

e-ISSN: 2319-8753 | p-ISSN: 2347-6710

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International Journal of Innovative Research in SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 2, February 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

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e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 8.423| A Monthly Peer Reviewed & Referred Journal |



Volume 13, Issue 2, February 2024

DOI:10.15680/IJIRSET.2024.1302026

Analysis of Offshore Pipe Rack Structure by Using SACS

Abdul Gafoor, Dr.P.Lakshmaiahchowdary

PG Student, Dept. of Civil Engineering, Bheema Institute of Technology & Science (BITS), ADONI,

Karnool Dist.(A.P). India

Professor, Dept. of Civil Engineering, Bheema Institute of Technology & Science (BITS), ADONI,

Karnool Dist.(A.P). India

ABSTRACT: This Project / paper deals an overview of the key aspect in the design of offshore structures by using SACS. the main aim of this review is to introducing the different types of offshore platforms. Pipe racks are the structure in petrochemical, chemical and power platform that are design and supports pipes, power cables and instrument cables trays. they may also be used to support mechanical equipments, vessels and valves access platforms. pipe racks are non building structures that have similarities to structural steel building.

The design requirements of pipe rack structures the Analysis, codes and industry practice, design criteria, design loads and other designed conditions for pipe racks.

KEYWORDS: Floating Production; Offloading; Design modeling; Steel Structure; Piperack

I. INTRODUCTION

1.1 GENERAL

Offshore construction is the installation of structures and facilities in a marine environment, usually for the production and transmission of electricity, oil, gas, and other resources. One of the best disclosures of the twentieth century was oil, and it has such a large number of utilization that it can't be isolated from humanity. The oil investigation began in 1900, and the oil investigation at first was focused on a shore. As the requirement for oil extends at an unstable rate, the requirement to find new revelations was renowned. During the middle of the twentieth century, oil disclosure began in close shore and medium scope of water profundity. Initial well from a fixed stage seaward was penetrated by Kerr-McGee Corporation in 1947. Its framework, comprising of a freight ship and stage blend, implied a huge progressed in that period and denoted the start of the cutting edge maritime industry as today is known. By 1949, there were 11 oil fields in the Gulf of Mexico and another 44 exploratory wells in the procedure. From that point forward, around 16000 wells have been bored in the mainland rack in more profound and more profound waters extremely distant from the coast. Seaward apparatuses have penetrated in waters over 2200 meters down and to the extent 200 miles from shore. The requirement for qualified seaward auxiliary faculty is quickly expanding as the oil business moves into more

The requirement for quantied seaward auxiliary factify is quickly expanding as the off busiless moves into more profound water in the quest for extra supplies of oil and gas, new innovation is rising at to produce more energy from the offshore structures. Seaward stages are built to deliver hydrocarbons oil and gas. Oil is as of now the most significant fossil vitality source, pursued by coal and petroleum gas. Oil represented around 33 percent of world essential vitality utilization in 2011, trailed by coal and petroleum gas with around 30 and 24 percent individually. The rest of originates from atomic vitality, hydropower and other renewable, for example, sunlight based and wind vitality. In 2011, worldwide oil creation stretched around four billion tons, of which a full 61.5 percent was expended in the transportation segment. Be that as it may, oil isn't just fuel; it is likewise a vital contribution to the pharmaceutical and compound enterprises. The commitment of seaward oil generation in the year 1988 to the world vitality utilization was 9% and was assessed to be 24% in 2000.World oil creation in 1988 was 63 million barrel/day. These figures apparently show the test for the seaward architect: a developing commitment is required from seaward abuse, an exceptionally capital serious action. About 30% of world oil production is done by offshore structures. Deepwater wells have the ability to create more than 50,000 barrels of oil every day. One well can regularly get to an enormous repository. This more was remarkable profitability implies seaward boring destinations regularly have altogether fewer wells with a more extensive reach than tedious coastal territories. Seaward wells will in general produce at a similar high volume for



e-ISSN: 2319-8753, p-ISSN: 2347-6710 www.ijirset.com | Impact Factor: 8.423 | A Monthly Peer Reviewed & Referred Journal |

|| Volume 13, Issue 2, February 2024 ||

| DOI:10.15680/IJIRSET.2024.1302026 |

10 to 20 years, which can mean many millions to a considerable number of gallons before the well is finished. While the expense to assemble the wells is a lot higher, the more noteworthy yield after some time implies deepwater wells frequently observe more prominent net revenues at last. The payout is higher in light of the fact that the wells produce more oil every day. Deepwater oilfield advancement may take ten years from the principal exploratory well to the primary barrel of oil sold, and pre-generation costs, including improvement wells and uncommonly structured creation offices, might be a few billion dollars. Sheltered and compelling seaward boring and creation require broad seismic imaging and geologic examination, building structure and arranging, development of profoundly real hardware, and consistency with government or state ecological guidelines, all of which take a great deal of time and cash.

1.2 Types of Offshore Structures

Floating - Offshore platforms in this category are designed to float on the water's surface and have the capability to be relocated to different locations. Some illustrations of these platforms encompass semi-submersibles, SPAR platforms, platforms with floating legs, drill-ships, and Floating Production Storage and Offloading (FPSO) vessels.(Floating Production, Storage and Offloading systems)

Fixed Platforms These offshore units are stationary and permanently anchored in one location. They possess superior strength and longer-lasting qualities when compared to their floating counterparts. Once they are installed, they cannot be moved, making them operationally permanent. Examples of such units include Concrete/Gravity Platforms, Jacket Platforms, Tension-leg Platforms (TLPs), and Jack-Up Rigs, among others.1.3 Floating production storage and offloading (FPSO)

1.3 Floating Production Storage and Offloading



Fig1: Floating Production Storage and Offloading

FPSO (Floating Production Storage and Offloading) and FSO (Floating Storage and Offloading) systems today have become the primary method for many offshore oil and gas producing regions around the world.

An FPSO, which stands for Floating Production, Storage, and Offloading, is a floating production system designed to receive fluids, including crude oil, water, and various other components, from a subsea reservoir through risers. Once onboard, these fluids are separated into crude oil, natural gas, water, and impurities within the topsides production facilities.

The crude oil is then stored in the FPSO's storage tanks and subsequently offloaded onto shuttle tankers for transportation to the market or further refining onshore. In essence, an FPSO is a floating vessel strategically positioned near an offshore oil field, where it processes and stores oil until it can be transferred to a tanker for transport and additional refining.

FPSOs come in various forms, ranging from converted former super tankers to purpose-built vessels. When a similar vessel is utilized for processing natural gas, it is referred to as an FLNG, which stands for Floating Liquefied Natural Gas.

The majority of FPSOs and FSOs typically has a ship-like structure and can be anchored to the seafloor using various mooring systems, which are selected based on the particular environmental conditions. These vessels are well-suited for diverse water depths and environmental scenarios and can be engineered with the ability to remain stationed at a specific location for continuous operations lasting 20 years or more.



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Here's how an FPSO works and some of its key features:

Production:

FPSOs come equipped with facilities designed to handle the processing and separation of extracted hydrocarbons from water and other contaminants. This processing may involve activities like the removal of sand, gas, and water from the oil before it is either stored or transported.

Storage one of the key roles of an FPSO is the storage of processed oil and gas. The vessel is equipped with storage tanks capable of holding substantial volumes of hydrocarbons until they can be transferred to other ships or transported to onshore facilities.

Offloading: FPSOs are equipped with systems for transferring the stored oil and gas to shuttle tankers or other transport vessels. These offloading procedures can be carried out through diverse means, including flexible hoses or fixed loading arms.

Components of an FPSO: Hull: The hull of an FPSO is meticulously engineered to ensure stability in challenging open sea conditions and is equipped with mooring systems to maintain the vessel's position.

Processing Facilities: These encompass a wide array of equipment designed for the efficient separation of oil, gas, and water, as well as other facilities crucial for overseeing production and ensuring product quality.

Storage Tanks: FPSOs are equipped with storage tanks that serve as repositories for the separated oil and gas, holding them until they can be transferred to other vessels or transported to the shore.

Offloading Systems: These integral systems facilitate the seamless transfer of stored hydrocarbons to shuttle tankers or other vessels for onward transportation.

Living Quarters: FPSOs often include accommodations to house personnel working on the vessel, such as operators, maintenance teams, and support staff.

Utilities and Support Systems: FPSOs are equipped with utility systems that encompass power generation, water treatment, and other essential functions vital for the smooth operation of offshore activities.

FPSOs have significantly transformed the landscape of offshore oil and gas production, offering a versatile and adaptable solution for the extraction of resources from demanding offshore environments.



Fig.2: The ongoing operations to an FPSO and the production process

1.4 PIPE RACK

A pipe rack serves as the central hub of a process unit, linking all equipment with pipelines that cannot be routed through neighboring sections. Given its central role in most plants, it is essential to construct the pipe rack as the initial step, prior to it being obstructed by rows of equipment. Pipe racks support process and utility piping, in addition to accommodating instrument and electrical cable trays, along with equipment installed above all of these components. Pipe Racks are alternatively referred to as pipe bridges, pipe ways, and pipeline corridors. Within process plants like

refineries, petrochemical facilities, and other complexes including chemical and power plants, the flow of fluids holds immense importance for the effective operation of interconnected equipment and units. The strategic layout of these



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interconnected pipelines is essential for minimizing capital expenditures and enhancing plant efficiency, ultimately optimizing overall plant profitability.

Pipe racks are raised structures constructed from steel or concrete, specifically engineered to provide support for pipes, as well as electrical and instrument cable trays. On occasion, they may also serve as a foundation for mechanical equipment, vessels, and platforms granting access to valves.

The pipe rack plays a crucial role in supporting the primary process lines, which interconnect equipment like pumps, storage tanks, static vessels, and columns. Additionally, it provides connectivity for various relief and blow down headers. All lines, whether entering or exiting the plant, including utility supply lines such as steam, air, cooling water, and inert gas, are directed through this pipeline corridor. In an Oil and Gas processing facility, a typical feature is the presence of one or more "Main Pipe Racks" within the petrochemical facility, facilitating the transfer of materials between equipment and storage or utility areas. Furthermore, within the individual processing units, unit pipe racks are strategically located to connect the unit's equipment.



Fig 3 Pipe Racks

Offshore pipe rack structures serve several purposes:

- 1. Piping Support: These structures serve as a framework to suspend and uphold pipelines at appropriate heights, enabling the efficient conveyance of fluids like crude oil, natural gas, and water between various processing units and storage tanks on the platform.
- 2. Cable Routing: Offshore platforms necessitate extensive cabling for functions such as communication, power distribution, control systems, and safety equipment. Pipe rack structures provide organized pathways for the systematic routing of these cables throughout the platform, ensuring safety and efficiency.
- 3. Access and Maintenance: The organization of pipelines on a pipe rack simplifies access for maintenance personnel, enhancing safety and efficiency during routine inspections, repairs, and replacements.
- 4. Safety and Organization: Elevating and arranging pipes and cables on pipe racks reduces the risk of damage from environmental factors like waves and corrosion. Furthermore, it helps prevent accidental damage caused by equipment and personnel movements on the platform, contributing to safety and organization.
- 5. Space Optimization: Given the limited space on offshore platforms, the use of pipe racks is essential for maximizing available area. By vertically and horizontally stacking pipes and cables, the platform's layout becomes more space-efficient.
- 6. Fire Protection: Offshore pipe racks are meticulously designed to adhere to stringent fire safety standards. Their layout may incorporate fire-resistant materials and arrangements aimed at containing and mitigating fires effectively.

.The primary data required for detailed development of a pipe rack

- Plot Plan
- P&ID's
- Client Specification
- Construction Materials
- Fire proofing requirements
- Statutory requirements



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PIPE RACK LOADING : Pipe rack loads should be categorized based on stress groups and communicated to the Civil & Structural discipline to inform the design of the pipe rack.

Sustain Load (Dead Load) : The combined weight of the piping, valves, and insulation load

Thermal Load

The load caused by the thermal expansion of piping and the reactive force resulting from the internal pressure of expansion bellows.

Dynamic Load

The load induced by piping vibrations and the loads generated by wind and seismic events. Sustained Load (Live Load) The load applied for conducting a hydrostatic pressure test using a liquid.

RACK PIPING

Position of Lines

The primary focus is to position process lines predominantly on the lower tier, while placing utility and hot process lines on the upper tier.

Hot Lines & Cold Lines : Typically, hot lines and cold lines are segregated into different tiers or grouped separately within the same tier

Pipe Spacing :The minimum gap between adjacent lines is determined by considering factors such as the outside diameter (O.D.) of the larger flange (with a minimum rating of 300#), the O.D. of the smaller pipe, the thickness of individual insulation, and an additional 25mm clearance. Even if a flange is not present, the minimum spacing is based on the criteria mentioned above. Actual line spacing, especially at 'L' bend and loop locations, must account for thermal expansion, thermal contraction, and the absence of expansion in adjacent lines. At 'L' bend locations, the absence of expansion or thermal contraction may restrict the free movement of adjacent lines.

Bigger Size Lines

To minimize the bending moment on the beam, it is advisable to position large-diameter lines (14" and above) near the column. Water lines exceeding 30" in size should not be directed across the pipe rack but should instead be routed underground.

Anchor Bay

If the anchor bay concept is adopted, anchors on the racks should be placed within the anchor bay. Alternatively, if the anchor bay concept is not used, anchors should be distributed across two to three consecutive bays.

PipeRoute: The design of the racks should aim to minimize the length of the piping runs and ensure there is adequate vertical clearance above main walkways, secondary walkways, and platforms.

Trays In most cases, the upper tier is designated for Electrical cable trays (unless they are placed in an underground trench) and Instrument cable ducts/trays. The installation of cable trays should account for the required clearances needed for the fireproofing of the structure.

Pipe Rack Types : In the process plant, you can see either of the following types of racks to support piping.

- Steel Structure
- RCC / Pre-cast

The erection of RCC racks on-site is a time-consuming process, mainly due to the necessary curing time for the concrete. In the case of concrete racks, the reinforcement is achieved through the tensile strength of steel bars, while cement provides the compression strength. Nowadays, pre-cast beams and columns are increasingly utilized for the construction of concrete racks at the site, resulting in time and cost savings. Insert plates are incorporated into columns and beams to facilitate the welding of steel members onto them.

Steel racks, on the other hand, are constructed using beams, channels, and angles. They are predominantly fabricated in a workshop and then either bolted or welded together on-site, enabling swift installation. However, these steel racks necessitate regular maintenance, including painting, to mitigate issues related to corrosion.



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Structural steel pipe racks : Pipe racks typically provide support for pipes, power cables, and instrument cable trays in industries such as petrochemical, chemical, and power plants. Occasionally, they may also bear the weight of mechanical equipment, vessels, and platforms for valve access. Main pipe racks play a pivotal role in transferring materials between equipment and storage or utility areas within these facilities. It's important to note that storage racks found in warehouses, even if they store pipe lengths, do not qualify as pipe racks.

In essence, a pipe rack serves as the central artery of a process unit, accommodating process and utility piping, as well as instrument and cable trays, and equipment mounted above them. The design typically consists of a series of transverse beams running longitudinally along the pipe system at regular intervals, often around 20 feet apart. To allow for maintenance access beneath the pipe rack, these transverse beams are typically designed as moment frames and connected with longitudinal struts.

Within the pipe rack structure, different types of pipes are organized. Utility pipes, which convey substances like steam, cooling water, extinguishing water, and fuel oil, are usually positioned in the middle of a single-level pipe rack or on the upper level when there are two levels. In contrast, process pipes carry materials integral to chemical reactions and are typically located on the outer sides of utility pipes or on the lower level when multiple tiers are present. Finally, relief and flare pipes serve a safety purpose by protecting the installation against excessive pressure and are consistently positioned on the outer edges of the pipe rack.

II. LITERATURE REVIEW

2.1 GENERAL

Project introduction, along with the background of the research, necessity of the project and thesis organization, is provided in the previous chapter. In this chapter, the literature survey on offshore structure analysis and guideline for offshore structure construction and objectives of the project are reported.

1.Haritos et al., [2007] study are conducted on an overview of the analysis and design of offshore structures. This paper basically deals with critical factors used in offshore structure structures. Hydrodynamic force, airy wave theory, stretch wave theory, load on offshore structures, and the response of offshore structures are discussed. Hydrodynamic contact and dynamic response are major factors which should consider in the design kinematic of water particle, which causes the load on structures in terms of wave load and current. LRFD method is considered for design. Water particle kinematics is also affected by the topology of the ocean sea bed. Water particle forms elliptical shape for low water depth and circular shape for the high water depth. The wind is the main reason for the generation of ocean waves. P-M wave spectrum is used for spectral density with full sea state condition. Fourier series of air wavelets are taken for irregular sea state. Wind load that acts on an offshore structure differs from wind load act on land because the ocean does not provide any restriction to the moment of wind. Wind load is calculated by using wind speed, an area exposed, and drag coefficients. For wave load calculation Morison equitation is used. If the diameter to wavelength ratio is more significant than 2, it undergoes diffraction regime. Marine growth increments width of diameter along with increment in the roughness coefficients. Many offshore structures in the world are designed using Morison equation and airy wave theory.

2.Kamesh A Rajai et al., [2018] This study involves comparing two different pipe rack structures, each using a different type of bracing system. The purpose is to understand how these structures behave in terms of displacement, safety, material usage, and cost-effectiveness. Here's a simplified summary of the findings:

- Displacement and Bracing Patterns: The two pipe rack designs were compared, and it was clear that the one with an X bracing pattern (Case 1) had less movement than the one with an inverted V bracing pattern (Case 2).
- Structural Safety: Both designs were found to be safe. They didn't experience excessive stress, as shown by the utilization ratio, and their bending and movement were within acceptable limits.
- Extreme Forces: The maximum forces experienced by the structures were different. Case 1 had lower axial and shear forces compared to Case 2, suggesting that it was better at handling heavy loads.
- Material Usage: The amount of steel needed for the structures was calculated. Case 1 required 57.23 tonnes of steel, while Case 2 needed only 34.31 tonnes. This makes Case 2 more efficient in terms of material use.
- Structural Length: It's recommended to keep the length of the pipe rack under 60 meters to maintain its integrity. Beyond this length, an expansion joint should be added to accommodate temperature-related expansion and prevent damage.
- Cost Considerations: Because Case 2 used less steel, it turned out to be more economical. Its reduced steel requirement makes it a cost-effective choice compared to Case 1.



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It's important to note that the validity of these findings relies on the thoroughness of the analyses conducted earlier. Additionally, it's crucial to consider not only structural factors but also practical aspects like construction feasibility, maintenance implications, and the ability to adapt to future changes.

3. Priya D Meshram et al., [2021] this review thoroughly examines a structural design from various angles, providing valuable insights into its strength and compliance with engineering standards. The study explores different aspects of the design, shedding light on its effectiveness and contribution to the field of structural engineering.

The study primarily focuses on how well the design's components are used, showing that all parts are working within their limits. This suggests the design can handle the loads and stresses it's meant to. Additionally, the review checks how much the parts bend under different conditions. This confirms that the design meets the requirements for strength and can handle different forces without any structural problems.

The way the design includes cross vertical bracings is crucial. These help distribute forces and make sure the structure remains stable. This shows a good understanding of how structures distribute loads and stay steady.

It's interesting that the vertical bending varies between different cases. Even though there's more bending in one case, it's still within safe limits, which means the design can handle different situations. This shows the review is practical and considers real-world scenarios.

The review also points out that the number of columns was reduced strategically. This not only saves money but also shows that the designers thought about how the structure looks while ensuring it's strong.

By looking at stress and bending, the review tries to find the best distance between supports. This shows a careful effort to make the structure efficient while staying safe.

The study also gives data about how much weight each design can hold. This adds numbers to the review, making it even more trustworthy.

The review also makes sure the design doesn't bend too much, which is important for safety. The fact that the actual bending is within limits shows how serious the designers were about safety.

The study pays attention to how much load the design can handle, making sure it's not pushed too far. This practical approach highlights how safety was a priority.

Lastly, the review makes sure the design follows the proper engineering standards. This shows that the design was made carefully, following the rules.

In conclusion, this review provides a thorough exploration of a structural design's strength and adherence to safety rules. By examining how loads are distributed, how parts bend, and how standards are followed, this review significantly adds to our understanding of structural engineering.

4. B Ashwini Chalke at el., [2020] the way we design offshore platforms to keep them safe has changed over time. One big influence on this is "The American Petroleum Institute" (API). In 1993, they introduced new rules that shifted how we design platforms, focusing on safety factors rather than just stress.

These rules from API have been important in understanding the forces that affect offshore platforms, like wind and waves. Wind creates pressure on the platform, and waves add dynamic forces. Thinking about these forces carefully when designing is crucial to make sure the platform can handle different conditions and stay strong.

Today, we use special computer programs like SAP2000 V20 to understand how these platforms behave. These programs simulate different situations to predict how the platform will react. This helps engineers see how the platform might bend or where it might have too much stress. Getting this information is vital for making sure the design is really safe and follows the rules.

Looking back, we can see that the changes made over time, driven by API's influence and the switch to new design ideas, have improved how we design offshore platforms. Using advanced software for analysis shows how serious we are about making sure these platforms can handle the challenges they face.

5. J. K. Sumanth at., [2018] the literature review thoroughly examines the design and analysis of the PR 18-01 pipe rack steel structure. It studies how the structure was made, how it handles different loads, and its strength. The review follows strict rules and uses a well-known design code for accuracy.

The review shows that the structure can hold 1365.068 tonnes, which is a measure of its strength. The way the columns are placed considers their shape and how they handle weight. Special supports called bracings make sure the structure can handle side forces, like wind, keeping it safe.

Different shapes of bracings are used for different reasons, and they also help save money by making the structure efficient. Certain connections in the structure help spread the load evenly. Other connections handle twisting forces. This makes the structure strong and flexible.

To handle temperature changes, the structure has special loops. The review explains that the structure doesn't bend too



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much, even under different conditions. Actual data from the foundation is used to make sure the review is accurate and practical.

A picture of a single column is included, so readers can see an important part of the structure. The review also talks about different types of loads, like wind and weight of pipes, which help understand how the structure works in real life. In short, this detailed review talks about the design and analysis of the PR 18-01 pipe rack steel structure. It looks at how it's built, handles different weights, and other important things. The review helps us learn more about making strong structures.

6. Mohammad ishtiyaque et al., [2015] This review looks at how to make pipe rack designs better. Pipe racks are structures that hold pipes and need to be strong, cost-effective, and practical. The review uses existing research to explain the study's findings. The study focuses on making structures stronger and cheaper by designing them carefully.

Strong Connections: Using strong connections in pipe rack design is important. Other research agrees with this. Good connections help spread weight and make the structure work better. Strong connections can handle more weight and stress, making the supports strong.

How Supports are Placed and Stress: Placing supports in the right way while keeping stress low is a common topic in structural engineering. The study tries to put supports far apart while managing stress. This is important because it balances stability and using materials wisely.

Arranging Beams: Arranging beams in specific patterns to fit larger pipes makes sense. This is supported by research promoting flexible designs. This shows an understanding of practical building needs and using materials smartly.

Saving Costs: Using fewer supports to save money fits with cost-saving ideas in engineering. Less unnecessary supports are in line with smart design. This balance between safety and cost comes from good planning.

Bracing for Strength: Using bracings in certain shapes to stop sideways bending is like what other research says. Smart bracing helps the structure stay stable. It also uses less material, which is better for the environment.

Different Types of Connections: Using certain connections to handle forces and stress makes sense. Past research shows this is important for strong structures. Different connections make sure forces are managed well and the structure stays strong.

Strategy for Reducing Force: Adding anchor bays to reduce forces matches what other studies suggest. Doing this right saves money and materials while keeping the structure strong.

Handling Temperature Changes: Adding loops to manage temperature changes is a good idea. This is important for the structure's durability. Managing temperature changes helps the structure last longer and stay strong.

Balancing Connections: Limiting how much stress certain connections can handle is a good idea. Other research agrees with this balanced design approach. This keeps the connections strong and the structure stable.

Smart Distribution: Putting base plates together based on how forces work is supported by research. This helps spread the load and makes the structure stronger. It also reduces stress points.

In the end, the study's findings match what we already know from structural engineering research. The ways they made the structures better are based on good ideas. This focuses on strength, safety, and making the structures work without wasting money or materials.

7. Rupam Saikia et al., [2014]The study involved looking at different aspects, and the results showed that adding something called "bracings" made the structures stronger. These bracings helped reduce how much the top part of the structure moved, and they also made the forces in the beams lower. This was a big improvement compared to when the structures didn't have these bracings.

The researchers found that the most effective type of bracing was the regular X-shaped one. But they also talked about another type, which looked like an upside-down V. This one worked well too, and it had the advantage of creating more space in the structure. In most of the situations they studied, this upside-down V-shaped bracing worked almost as well



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as the X-shaped one.

They also found that if a structure had parts that were not even when going up and down, it was important to add either bars going side to side or more of these bracings. This helped a lot in stopping the top part of the structure from moving too much.

In summary, this research looked at different ways to make structures stronger. They found that adding bracings was a good idea, and they compared different types of bracings. They also explained that when a structure was uneven, adding special bars or more bracings was important to keep it steady.

8. Mrs. Sabade Madhuri et al., [2017] In the world of engineering, there are two important codes called AISC 360-05 and AISC 360-10. These codes offer different ways to check if a structure is stable. There are three methods: first order, effective length, and direct analysis. The newer AISC code lets engineers pick the method they like.

This thesis is about studying a specific kind of structure called a pipe rack. It uses a computer program called STAAD.Pro V8i to compare these stability methods. The study looks at things like how the structure moves, the way it bends, and even how it might change shape over time. This is important because pipe racks are used in places like chemical plants to hold pipes and cables.

The rules for designing pipe racks can be confusing. This thesis tries to figure out how to use the rules in practice. It also looks at what other engineers usually do when they design pipe racks. They think about things like how heavy the pipes are and how the structure needs to handle different loads. This kind of information is important for designing strong and safe pipe racks.

9. Prashantet al. [2017] conducted an analytical study on the load analysis of offshore jacket structures. Depth of water is 200 m, and steel piles are used in the substructure. Grouting is done between pile and jacket. High depth water is taken for the study. Strengthen of the jacket is done by using x brace and a horizontal member. Bottom and deck sizes are 110 m x 70 m and 50 mx30 m respectively. Diameter and wall thickness of the leg is 1.5 m and 0.015 m. The load of 20000 tonnes is taken as total dead and live load. Wind, wave, and earthquake load are considered for analysis. Airy wave theory and storks theory is considered for two types of wave, namely swell wave, and freak wave .P-M spectrum is used with full sea state condition. The modeling is done by using finite element analysis software SAP 2000. For earthquake analysis Buhj earthquake, data is put in software. The analytical result shows that deflection is maximum for freak wave in both airy wave and strokes theory method. Maximum deflection value is 15.6 mm for wave height 20 m and wave period 25 sec. Similarly, a bending moment is also maximum for freak wave by using strokes theory having values of 7850 KN m. Maximum bending moment is at base of the leg. Maximumresponse values are for a combination of wave and wind load. Response spectrum analysis shows that there more acceleration and displacement for earthquake load near the base joint compare to the free end joint.

10. Jaydeep Borkar et al., [2021] this study looked at how to design pipe racks better. They found some important things:

Strong Connections: It's better to connect pipes to the structure with strong framed connections. They also tried to space the supports further apart while keeping the pipes safe. This helps the structure stay stable.

Supporting Beams: The beams that hold the pipes are spaced 6 meters apart. This is to fit bigger pipes. This way, they needed fewer beams, which is good for saving money.

Fewer Supports: Using fewer supports is smart to save money when building. This helps the design work well and be cost-effective.

Stopping Sideways Movement: They added diagonal bracings in shapes like K and L to stop the structure from moving sideways. This also made the design cheaper by using smaller materials.

Stronger Connections for Big Forces: For long bays or big pipes, they used special connections that can handle more force. This makes sure the pipes are safe.

Connections for Spreading Stress: They used vertical bracings to spread out the forces and stress. This makes the structure stronger and able to handle more weight.

Stability with Anchor Bays: Each structure had an anchor bay to keep the forces in check. This made the structure lighter and more cost-effective.

Choosing Column Shape: The columns that hold up the structure were designed based on how strong they needed to be. The shape of the columns was chosen this way.

In short, this study found that by using good ideas for connections, bracing, and supports, pipe racks can be made strong and cost-effective. These ideas help save money and make sure the structure does its job well.

e-ISSN: 2319-8753, p-ISSN: 2347-6710] www.ijirset.com | Impact Factor: 8.423| A Monthly Peer Reviewed & Referred Journal |



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DOI:10.15680/IJIRSET.2024.1302026

III. OBJECTIVES

- 1. Analysis of offshore pipe rack structure using SACS software.
- 2. To study the Unity Check comparison for normal and extreme operating condition.
- 3. To study the Unity Check comparison for normal operating condition with and without wind consideration.
- 4. To study the Unity Check comparison for extreme operating condition with and without wind consideration.
- 5. Joint displacement comparison for normal operating condition with and without wind consideration.

IV. METHODOLOGY

4.1 GENERAL

Literature review on offshore structure analysis and guideline for offshore structure construction has been reported in detail in the previous chapter. In this chapter, various methodologies that are involved in this study have been explained briefly, along with the necessary diagrams and Tables. The analysis is done by using finite element analysis software SACS 5.7 version. Static, dynamic, and soil-structure interaction analysis is done. API RP 2A recommendation is to consider for the analysis. SACS is finite element analysis software by Bentley Systems. Structural Analysis Computer System developed by Engineering Dynamics Inc. USA. SACS is a finite element structural analysis suite of programs for the offshore and civil engineering industries. This software is one of the best offshore stricter analysis software compared to others. It is easy to work, and less time consuming .it has features like impact analysis, gap analysis, hull modeler, and extreme wave response analysis.

4.2 MODELING

Modeling is done by using SACS software. The modeling is done in a three-dimensional view. Modeling is done such a way that it should match the actual geometry of the structure. Modeling is done by a collection of the required data. Data used for modeling is the type of offshore platform, water depth, number of columns, and number of the plans and number of tray supports. As we open the software, we see three options.

- 1. Modify the existing model
- 2. Open the last model
- 3. Create a new model.

Before choosing any type of modeling option, the unit should be set. The selected unit will apply for the modeling, loading, and analysis results. The unit selected for the structure is Force – kilo Newton (KN) Length – meter (m)

1. Modify the existing model : Modify the existing model option should be used when the design model is present or to change the values of the default model. This option is used to change the water depth, the thickness of the members and deck height. By using this option load, data may cause loss or vary. It is typically used to change the geometrical properties of the structure.

2. Open the last model : Open last model option used to change the last model. Initial create model option is used, and the model is created, and analysis is done. After analysis, any change is required related to geometrical property and load condition this option is used.

3. Create a new model : Create a new model option is used for the new model. In this option, we should enter new data related to modeling. No data present in this model like other modeling option. Geometrical properties and load condition should add in this option. In some cases, analysis generator set should be done to perform the analysis. Modeling is done in two ways.

4. 2.1 Co-ordinate system In geometry, an organizer framework is a framework that utilization at least one numbers, or facilitates, to remarkably decide the situation of the focuses or other geometric components on a complex, for example, Euclidean space. The request of the directions is critical, and they are some of the time recognized by their situation in an arranged and some of the time by a letter, as in "the X facilitate." The directions are considered to be genuine numbers in basic arithmetic, yet might be perplexing numbers or components of an increasingly conceptual framework, for example, a commutative ring. The utilization of an organizing framework allows issues in geometry to be converted

e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 8.423| A Monthly Peer Reviewed & Referred Journal |

Volume 13, Issue 2, February 2024

| DOI:10.15680/IJIRSET.2024.1302026 |

into issues about numbers and the other way around; this is the premise of investigative geometry. The coordinate system in the offshore structure is related to joint creation. The coordinate system has Coordinate in X and Z direction. Z-direction indicates depth .X, and Y indicates the length and width of the structure. First Coordinate is format values of (0, 0, and 0). The first joint is formed at the first bracing level. A negative value of Z Coordinate should be given for the levels below mean sea level. As we start as the blank model, we should use the option joint.We should go for add joint. Then individual joint Coordinate value is entered.Now in add member property, we should give group label like SA6, SA3. Add brace option is used to add diagonal bracing system. During this process, we give the bracing property. Bracing is added at a different elevation. Bracing is diagonal and horizontal in direction. Bracing is added at north & south faces of the structure & tray support are modeled @ top plan.

4.2.2. Structural wizard definitions system.

Skeletal wizard definitions system is an easy way of the modeling method. In this method, already, the structure is present. We can add or delete any property. It gives a three-dimensional view of the structure. It works on finite element modeling method in which the components are interconnected uniquely at the outside hubs, and out and out they should cover the whole space as precisely as could reasonably be expected. Hubs will have nodal removals or degrees of opportunity which may incorporate interpretations, pivots, and for extraordinary applications, higher request subsidiaries of relocations. At the point when the hubs uproot, they will drag the components along within a specific way managed by the component detailing. Symmetry or anti-symmetry conditions are exploited in order to reduce the size of the model. Displacement compatibility, including any required discontinuity, is ensured at the nodes, and preferably, along the element edges as well, particularly when adjacent elements are of different types, material or thickness. Compatibility of displacements of many nodes can usually be imposed via constraint relations. Elements behavior must capture the dominant actions of the actual system, both locally and globally. As we select the structural wizard definition system, it shows the default structure. For which we should know to collect data of the whole offshore structure. Collection of this data is significant before modeling of any offshore structure. Data includes information related.

Water depth: Before we start water depth should select. The offshore structure has different water depth. The depth of the FPSO offshore structure generally more than 2000mdepending on site condition. Water depth is a distance of mean sea level from its sea bed. Water depth should measure accurate before installation of the structure. The water depth & other environmental condition are considered for 100 year & 1000 year return period for preparing metaocean data. Acceleration from the mataocean data are used for analysis for normal operating & extreme operating conditions.

4.2.3 Working point elevation : Working point elevation is the elevation above the above deck level or MSL. It's the elevation were the bottom of column should be placed.

4.2.4 Joint : Joint is a point or edge where at least two bits of metal or plastic are consolidated. They are shaped by welding at least two work pieces as per a specific geometry. There are five types of joints butt, corner, edge, lap, and tee. These setups may have different designs at the joint where genuine welding can happen. For steel materials, oxyacetylene cutting is the most common form of preparation. This technique is advantageous because of its speed, low cost, and adaptability. Machining is the more effective for reproducibility and colossal production of parts. Preparation of joints is generally prepared by machining due to the need for high accuracy. Joint is considered as fixed for design. The fixed joint is indicated as 0000 in the model. The tubular joint is used, which are welded. All members are welded to each other. Tubular joints are subject to local stress concentrations, which lead to local yielding and plastic strains at the design load. For underwater welding, special care should take .the underwater welded element should test for NRL test, v notch test. The joint above water level have less temperate and effect from the boat. Due to this, there is the rise of the critical joint at any place. The area in which critical joint may exist should be provided with more robust class steel. The tubular welded joint is provided.

4.6 Weight

1. Self Weight/Dead weight of the structure: Structure is modeled with all primary, secondary and tertiary members with a density of 7850kg/m³

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Fig 4: Self weight details

2. Non model structural weight (STN): STN incudes Handrail, Grating and Connection weight



Fig 5: Non model structural weight details

3. ELECTRICALWEIGHT (EIDB) : Tray length is assumed as 2.075 and 6inch 3 tray are placed at each tray support beam. Tray length is assumed as 2.075 and 6inch 3 tray is placed at each tray support beam. Weight of each tray $(6^{\circ}) = 0.67 \text{ KN}$

Number of trays=3

Total eight on each tray support beam= 0.67x3 =1.998KN Weight as UDL=1.998/2.075=0.96 KN/M



Fig 6: Electrical weight details

3.1. Wind load

1- Hour average wind speed is considered for analysis .open area wind method is used by considering area & design wind speed. Wind is applied in the 8 direction from 0 to 360 degree. Four faces of the structure are considered for wind area calculation & load application.

|e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 8.423| A Monthly Peer Reviewed & Referred Journal |



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| DOI:10.15680/IJIRSET.2024.1302026 |

1. South Face



Fig 7: Wind load details acting on south face

V. RESULTS AND DISCUSSIONS

Table 6: BASIC LOAD CASE								
LOAD	LOAD	FX	FY	FZ	MX	MY	MZ	
CASE	LABEL	(KN)	(KN)	(KN)	(KN-M)	(KN-M)	(KN-M)	
1	101	0	0	- 2242.79	3780	509580.4	0	
2	102	0	0	-408.38	663.6	92630.1	0	
3	ELD	0	0	-173.73	336.6	39587.8	0	
4	IND	0	0	-173.59	336.8	39533.8	0	
5	PIC	0	0	-388.94	632	88219.1	0	
6	PID	0	0	-973.72	1582.3	220910.4	0	
7	STL	0	0	-798.4	1312.2	181515.2	0	
8	E000	114.18	0	0	0	5322.1	186.1	
9	E045	80.74	396.66	0	- 18453.2	3763.3	90043.7	
10	E090	0	560.96	0	- 26096.8	0	127154.9	
11	E135	-80.74	396.66	0	- 18453.2	-3763.1	89780.5	
12	E180	- 114.18	0	0	0	-5321.8	-186.1	
13	E225	-80.74	-396.66	0	18453.2	-3763.1	-90043.7	
14	E270	0	-560.96	0	26096.8	0	-127155	
15	E315	80.74	-396.66	0	18453.2	3763.3	-89780.5	
16	EOAX	259.82	0	0	0	12249.5	435.5	
17	EOAY	0	1370.65	0	- 64622.5	0	311342.9	
18	EOAZ	0	0	593.86	-995.4	-134895	0	
19	N000	68.09	0	0	0	3173.7	111	
20	N045	48.15	236.55	0	- 11004.1	2244.1	53697.1	
21	N090	0	334.53	0	- 15562.1	0	75828.2	
22	N135	-48.15	236.55	0	- 11004.1	-2244	53540.2	
23	N180	-68.09	0	0	0	-3173.5	-111	

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|e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 8.423| A Monthly Peer Reviewed & Referred Journal |

Volume 13, Issue 2, February 2024

24	N225	-48.15	-236.55	0	11004.1	-2244	-53697.1
25	N270	0	-334.53	0	15562.1	0	-75828.2
26	N315	48.15	-236.55	0	11004.1	2244.1	-53540.2
27	NOAX	259.82	0	0	0	12249.5	435.5
28	NOAY	0	501.07	0	- 23624.1	0	113817.7
29	NOAZ	0	0	593.86	-995.4	-134895	0

| DOI:10.15680/IJIRSET.2024.1302026 |

5.1 EXTREME OPERATING CONDITION

Table 8 : Member group uc ratio without wind consideration Extreme operating condition

Member	Member Length	Displacement		Allowable displacement	
Name	MM	X(mm)	Y(mm)	X(mm)	Y(mm)
S001- 0174	14450	3	-25	48.17	48.17
S002- 0172	14450	2	-28	48.17	48.17
S003- 0170	14450	2	28	48.17	48.17
S004- 0176	14450	2	28	48.17	48.17
S005- 0178	14450	2	29	48.17	48.17
S006- 0180	14450	2	29	48.17	48.17
S007- 0175	14450	2	-25	48.17	48.17
S008- 0173	14450	2	-28	48.17	48.17
S009- 0171	14450	2	-28	48.17	48.17
S010- 0177	14450	2	-28	48.17	48.17
S011- 0179	14450	2	29	48.17	48.17
S012- 0181	14450	-2	29	48.17	48.17

5.2 JOINT DISPLACMENT



e-ISSN: 2319-8753, p-ISSN: 2347-6710 www.ijirset.com | Impact Factor: 8.423 A Monthly Peer Reviewed & Referred Journal |

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DOI:10.15680/IJIRSET.2024.1302026

VI. CONCLUSION AND FUTURE WORK

- 1. UC COMPARISSON FOR NORMAL AND EXTREME OPERATING CONDITION
- For PB5section PG390B column group we got the difference UC ratio value for normal operating condition (0.56) and extreme operating condition (0.87) there is an increase of 35.6% of UC for extreme operating condition and for SA6 column group the difference UC ratio value for normal operating condition (0.27) and extreme operating condition (0.38) as there is a increase of 28.60% of UC for extreme operating condition.
- For TA4section H194X150 Beam group we got the difference UC ratio value for normal operating condition (0.81) and extreme operating condition (0.61) there is an decrease of 32% of UC for extreme operating condition and for SA3 Beam group the difference UC ratio value for normal operating condition (0.46) and extreme operating condition (0.69) there is an increase of 33.3% of UC for extreme operating condition.
- 2. For V08 section H250X250 Bracing group we got the difference UC ratio value for normal operating condition (0.27) and extreme operating condition (0.25) there is an decrease of 8% of UC for extreme operating condition and for V06 Bracing group the difference UC ratio value for normal operating condition (0.15) and extreme operating condition (0.13) as there is an decrease of 15.4% of UC for extreme operating condition.
- 3. UC COMPARRISON FOR NORMAL OPERATING CONDITION WITH AND WITHOUT WIND CONSIDERATION
- For PB5section PG390B column group we got the difference UC ratio value for normal operating condition with wind consideration (0.5) and without wind consideration (0.43) there is an decrease of 30% of UC for Normal operating condition without wind and for SA6 column group the difference UC ratio value for normal operating condition with wind consideration (0.27) and without wind consideration (0.23) there is a decrease of 17.4% of UC for Normal operating condition without wind.
- For TA4section H194X150 Beam group we got the difference UC ratio value for normal operating condition with wind consideration (0.81) and without wind consideration (0.91) as there is an increase of 11% of UC for Normal operating condition without wind and for SA3 Beam group the difference UC ratio value for normal operating condition with wind consideration (0.46) and without wind consideration (0.36) there is an decrease of 27% UC for Normal operating condition without wind.
- For V08 section H250X250 Bracing group we got the difference UC ratio value for normal operating condition with wind consideration (0.27) and without wind consideration (0.23) there is an decrease of 17.4% UC for Normal operating condition without wind and for V06 Bracing group the difference UC ratio value for normal operating condition with wind consideration (0.15) and without wind consideration (0.14) as there is an decrease of 7.1% UC for Normal operating condition without wind.
- 4. UC COMPARRISON FOR EXTREME OPERATING CONDITION WITH AND WITHOUT WIND CONSIDERATION
- For PB5section PG390B column group we got the difference UC ratio value for Extreme operating condition with wind consideration (0.87) and without wind consideration (0.69) there is an decrease of 26.1% of UC for extreme operating condition without wind and for SA6 column group the difference UC ratio value for Extreme operating condition with wind consideration (0.38) and without wind consideration (0.33) there is a decrease of 15.2% of UC for extreme operating condition without wind.
- For TA4section H194X150 Beam group we got the difference UC ratio value for Extreme operating condition with wind consideration (0.61) and without wind consideration (0.69) there is an increase of 11% of UC for extreme operating condition without wind and for SA3 Beam group the difference UC ratio value for Extreme operating condition with wind consideration (0.69) and without wind consideration (0.56) as there is an decrease of 23.2% of UC for extreme operating condition without wind.
- For V08 section H250X250 Bracing group we got the difference UC ratio value for Extreme operating condition with wind consideration (0.25) and without wind consideration (0.19) there is an decrease of 31.6% of UC for extreme operating condition without wind and for V06 Bracing group the difference UC ratio value for extreme operating condition with wind consideration (0.13) and without wind consideration (0.1) there is an decrease of 30% of UC for extreme operating condition without wind.
- 5. JOINT DISPLACEMENT FOR NORMAL OPERATING WITH AND WITHOUT WIND CONSIDERATION.
- When the analysis result for displacement for column under normal operating condition with wind & normal operating condition without wind it observed that there is no significant difference in X-direction displacement but there is increase of 50% displacement value in Y –direction with wind load application.

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|e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 8.423| A Monthly Peer Reviewed & Referred Journal |

Volume 13, Issue 2, February 2024

| DOI:10.15680/IJIRSET.2024.1302026 |

REFERENCES

- 1. Haritos, N., (2007). "Introduction to the analysis and design of offshore structures", and overview. EJSE special issue: loading on structures the University of Melbourne, Australia.
- 2. Kamesh A Rajai, Sandeep Kulkarni (2022): comparative analysis of pipe rack structure with different bracing system.
- 3. Priya D Meshram, R V R K Prasad (2021): Design of optimum pipe rack for various bays.
- 4. Ashwini Chalke, Supriya Nalawade, Navnath Khadake(2020): Review on analysis of offshore structure.
- 5. J.K. Sumanth, Dr. C.Sashidhar(2018): Design and Analysis of Pipe Rack System Using STAAD PRO V8i Software.
- 6. Nitesh J Singh, Mohammad Ishtiyaque(2014): Optimized design & analysis of steel pipe racks for oil & gas industries as per international codes & standards.
- 7. Rupam Saikia and Jayanta Pathak(2014): Seismic response of steel braced pipe racks and technological platforms in oil refineries.
- 8. Mrs. Sabade Madhuri, Prof. A.A.Hamane(2017): Stability Analysis of Pipe Rack in Petrochemical Facilities.
- 9. Prashantet(2017): conducted an analytical study on the load analysis of offshore jacket structures.
- 10. Sudarshan Jaydeep Borkar, Shashir Daule(2021): Dynamic analysis of pipe rack system subjected to seismic excitations.
- 11. American Institute of Steel Construction (AISC). (2010) "Specification for structural steel buildings (ANSI/AISC 360-10)." American Institute of Steel Construction, Inc. Chicago.
- 12. American Society of Civil Engineers (ASCE). (2006) "Minimum Design Loads for Buildings and Other Structures (ASCE 7-05)." American Society of Civil Engineers, Reston, VA.









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