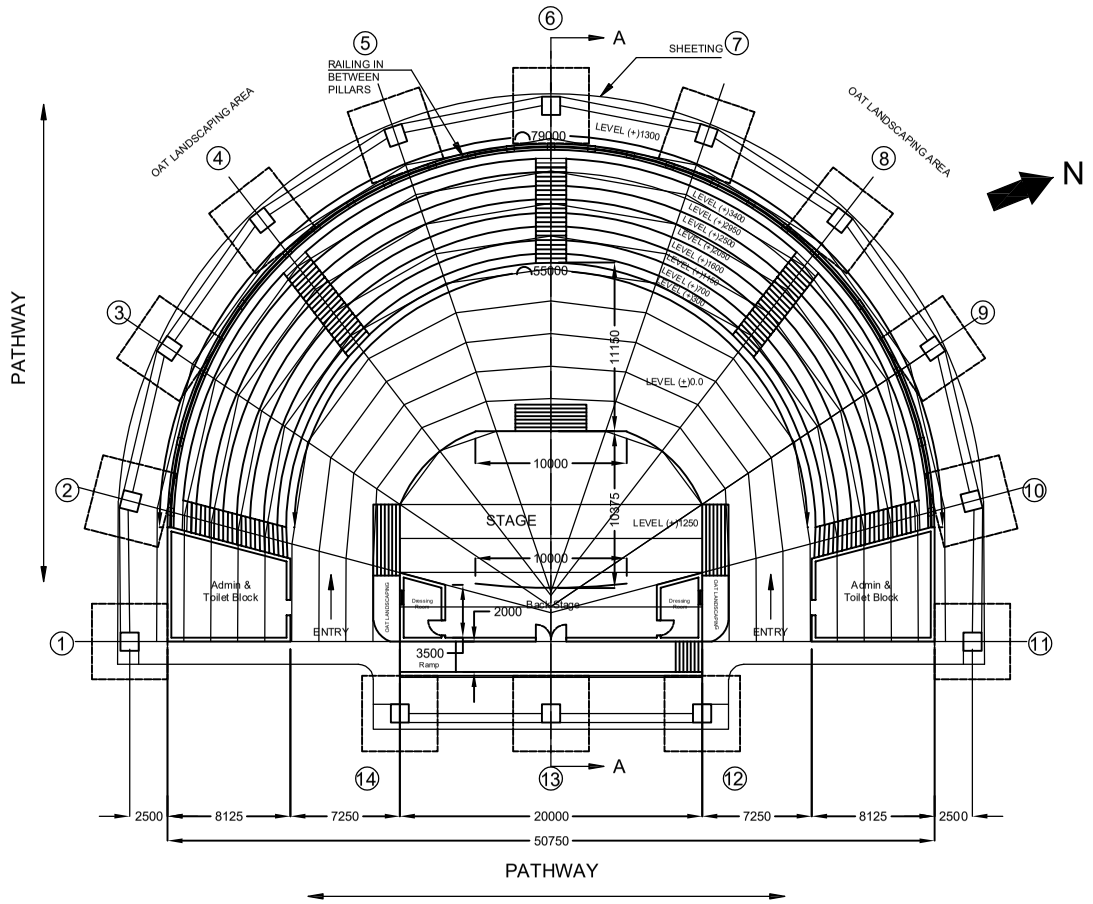
Bitan Bera

of

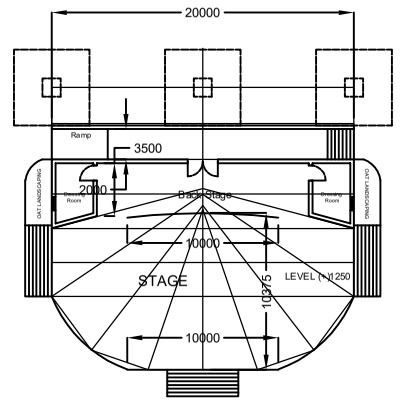
Meghnad Saha Institute of Technology

Nazirabad Road, Uchhepota, South 24 Parganas

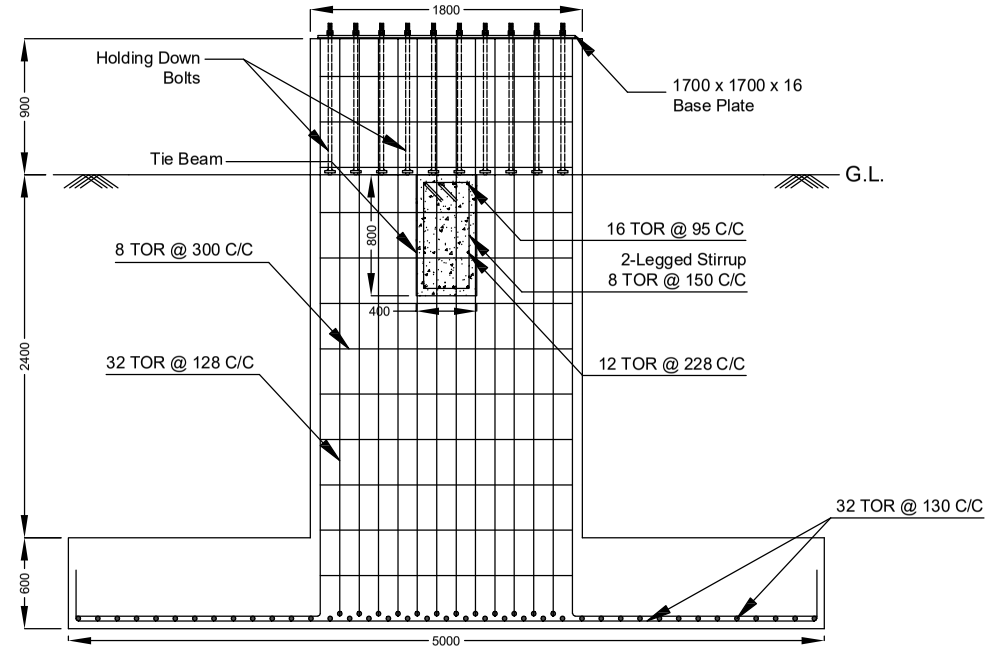
Kolkata - 700150



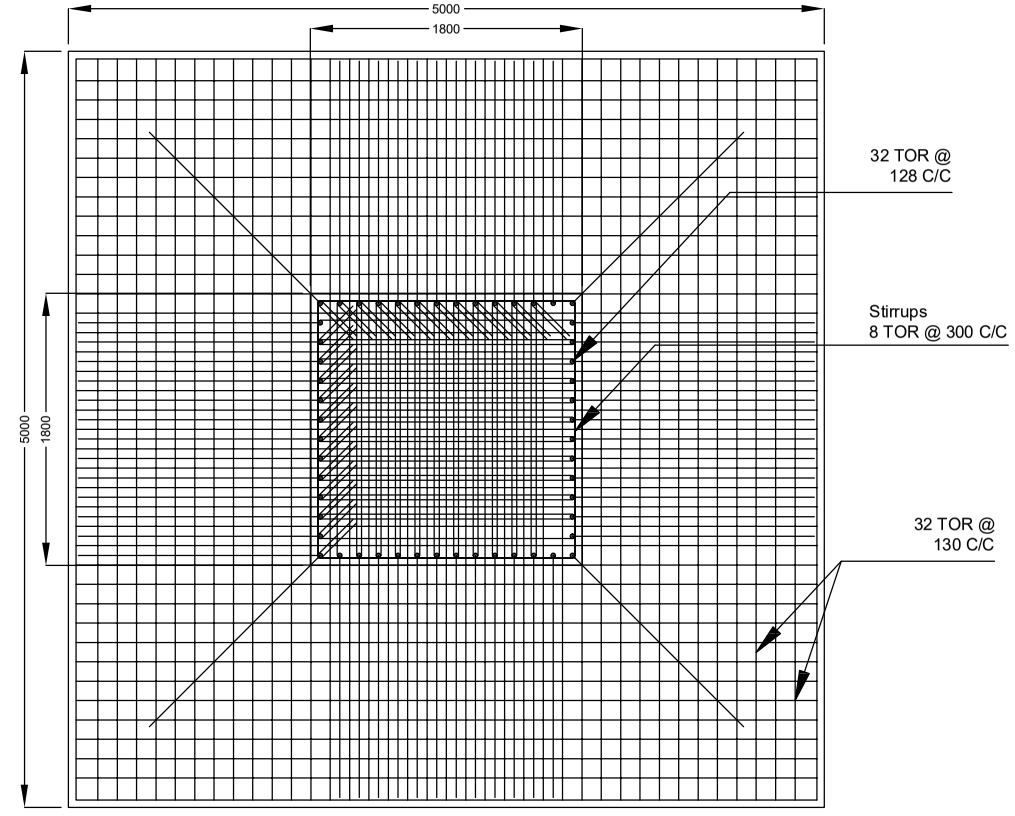
OAT PLAN
SCALE 1:500



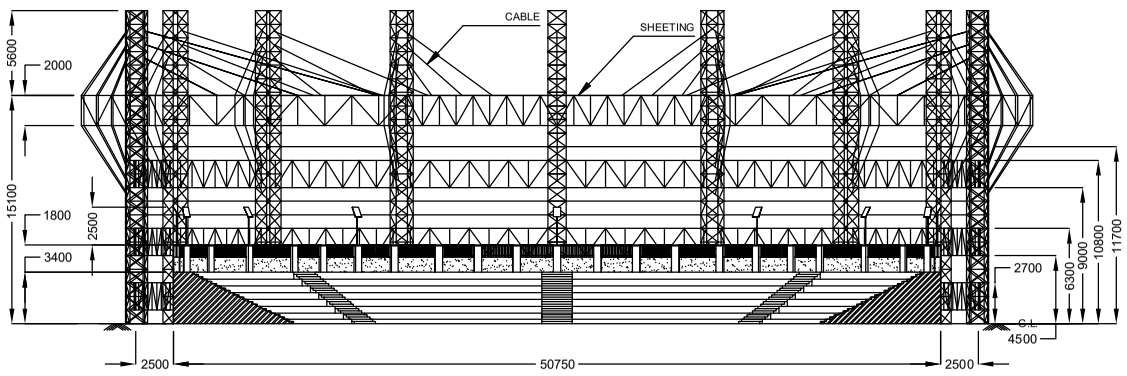
OAT STAGE PLAN
SCALE 1:500



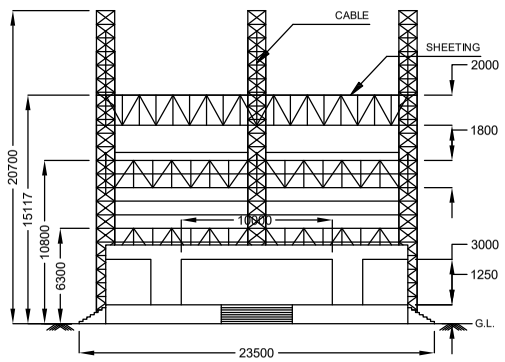
SECTIONAL ELEVATION FOUNDATION AND PEDESTAL
SCALE 1:50



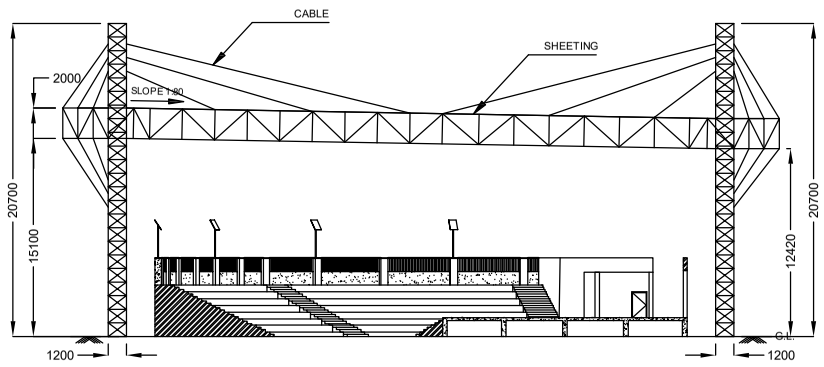
PLAN OF ISOLATED COLUMN FOUNDATION
SCALE 1:50



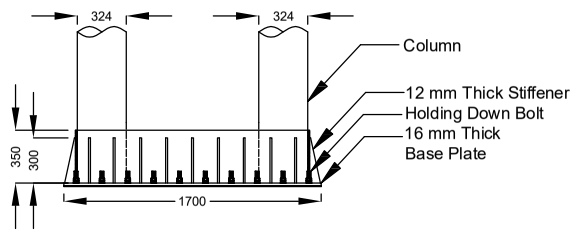
OAT SEATING ELEVATION
SCALE 1:500



OAT STAGE ELEVATION
SCALE 1:500



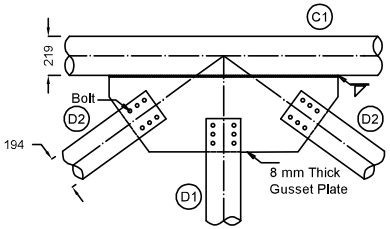
SECTION A-A
SCALE 1:500



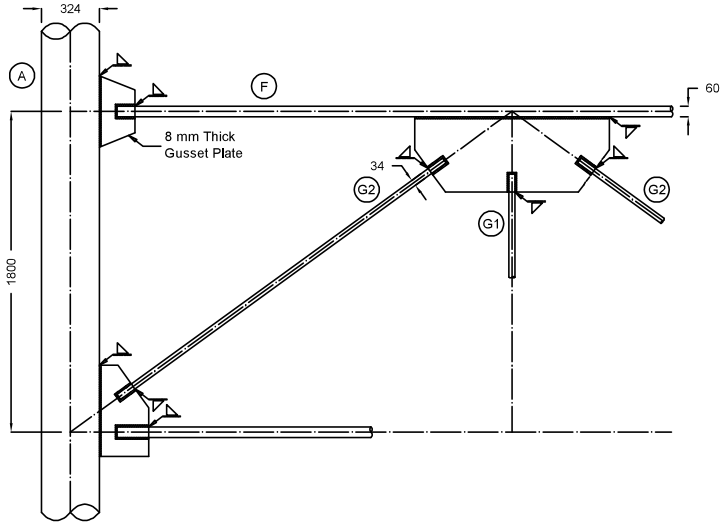
BASE PLATE
SCALE 1:50

NOTE: All dimensions in this sheet are in mm.

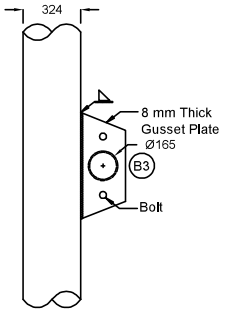
CLIENT: INSDAG	
PROJECT: ICONIC STEEL ROOF STRUCTURE OVER AN OPEN-AIR THEATRE & STAGE	
TITLE: DETAILED GENERAL ARRANGEMENT DRAWINGS	
GROUP NUMBER: E-06	
MEMBERS: ARIJIT BHATTACHARYA ARCHISHA BHAR DEBU ADDHYA BITAN BERA	GUIDE: ATANU DEBNATH SHEET NUMBER: 1 SCALE: 1:500 DATE: 15.12.2021
COLLEGE: MEGHNAD SAHA INSTITUTE OF TECHNOLOGY	



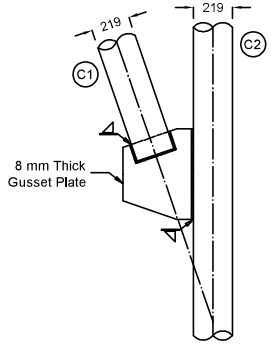
GIRDER AND BRACING
SCALE 1:30



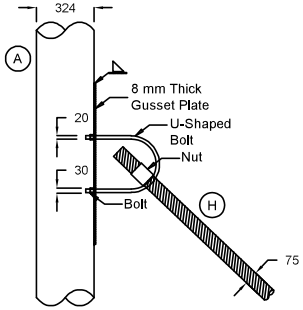
COLUMN AND CROSS-GIRDER
SCALE 1:30



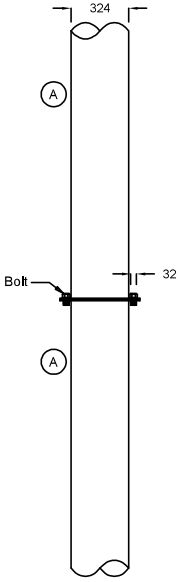
COLUMN AND SIDE-RUNNER
SCALE 1:30



MAIN-GIRDER AND CROSS-GIRDER
SCALE 1:30



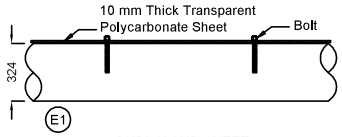
CABLE AND COLUMN
SCALE 1:30



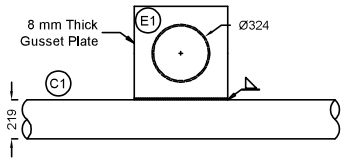
COLUMN SEGMENTS
SCALE 1:30

MARKED AS	TYPE OF MEMBER	OUTER DIAMETER (mm)	UNIT WEIGHT (kg/m)	CUTTING LENGTH (m)	TOTAL LENGTH (m)
A	COLUMN	323.9	49.34	5	20.7
B1	COLUMN BRACING	168.3	21.69	1.2	1.2
B2	COLUMN BRACING	168.3	21.69	1.5	1.5
C1	GIRDER	219.1	31.02	5	33.7
C2	GIRDER	219.1	31.02	5	21.4
D1	GIRDER BRACING	193.7	27.33	2	2
D2	GIRDER BRACING	193.7	27.33	2.95	2.95
E1	PURLIN	323.9	62.32	9.9	9.9
F	COLUMN-TO-COLUMN GIRDER	60.3	6.19	3	9.3
G1	COLUMN-TO-COLUMN GIRDER BRACING	33.7	2.93	1.8	1.8
G2	COLUMN-TO-COLUMN GIRDER BRACING	33.7	2.93	2.2	2.2
H	CABLE	75	34.68	19.3	19.3

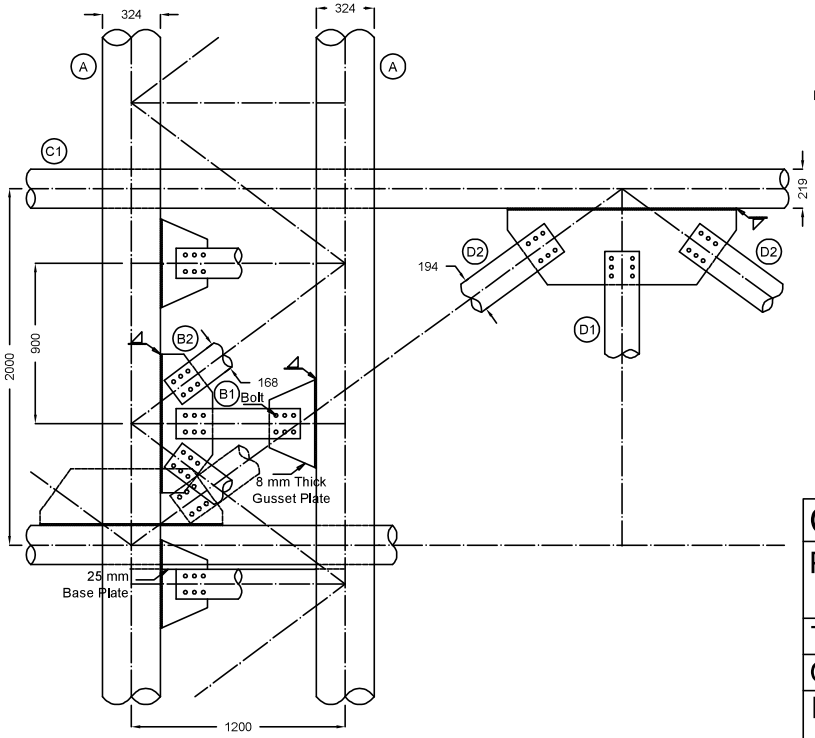
NOTE: All dimensions in this sheet are in mm.



PURLIN AND SHEET
SCALE 1:30



PURLIN AND GIRDER
SCALE 1:30



COLUMN AND MAIN-GIRDER
SCALE 1:30

CLIENT: INSDAG	
PROJECT: ICONIC STEEL ROOF STRUCTURE OVER AN OPEN-AIR THEATRE & STAGE	
TITLE: DETAILED CONNECTION DRAWINGS	
GROUP NUMBER: E-06	
MEMBERS: ARIJIT BHATTACHARYA ARCHISHA BHAR DEBU ADDHYA BITAN BERA	GUIDE: ATANU DEBNATH SHEET NUMBER: 2 SCALE: 1:30 DATE: 15.12.2021
COLLEGE: MEGHNAD SAHA INSTITUTE OF TECHNOLOGY	

Estimation of Structural Steel

Serial Number	Marked as	Description of Item	Number	Length (m)	Unit Weight	Weight (kg)	Weight (tonne)	Explanatory Notes
1	A	NB 300 Thk. 6.3 mm	56	20.7	49.36	57218.11	57.22	Number of legs in each column = 4 Number of columns = 14 Total number of sections = 14 x 4 = 56
2	B							
	B1	NB 150 OD. 168.3mm Thk. 5.4 mm	1120	1.2	21.69	29151.36	29.15	Used as the horizontal member of column bracing
	B2	NB 150 OD. 168.3mm Thk. 5.4 mm	1120	1.5	21.69	36439.2	36.44	Used as the diagonal member of column bracing
	B3	NB 150 OD. 168.3mm Thk. 5.4 mm	108	9.5	21.69	22253.94	22.25	Used as cladding member
3	C							
	C1	NB 200 Thk. 5.9 mm	22	33.70	31.02	22998	23.00	Used as girder member which are over the sitting area
	C2	NB 200 Thk. 5.9 mm	2	21.4	31.02	1328	1.33	Used as girder member which is the longer girder over the stage
	C3	NB 200 Thk. 5.9 mm	4	16.5	31.02	2047	2.05	Used as girder member which are the shorter girder over the stage
	C4	NB 200 Thk. 5.9 mm	12	4.50	31.02	1675	1.68	Used as girder member in the chamfer portion
4	D							
	D1	NB 175 Thk. 5.9 mm	266	2	27.33	14539.56	14.54	Used as the vertical member of girder bracing
	D2	NB 175 Thk. 5.9 mm	285	2.95	27.33	22977.7	22.98	Used as the diagonal member of girder bracing
5	E							
	E1	NB 300 Thk. 8 mm	10	9.9	62.32	6169.68	6.17	Used as the outermost purlins
	E2	NB 300 Thk. 8 mm	10	9.3	62.32	5795.76	5.80	Used as the second outermost purlins
	E3	NB 300 Thk. 8 mm	10	8.7	62.32	5421.84	5.42	Used as the third outermost purlins
	E4	NB 300 Thk. 8 mm	10	8	62.32	4985.6	4.99	Used as the fourth outermost purlins

	E5	NB 300 Thk. 8 mm	10	7.5	62.32	4674	4.67	Used as the fifth outermost purlins
	E6	NB 300 Thk. 8 mm	10	6.9	62.32	4300.08	4.30	Used as the sixth outermost purlins
	E7	NB 300 Thk. 8 mm	10	6.3	62.32	3926.16	3.93	Used as the seventh outermost purlins
	E8	NB 300 Thk. 8 mm	10	5.7	62.32	3552.24	3.55	Used as the eigth outermost purlins
	E9	NB 300 Thk. 8 mm	10	5.1	62.32	3178.32	3.18	Used as the inermost purlins
	E10	NB 300 Thk. 8 mm	10	10	62.32	6232	6.23	Used as purlins over the stage
6	F	NB 50 Thk. 4.5 mm	72	9.3	6.19	4144.824	4.14	Used as the member of column to column girder
7	G							
	G1	NB 25 Thk. 4 mm	288	1.8	2.93	1518.912	1.52	Used as the vertical member of column girder
	G2	NB 25 Thk. 4 mm	252	2.2	2.93	1624.392	1.62	Used as the diagonal member of column girder
8	H							
	H1	75mm dia. steel	14	19.3	34.68	9370.536	9.37	Used as the longer cable towards the stage
	H2	75mm dia. steel	14	12.7	34.68	6166.104	6.17	Used as the mid cable towards the stage
	H3	75mm dia. steel	14	6.4	34.68	3107.328	3.11	Used as the shorter cable towards the stage
	H4	75mm dia. steel	14	5.9	34.68	2864.568	2.86	Used as the longer cable behind the stage
	H5	75mm dia. steel	14	4.6	34.68	2233.392	2.23	Used as the mid cable behind the stage
	H6	75mm dia. steel	14	3.3	34.68	1602.216	1.60	Used as the shorter cable behind the stage
	H7	75mm dia. steel	14	5.6	34.68	2718.912	2.72	Used as the longer cable bottom of the column
	H8	75mm dia. steel	14	4.4	34.68	2136.288	2.14	Used as the mid cable bottom of the column
	H9	75mm dia. steel	14	3.2	34.68	1553.664	1.55	Used as the shorter cable bottom of the column
TOTAL							**297.90**	