STRUCTURAL STEEL PIPE RACK FORTHERMAL POWER PROJECTS-ANALYSISANDDESIGN

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Abstract: This study evaluates the Analysis and Design of Pipe carrying structure in Thermal Power Project such as Pipe Racks.Pipe racks are the most important structure in Oil and Gas, Refineries, Petrochemical Projects, Power Plants and many otherindustrialstructures.FormostloadsthePiperacksweredesignedasprimarycriticalloadsandpipeloads.Inthisreport,theanalysisofthe piperackwithsufficientloadsandsuitableconfigurationisperformedusingsoftwaresuchasSTAADPro.AspertheIndiancode, the design and analysis of pipe rack was done. Various loads such as Dead Load, Live Load, Wind Load, Pipe Empty Load,PipeFullLoadandtheircombinationsare considered.

IndexTerms- **Piperack,Deadload,Liveload,Windload,Pipeemptyload,Pipefullload,OilandGas,Refineries,PetrochemicalProjectsandPower Plants.**

1 Introduction

Thepipecarryingstructureusedinthermalpowerprojectwhichweconsideredforthisresearchpaperisa PipeRack.Itisaveryimportantstructureinthermalpowerprojectsofabout2kmlength.Piperackisasteelstructurewhichcarriesmultiplepipescarryingliquidorgasindifferenttierswithserviceplatformsandwalkways.PiperackscarrylargediametertosmallborelineswithliquidorgasfromoneEquipmenttoanotherEquipmentorfromoneunittoanotherunit.Pipenetworksareconsideredasmaincomponentsof industrial complexes like refineries and petrochemicals that transfer fluid and gas and any damage in their structures may bedangerous.Piperackdesigningisnotaone-manarmyjob.Itinvolvesalotofengineeringcalculationsandsorequiredcontributionfromthedifferentengineeringdisciplines.

Fig.1 PipeRackStructure

Piperacksarethemainhighwayinaprocessfacility.The Piperacksconnectalltheequipmentwithpipingthatcannotrunthroughthe equipment areas. Pipe racks are usually located in the middle of process plants. If the racks are located in the middle of theplant, then they have to be erected first, before becoming surrounded by process equipment. Pipe racks support not only processpiping but also utility piping, cable, and instrument trays as well as any equipment that is supported from and over the pipe racksuch as air coolers. Pipe racks require considerable planning and coordination with all disciplines to facilitate not only a logicaldesignbutalsotoreduce constructioncosts.

1.1. Problem Statement

A typical pipe rack is considered for a power project between FO P/H Area to ESP Control Room consisting of 54.06m length.There are three tiers - First tier is at 9.00m height, second at 10.50m height and third at 12.00m height. All heights are consideredatTopofSteel (TOS).

The Structural layout shall be prepared on the basis of Mechanical/Piping drawings and requirements. Two roads are crossing thepipe rack at 4.00m and 29.825m distance from origin. To give accessibility to road, a bridge is to be constructed considering thevehicleheights.

1.2. Necessity and Objective:

Piperacksarenecessaryforarrangingtheprocessandutilitypipelinesthroughouttheplant.Itconnectsalltheequipment(installedata differentlocation)withlinesthat cannotrunthroughadjacentareas.
Pipe racks are also used in secondary ways, as it also carries the electrical wire, instrument wire, firefighting systems, lights, etc.Air-cooled or fin-fan type heat exchangers are often supported above pipe racks to reduce the plant space requirements. Theobjective is to analyze and design a Pipe rack structure which is not as other structures. The specialty is various loads and loadcombinations are to be considered. The other objective of analysis and design of this kind of structure is to understand themultidisciplinarydrawingsanddata.

2.0. Design Methodology

In the proposed scope of work, the structure is analyzed in STAAD Pro Software and Design is done manually using IS:800-2007,IS:875-1987PartI,IS:875-1987PartIIandIS:875-2015PartIII.Thepipeforceswillbeconsideredaspointloadonthesupportasdatareceivedfromthe Mechanical/PipingDepartment.

3.0 Loads and Load Combinations

3.1 Loads

1) **DeadLoad**:The dead loads are calculated from the member sizes and estimated material densities.Unitweightofbuilding materialscanbeestimatedinaccordancewithIS875-1987 Part1.

2) **Live Load**: Live loads are considered as per IS:875-1987PartII .
3) **Wind Load**: Live loads are considered as per IS:875-1987PartIII .
4) **Pipe Loads:**The following table is obtained from the piping department which gives us the details about the material of the pipes, thickness ofthe pipes, diameter of the pipes, bare pipe weight, water weight, bare pipe + water weight, design weight, horizontal load, span,PELandPFL.Table 1representsthe pipe inputdetails.

Table No.1 Pipe Input Details

SR. NO	Service	Material of Pipe	Qty	NB (mm)	Pipe Thk (mm)	Pipe OD (mm)	Bare Pipe weight (Kg/m)	Water weight (Kg/m)	Bare pipe + water weight (Kg/m)	Design weight (Vertical load) (kg/m)	Horizontal load (30% of Vertical)	Remarks	Design weight (kg/m)
	SECTION : 03-03												
1	PLANT POTABLE	IS 1239	1	50	4.5	60.80	6.25	2.11	8.36	8.36	2.51	TOP TIER	10.4
2	IAD	IS 1239	1	100	5.4	115.00	14.60	8.53	23.12	23.12	6.94	TOP TIER	28.9
3	SAD	IS 1239	1	50	4.5	60.80	6.25	2.11	8.36	8.36	2.51	TOP TIER	10.4
4	PWD	IS 1239	1	25	4	34.20	2.98	0.54	3.52	3.52	1.06	TOP TIER	4.4
5	SWD	IS 1239	1	40	4	48.80	4.42	1.31	5.73	5.73	1.72	TOP TIER	7.2
1	HFO PUMP HOUSE	IS 1239	1	65	4.5	76.60	8.00	3.59	11.59	11.59	3.48	MIDDLE	14.5
2	COOLING WATER	IS 1239	1	50	4.5	60.80	6.25	2.11	8.36	8.36	2.51	MIDDLE	10.4
3	HOT WATER OUT	IS 1239	1	50	4.5	60.80	6.25	2.11	8.36	8.36	2.51	MIDDLE	10.4
4	CONDENSATE	IS 1239	1	40	4	48.80	4.42	1.31	5.73	5.73	1.72	MIDDLE	7.2
5	SUMP PUMP FROM	IS 1239	1	65	4.5	76.60	8.00	3.59	11.59	11.59	3.48	MIDDLE	14.5
6	FUEL OIL	IS 1239	1	80	4.8	89.50	10.03	5.01	15.04	15.04	4.51	MIDDLE	18.8
7	DM NEUTRALIZED	IS 1239	1	150	5.4	166.50	21.45	19.04	40.49	40.49	12.15	MIDDLE	50.6
8	DM TRANSFER	IS 3589	1	200	6.3	219.10	33.06	33.49	66.55	66.55	19.97	MIDDLE	83.2
9	SERVICE WATER	IS 3589	1	200	6.3	219.10	33.06	33.49	66.55	66.55	19.97	MIDDLE	83.2
1	AUXI STEAM -	A 106	1	150	7.11	168.30	28.26	18.65	46.91	46.91	14.07	BOTTOM	58.6
2	HFO - SUPPLY	A 106	1	150	7.11	168.30	28.26	18.65	46.91	46.91	14.07	BOTTOM	58.6
3	HFO - RETURN	A 106	1	100	6.02	114.30	16.08	8.21	24.29	24.29	7.29	BOTTOM	30.4
4	LDO - SUPPLY	A 106	1	80	5.49	88.90	11.29	4.77	16.06	16.06	4.82	BOTTOM	20.1
5	APH WASH PUMP	IS 3589	1	300	7.1	323.90	55.47	75.33	130.80	130.80	39.24	BOTTOM	163.5
	TOTAL									548.31	164.49		
	Total Pipe Load for Rack Design Considering 20% Contingency									657.97			

3.2 Load Combinations:

The followingaretheloadcombinationsoftheloads (LiveLoad(LL), DeadLoad(DL), PipeEmptyLoad(PEL), PipeFullLoad(PFL),and WindLoad (WL)) applied onthestructure.Table2 representstheloadcombinations.

Table no.2 – Load Combinations

LOADCOMB01 1.5(DL+LL+WL(+X))	LOAD COMB34 1.2(DL+WL(-Z)+PFL)
LOADCOMB021.5(DL+LL+WL(-X))	LOAD COMB35 1.2(DL+LL+PEL)
LOADCOMB031.5(DL+LL+WL(+Z))	LOAD COMB36 1.2(DL+LL+PFL)
LOADCOMB041.5(DL+LL+WL(-Z))	LOAD COMB371.2 (DL+LL+WL(+X)+PEL)
LOADCOMB051.5(DL+LL+WL(+X)+PEL)	LOAD COMB 38 1.2 (DL+LL+WL(-X)+PEL)
LOADCOMB061.5(DL+LL+WL(-X)+PEL)	LOAD COMB391.2 (DL+LL+WL(+Z)+PEL)
LOADCOMB071.5(DL+LL+WL(+Z)+PEL)	LOAD COMB 40 1.2(DL+LL+WL(-Z)+PEL)
LOAD COMB 08 1.5 (DL+ LL+ WL(-Z) + PEL)	LOAD COMB 66 DL+ LL + PF
LOAD COMB 09 1.5 (DL+ LL+ WL(+X) + PFL)	LOAD COMB 41 1.2 (DL + LL + WL(+X) + PFL)
LOAD COMB 10 1.5 (DL+ LL+ WL(-X) + PFL	LOAD COMB 42 1.2 (DL + LL + WL(-X) + PFL)
LOAD COMB 11 1.5 (DL+ LL+ WL(+Z) + PFL)	LOAD COMB 43 1.2 (DL + LL + WL(+Z) + PFL)
LOAD COMB 12 1.5 (DL+ LL+ WL(-Z) + PFL)	LOAD COMB 44 1.2 (DL + LL + WL(-Z) + PFL)
LOAD COMB 131.5 (DL+ LL+ WL(-Z) + PFL	LOAD COMB 45 DL + LL+WL(+X)
LOAD COMB 14 1.5 (DL+ WL(-X) + PEL)	LOAD COMB 46 DL + LL+WL(-X)
LOAD COMB 15 1.5 (DL+ WL(+Z) + PEL)	LOAD COMB 47 DL + LL+WL(+Z)
LOAD COMB 16 1.5 (DL+ WL(-Z) + PEL)	LOAD COMB 48 DL + LL+WL(-Z)
LOAD COMB 17 1.5 (DL+ WL(+X) + PFL)	LOAD COMB 49 DL + LL+WL(+X) + PEL
LOAD COMB 18 1.5 (DL+ WL(-X) + PFL)	LOAD COMB 50 DL + LL+WL(-X) + PEL
LOAD COMB 19 1.5 (DL+ WL(+Z) + PFL)	LOAD COMB 51 DL + LL+WL(+Z) + PEL
LOAD COMB 20 1.5 (DL+ WL(-Z) + PFL)	LOAD COMB 52 DL + LL+WL(-Z) + PEL
LOAD COMB 21 1.5 (DL+ LL + PEL)	LOAD COMB 53 DL + LL+WL(+X) + PFL
LOAD COMB 22 1.5 (DL+ LL + PFL)	LOAD COMB 54 DL + LL+WL(-X) + PFL
LOAD COMB 23 1.2 (DL+ LL + WL(+X))	LOCOMB 55 DL + LL+WL(+Z) + PFL
LOAD COMB 24 1.2 (DL+ LL + WL(-X))	LOAD COMB 56 DL + LL+WL(-Z) + PFL
LOAD COMB 25 1.2 (DL+ LL + WL(+Z))	LOAD COMB 57 DL+ WL(+X) + PEL
LOAD COMB 26 1.2 (DL+ LL + WL(-Z))	LOAD COMB 58 DL+ WL(-X) + PEL
LOAD COMB 27 1.2 (DL + WL(+X) + PEL)	LOAD COMB 59 DL+ WL(+Z) + PEL
LOAD COMB 28 1.2 (DL + WL(-X) + PEL)	LOAD COMB 60 DL+ WL(-Z) + PEL
LOAD COMB 29 1.2 (DL + WL(+Z) + PEL)	LOAD COMB 61 DL+ WL(+X) + PFL LOAD
LOAD COMB 30 1.2 (DL + WL(-Z) + PEL)	COMB 62 DL+ WL(-X) + PFL
LOAD COMB 31 1.2 (DL + WL(+X) + PFL)	LOAD COMB 63 DL+ WL(+Z) + PFL
LOAD COMB 32 1.2 (DL + WL(-X) + PFL)	LOAD COMB 64 DL+ WL(-Z) + PFL
LOAD COMB 33 1.2 (DL + WL(+Z) + PFL	LOAD COMB 65 DL+ LL + PEL

4.0 STAAD MODEL

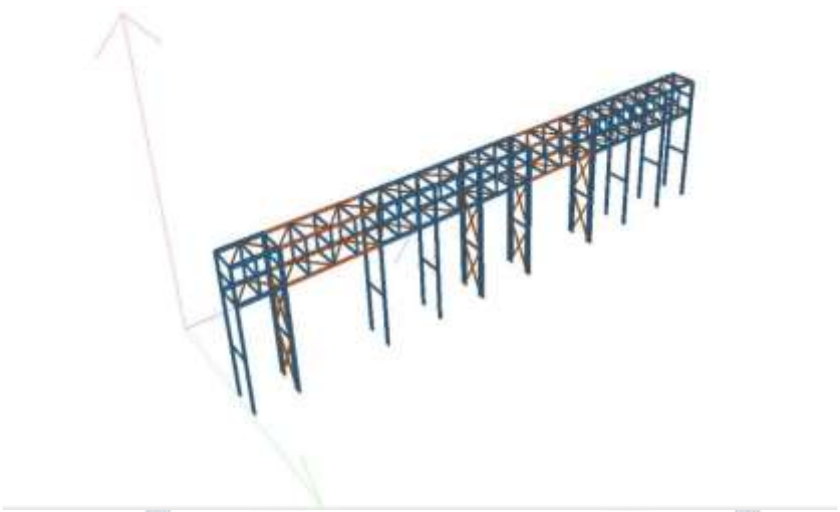

Fig.2.3DRenderedVie

5.0 Design

After analysis in Staad Software , following Members are designed:

Table No.3 Design Check for Member No. 662

BEAM	662
LENGTH	2.7
FORCE	64
1.AREA (AG)	281.6
2.AN	216.802168
SECTION SELECTED	ISMB200
AREA PROVIDED	3233
CHECK	OKAY
2.DESIGN STRENGTH DUE TO YIELDING	
TDG	734.7727273
CHECK	OKAY
3)DESIGNSTRENGTH DUE TO RUPTURE AT NET CRITICAL AREA	
TDN	318.1272
CHECK	OKAY

Table No.4 Design Check for Member No. 599

COLUMN	599
LENGTH	4.5
FORCE	62
1.AREA (AG)=	272.8
2.AN	210.0271003
SECTION=	ISMC400 D
AREA PROVIDED	7846
CHECK	OKAY
2.DESIGN STRENGTH DUE TO YIELDING	
TDG=	1783.181818
CHECK	OKAY
3)DESIGNSTRENGTH DUE TO RUPTURE AT NET CRITICAL AREA	
TDN=	772.0464
CHECK	OKAY

6.0 Conclusion

After Analysis and Design of Pipe rack for power project for three tiers, the total weight was found to be 52961.0068 kg. It can be concluded that the pipe rack weight per meter length is 979.6708 kg/m.

The scope of further study can be an alternative with replacing steel column with RCC column. This alternative can be analyzed, designed and compared with structured steel pipe rack.

7.0 References

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