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STADIUM STRUCTURE DESIGN USING MEDIUM MOMENT RESISTING FRAME SYSTEM WITH SPACE FRAME ROOF STRUCTURE

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ABSTRACT

Football is the most popular and popular sport not only in Indonesia but also in the world today. The stadium building is a building devoted to sports such as football and rugby. However, over time, the stadium is now a multi-purpose building that can be used for many other activities such as music concerts, political campaigns, and also as a venue for other events.

In the previous design carried out by Irfandianto the stadium building had a span between columns of 8m, with a roof truss structure Space frame with a corner welded connection type, taking into account the function of the stands which prioritized comfort of view so that no points were obstructed by the supporting columns, therefore a lightweight long-span structure system is used, namely the Space Frame roof structure.

In preparing this final project, it will be planned for the stadium to use a Space frame roof truss structure with a ball joint connection type, with an Intermediate Moment Resisting Frame System (SRPMM) which refers to SNI 1726-2012 and SNI 2847-2013. The results obtained from the analysis for beam dimensions 40 x 55 cm (B1), 40 x 50 cm (B2), 30 x 40 cm (B5), 30 x 40 cm (B6), 30 x 40 cm (BA1), 25 x 35 cm (BA2), 15 x 20 cm (BA5), 30 x 40 cm (BAT), 40 x 55 cm (E). With D16 reinforcement for main reinforcement and D10 for shear and torsion reinforcement. As for the columns, the dimensions are 40 x 40 cm (K1), 50 x 50 cm (K2), 60 x 60 cm (K3) with main reinforcement D36 and D13 for transverse reinforcement. And for floor slabs use a thickness of 180 mm at an elevation of 3, 150 mm for floor slabs 1, and 125 mm for elevation 9 with the main support and field reinforcement on floor slabs all using D10 reinforcement, except for floor slabs at 3 m elevation using D16

Keywords: Space frames

1. PRELIMINARY

Football is the most popular and popular sport not only in Indonesia but also in the world today. The world has replaced news about other sports in print and electronic media. The stadium is the most important facility in this sport, the stadium must be able to provide comfort and safety for both spectators and players, in accordance with stadium building planning standards based onSNI 03-3646-1994.

The planning of a building depends on the condition of the building. The condition of the building can be in the form of dimensions and materials. Not only that, soil conditions and the environment also play a role in planning. Conditions and environment related to the location where the building will be built. If the building is located in an area that is not prone to earthquakes, then it is planned with an Ordinary Moment Resisting Frame System (SRPMB). And if it is in an area that is prone to frequent earthquakes, then it is planned with an Intermediate Moment Resisting Frame System (SRPMM) and a Special Moment Resisting Frame System (SRPMK). The three frame systems are ways of constructing a building (Irfandianto, undated).

In the preparation of this final project, the building of the stadium, which is a means of sports infrastructure in the fields of football and athletics. Using a space frame roof frame structure with a ball joint connection type, with a Medium Moment Resisting Frame System (SRPMM) that refers to SNI 1726-2012 and SNI 2847-2013.

2. LITERATURE REVIEW

2.1 Stadium

Table 1 Stadium Classification

Type A	Type B	Type C
Its users serve the province with a seating capacity of 30,000 - 50,000 seats.	Users serve district or municipal areas with seating capacity of 10,000 - 30,000 seats.	Its users serve the sub-district area with a capacity of 5000-10000 seats.

(Source: SNI 3646:1994)

2.1.1 Technical Planning

1) The spectator's line of sight of an object on the field is a minimum of 90 m from the center of the field, a maximum of 190 m from the corner of the field (SNI 3646:1994), can be seen in Figure 1

2)

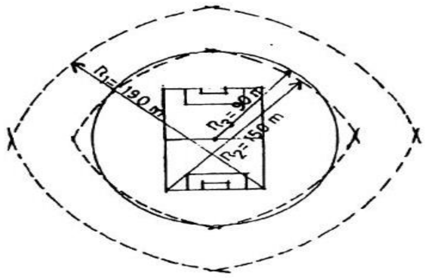

Figure 1 Visibility Distance (Source : SNI 3646:1994)

Information :

R1: Maximum visibility from the corner point of the field, which is 190m

R2: Optimal visibility from the corner point of the field, which is 190m

R3: Optimum viewing distance from the center of the circle

3) The minimum stadium security zone is 0.5 m2 x the number of spectators (SNI 3646:1994), can be seen in Figure 2.2.

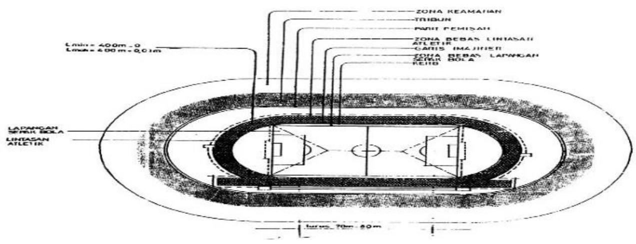

Figure 2 Stadium Security Zone (Source: SNI 3646:1994)

2.2 Moment Bearing Frame Structure

According to Suharjanto (2013), the moment-bearing frame system (SRPM) is a structural system that basically has a complete gravity load-bearing space frame. The lateral load is carried by the moment-bearing frame mainly through the bending mechanism. There are 3 moment-bearing frame systems, namely:

1. Typical Moment Resisting Frame System (SRPMB)
2. Intermediate Moment Resisting Frame System (SRPMM)
3. Special Moment Bearing Frame System (SRPMK)

2.2.1 Beam with SRPMM (SNI 2847:2013 Article 21.3.4)

At both ends of a flexural member, stirrup reinforcement shall be installed along a distance of twice the height of the flexural member (2h), measured from the face of the bearing to the center of the span. The first stirrup is placed no more than 50 mm from the face of the placement. Provisions regarding the spacing of stirrups must be taken from the smallest value between:

a. d/4
b. 8 x smallest diameter of the longitudinal reinforcement
c. 24 x stirrup diameter
d. 300mm

Stirrups shall be provided along the span of beams with a spacing of not more than d/2.

2.2.2 Column with SRPMM(SNI 2847:2013 Article 21.3.5)

At both ends of the column, stirrups shall be provided with spacing so that the length of the lo is measured from the face of the joint. Space so cannot exceed the smallest value of:

8 x smallest diameter of longitudinal reinforcement

24 x diameter of stirrup reinforcement

1/2 x the smallest size of the column cross-section

300mm

Meanwhile, the length of lo must be taken not less than the largest valueAmong :

1/6 the net length of the column

The largest size is the column cross-sectional dimension

450mm

The first stirrup must be placed at a distance of not more than 2 ft from the front of the HBK. Outside the area along the lo, stirrups shall be provided with a spacing of not more than d/2 or 600 mm.

2.3 Roof Frame Structure

2.3.1 Space Frame Roof Structure

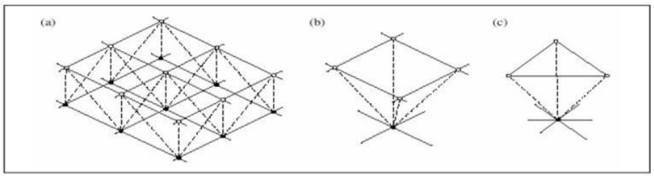

Figure 3 Basic elements forming a space frame system

(Source: Schodek, 1999)

2.3.2 Space Frame Components

1) members

The shape of the structural steel used in the pyramidal space frame structure system can be in the form of a tube, channel, T-shape, and W-shape. The tube-like steel shape is the steel form that is more often used in buildings due to its simple nature and can be creates a dynamic and flexible impression.

2) Connection or Connector

The connector consists of 3 types of facetsways of joining, namely welding connection, bolt connection, and Thread connection. Several subsequent systems were developed based on the development of the connection construction system based on the spatial frame model, including:

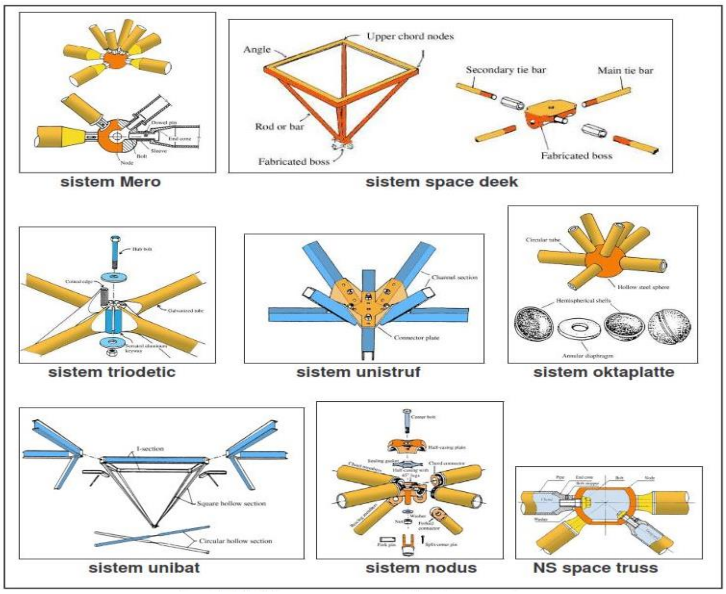

Figure 4 Various types of space frame systems
(Source: Schodek, 1999)

3. RESEARCH METHOD

3.1 Structure Modeling

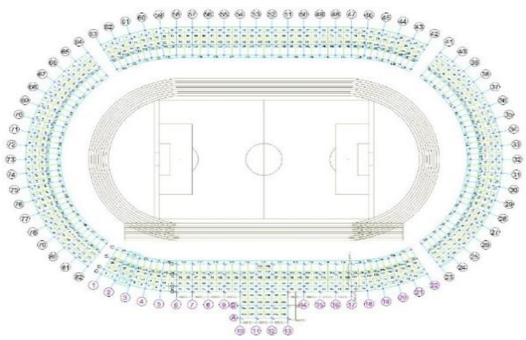

Figure 5 View of the Stadium Plan

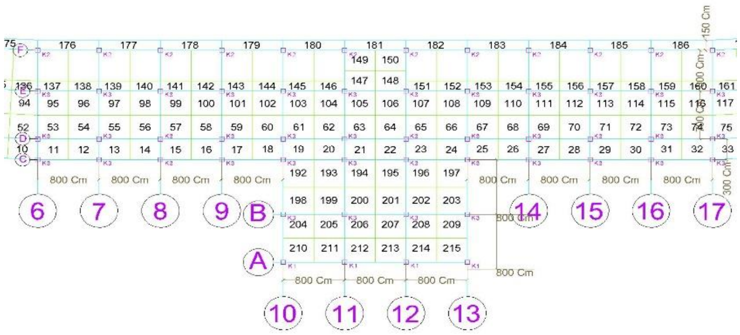

Figure 6 The layout of the West Tribune being reviewed

Figure 7 3D view

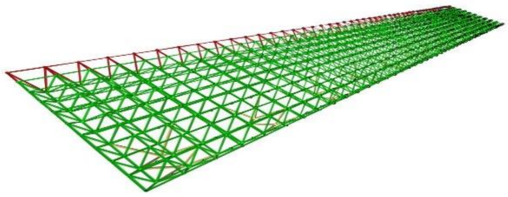

Figure 8 3D Roof Truss Plan

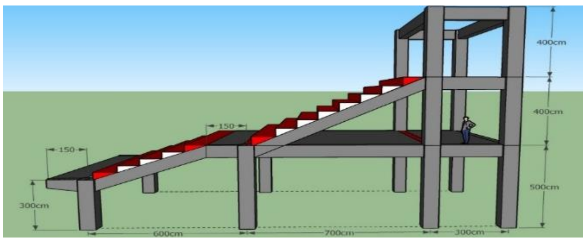

Figure 9 Portal Cross Section

3.2 Loading Combination

The combination of loading refers to SNI 1727-2013 Article 2.3.2.

3.3 Structural Analysis Modeling

After carrying out the preliminary design, the results of the preliminary design are applied in the form of 3D structure modeling with the help of SAP 2000 software.

4. RESULTS AND DISCUSSION

4.1 Roof Structure Steel Profile

Horses / Rafters

truss (RF) is planned using a space truss, can be seen in Figure 4.2.

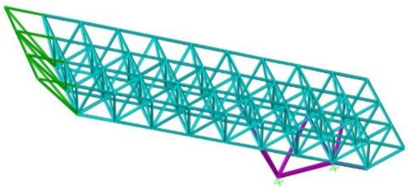

Figure 10 Horse Frame Plans

4.2 Preliminary Design of Concrete Structures

Table 2 Preliminary Beam Design

TYPE	Long (mm)	h (mm)	b (mm)	Taken h (mm)	Taken b (mm)	Beam Dimensions (cm)
B1	8000	485,714	366,667	550	400	40/55
B2	7000	425	333,333	500	350	35/50
B5	3000	242,857	233,333	400	300	25/35
	1500	242,857	233,333	350	250	25/35
B6	8000	370,068	266,667	400	300	30/40
BA1	8000	370,068	266,667	400	300	30/40
BA2	7000	323,81	233,333	350	250	25/35
BA5	3000	138,776	133,333	200	150	15/20
BAT	8060	153,524	266,667	400	300	30/40
BT	8060	489,357	366,667	550	400	40/55

Table 3 Preliminary Plate Design

Floor Plate	Plate Thickness (mm)
1st Floor Plate, Inner Corridor, and Dak	125
Upper Tribune Corridor Floor Plate	150
West grandstand aisle floor plate	180

Table 4 Column Preliminary Design

Type	Column Dimensions
K1	40/40
K2	50/50
K3	60/60

4.3 Structure Analysis Results

Table 5 The forces on the Column Components

Code	Dimensions (cm)	Design Moment (kN.m)	Axial Force (kN)	Shear Force (kN)
K1	40/40	23,75	138,40	7,12
K2	50/50	136,31	1535,31	68,20
K3	60/60	149,28	1945,84	45,13

Table 6 The styles of the Beam Component

Code	Long (mm)	Beam Dimensions (cm)	Design Moment		Shear Force (kN)	Torque (kN.m)
			Pedestal (kN.m)	Field (kN.m)		
B1	8000	40/55	148,48	57,39	80,76	15,96
B2	7000	40/50	79,49	59,67	52,90	10,33
B5	3000	30/40	461,71	59,68	412,40	23,87
B6	8000	30/40	18,91	12,02	16,24	0,96
BA1	8000	30/40	85,58	63,71	62,37	14,23
BA2	7000	25/35	27,37	15,27	20,49	0,22
BA5	3000	15/20	6,78	5,02	5,42	0,04
BAT	8060	30/40	72,31	78,31	104,34	1,19
BT 1	8060	25/35	213,26	226,82	298,80	2,94

4.4 Reinforcement Design

Table 7 Calculation results of longitudinal beam reinforcement

Code	Long	Dimension	Reinforcement Pedestal		Reinforcement Field	
	mm	cm	Tensile	Compressive	Tensile	Compressive
B1	8000	40/55	5D-16	3D-16	3D-16	2D-16
B2	7000	35/50	4D-16	3D-16	4D-16	3D-16
B5	3000	30/40	9D-16	5D-16	9D-16	6D-16
B6	8000	30/40	3D-16	2D-16	3D-16	2D-16
BA1	8000	30/40	3D-16	2D-16	2D-16	2D-16
BA2	7000	25/35	2D-16	2D-16	2D-16	2D-16
BA5	3000	15/20	2D-16	2D-16	2D-16	2D-16
BAT	8060	30/40	4D-16	3D-16	4D-16	3D-16
BT 1	8060	40/55	5D-16	4D-16	6D-16	4D-16

Table 8 Calculation results of transverse reinforcement and beam torsion

Beam	L	b	Ln	Perlu		Minimum		Reinforcement Torque
				Øs	S	Øs	S	
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	
Floor Beams								
B1	8000	400	7250	10	-	10	200	8D-10
B2	7000	350	6250	10	-	10	200	6D-10
B5	3000	300	2250	10	50	10	-	6D-10
B6	8000	300	7250	10	-	10	150	-
BA1	8000	300	7250	10	-	10	150	4D-10
BA2	7000	250	6250	10	-	10	400	-
BA5	3000	150	2250	10	-	10	50	-
BAT	8060	300	7310	10	150	10	-	-
BT 1	8060	400	7310	10	150	10	-	-

Table 9 Conclusion Column reinforcement

TYPE	Dimension (mm)		Reinforcement	
	b	h	Longitudinal	Shear
K1	400	400	8 D36	D13-150
K2	500	500	12 D36	D13-150
K3	600	600	16 D36	D13-150

Table 10 Conclusion of slab reinforcement for each floor

Floor	Reinforcement Used		
	Pedestal	Field	Shrinkage
Elevasi 3 meter	D16 - 100	D10 - 200	D10 - 300
Elevasi 5 meter			
Selasar	D10 - 500	D10- 400	D10 - 300
Lantai 1/Koridor	D13 - 400	D10 - 400	D10 - 350
Kantor	D10 - 400	D10 - 400	D10 - 400
Elevasi 9 meter	D10 - 300	D10 - 300	D10 - 400
Lantai DAK	D10 - 300	D10 - 300	D10 - 400

5. CONCLUSION

From the results of the analysis and discussion, the following research conclusions are obtained:

a. Planning on beams obtained beam dimensions for 8 m span is 40 x 55 cm (B1), 7 m span is 40 x 50 cm (B2), 3 m span is 30 x 40 cm (B5), 8 m span is 30 x 40 cm (B6), 8 m span is 30 x 40 cm (BA1), 7 m span is 25 x 35 cm (BA2), 3 m span is 15 x 20 cm (BA5), 3 m span is 30 x 40 cm (BAT), span of 3 m is 40 x 55 cm (BT). Beam reinforcement is used D16 for main reinforcement and D10 for shear and torsion reinforcement.

b. Planning on the column is obtained column dimensions 40 x 40 cm (K1), 50 x 50 cm (K2), 60 x 60 cm (K3). Longitudinal reinforcement in columns K1, K2, and K3 used D36 reinforcement. The transverse reinforcement in the column uses D13 reinforcement.

c. The plan on the slab obtained the dimensions of the floor plate with an elevation of 3 meters and on the walkway that is 180 mm, the first floor plate is 150 mm, and the office floor plate with an elevation of 9m and not that is 125 mm. The main support and field reinforcement on the floor plate all use D10 reinforcement, except for the 3m elevation floor slab using D16

Suggestion

Based on the planning results above, there are suggestions, among others:

a. The need for a deeper understanding of the treatment and provisions that apply in designing buildings, especially stadiums.

b. Look for more references and calculation procedures for designing buildings, especially stadiums.

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