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Analysis of Different Configurations of Buckle Arrestors for Offshore Pipelines using ANSYS

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Abstract - *Offshore asset infrastructures (subsea pipelines, platforms, risers, jacket structures) are usually subjected to deterioration to a large extent. This growing degradation is recognized as "ageing" process. This ageing situation has become significantly important for the offshore oil and gas and the renewable energy industries because many assets within these sectors are beyond their original life expectancy. It is needed for these assets, some of which have passed their design life, to continue being utilized but with minimal human, environmental and economic risks. Structural damage including dent, metal loss and crack is identified and efforts are made to summaries critical damage factors such as dent length and crack depth. Furthermore, research and prediction methods on pipe residual ultimate strength in terms of experimental tests, numerical simulations and analytical predictions are summarized and discussed. The latest research progress on residual ultimate strength of metallic pipelines with structural damage is presented through literature survey. This research highlights the challenges to overcome effect of lateral and upheaval buckling using different stiffeners.*

Key Words: offshore structures, buckling, stiffeners, finite element analysis, buckling analysis.

1. INTRODUCTION

The development of an offshore industry is proportionally related to the development of offshore pipelines as well. As the industry expands towards deeper water depths, the pipelines are required to undergo improvement in material designs simply to withstand changes in the new environments. The transport of crude oil is performed at both elevated temperatures and high pressures. Because of these requirements, steel pipes have been considered as the optimal means of transport. The production of oil and gas from offshore oil fields is more. Because of the increasing demand for oil and gas, the industry is pushed forward to develop and exploit more difficult fields in deeper waters. Deepwater pipelines are used to carry oil and gas from wellheads and manifolds to platforms or to shore. Figure 1 shows a simple representation of a deep-water installation with the flow lines on the seabed and section of pipeline from the seabed to platforms or ships.

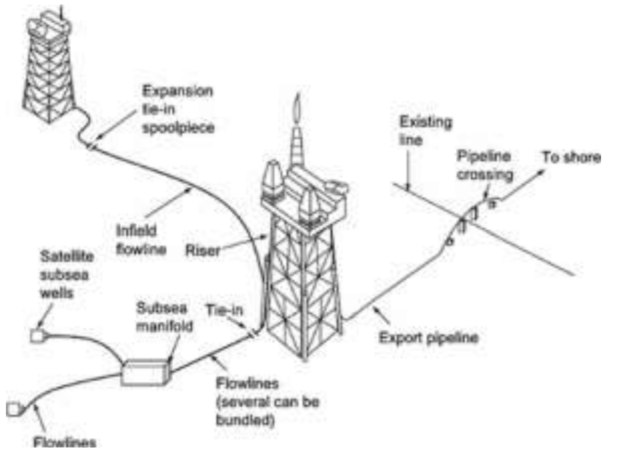

Fig 1: simple representation of a deep-water installation

A very important issue to consider in offshore pipeline is buckling phenomenon. The pipeline may buckle globally, either downwards (in a free span), horizontally ('snaking' on the seabed) or vertically (as upheaval buckling). Global buckling implies buckling of the pipe as a bar in compression (column mode).

1.1 Buckle Arrestor

Buckle arrestors are devices that locally increase the bending stiffness of the pipe in the circumferential direction. There are many different types of arrestors, as it can be observed in Fig 2 and fig 3; both of them typically take the form of thick-walled rings. The external pressure is necessary for propagating the collapse pressure through the buckle arrestors, this is known as collapse cross-over pressure (the minimum pressure value at which the buckle crosses over the arrestor). The integral ring buckle arrestor, where we can identify the collapse pressure, collapse propagation pressure and the cross-over pressure. In the first case, the external pressure was lower than the cross-over pressure. Collapse did not cross over the arrestor and the downstream pipe is not collapsed. In the second case, on the contrary, the external pressure was higher than the cross-over pressure and both, upstream and downstream pipes are collapsed.

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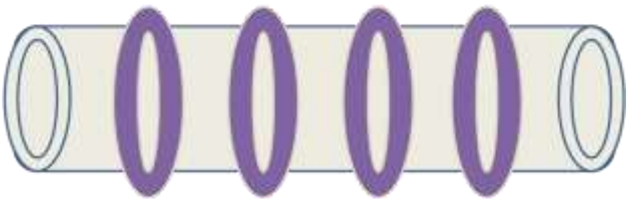


Fig 2: Pipeline with ring buckle arrestor

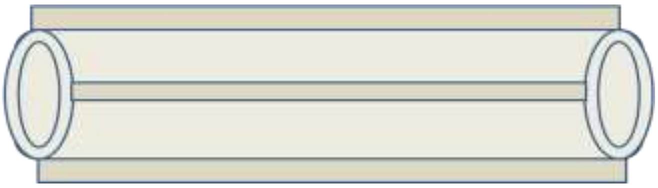
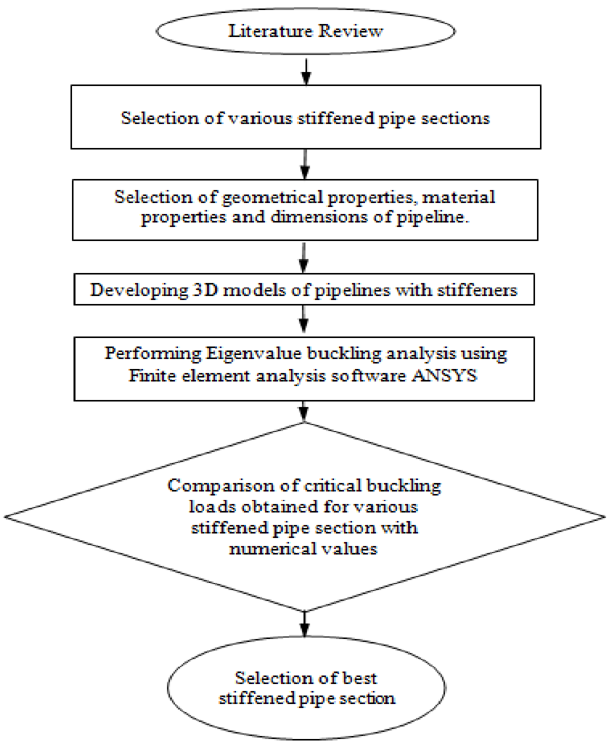


Fig 3: Pipeline with rectangular pin buckle arrestor

1.2 Objectives

- Reviewing existing issues and challenges concerned with design of buckle arrestors for offshore pipelines.
- Develop finite element models of offshore pipelines with two different types of arrestors and to mitigate effect of buckling due to axial compressive load.
- Identify the optimum buckle arrestor which carries more buckling load.

1.3 Methodology



Flowchart representing the methodology

2. FE ANALYSIS

Finite element method (FEM) is a numerical method has become one of the most important methods to carry out strength and deformation calculations. Ansys, a FEM based software is used to calculate buckling load carrying capacity of pipelines. Eigenvalue buckling analysis is carried by Ansys. The eigenvalue buckling analysis predicts the theoretical buckling strength of an ideal linear elastic structure. This method corresponds to the textbook approach to elastic buckling analysis.

2.1 Configurations and FE results

Geometrical details and engineering properties of pipe section used for analysis are shown in table 1. Fixed-Free end condition is considered for FE analysis and critical buckling load is found using Ansys

Description	Value
External diameter	1m
Internal diameter	0.65m
Configurations	Ring and Rectangular pin
Length	4m, 8m and 12m
Poisson's ratio	0.3
Young's modulus	$2.1*10^{11} (N/m^2)$

Table 1 Geometrical details of pipe section

2.2 Configurations and Results

Different types of configurations are used in strengthening of pipelines. This thesis concentrates mainly on finite element analysis of pipeline stiffened with two different types of buckle arrestors. Finite element analysis is carried on pipelines of different lengths and with different types of stiffeners (Ring and Rectangular pin) stiffened to it. Critical buckling load will be obtained by finite element software ANSYS. Geometrical data of pipe models and stiffeners are mentioned are shown in table 1.

- Ring buckle arrestor is stiffened around the circumference of pipeline. Thickness of ring buckle arrestor is taken as 35mm and lateral dimension as 100mm.
- Rectangular pin buckle arrestor is stiffened along the longitudinal direction of pipelines. Dimensions of rectangular pin buckle arrestor are 35 mm X 50 mm.

2.2.1 Configuration 1

Pipeline of length 4m stiffened with Ring and Rectangular pin Buckle Arrestors.

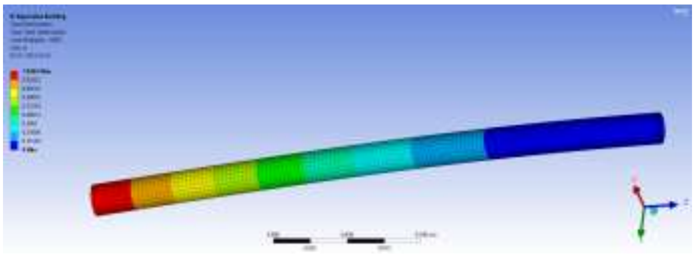


Fig 4: Critical buckling load for simple hollow pipe section.

Critical Buckling Load: Buckling of simple hollow section is shown in the fig 4. Critical buckling load is found to be $15X10^3$N.

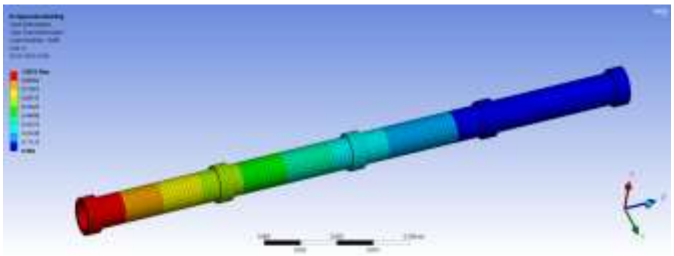


Fig 5: Critical buckling load for pipe section with ring buckle arrestor.

Critical Buckling Load: Buckling load of pipe section stiffened with ring buckle arrestor is shown in the fig 5. Critical buckling load is found to be $15.48X10^3$N.

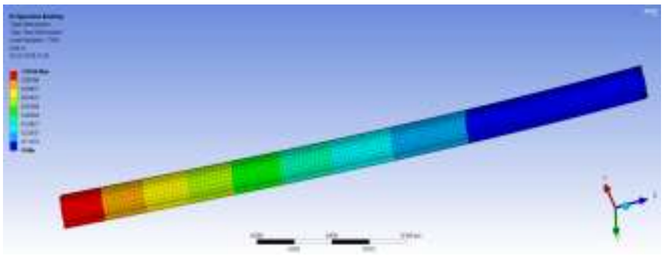


Fig 6: Critical buckling load for pipe section stiffened with rectangular pin buckle arrestor.

Critical Buckling Load: Buckling load of pipe section stiffened with rectangular pin buckle arrestor is shown in the fig 6. Critical buckling load is found to be $17.50X10^3$N.

2.2.2 Configuration 2

Pipeline of length 8m stiffened with Ring and Rectangular pin Buckle Arrestors.

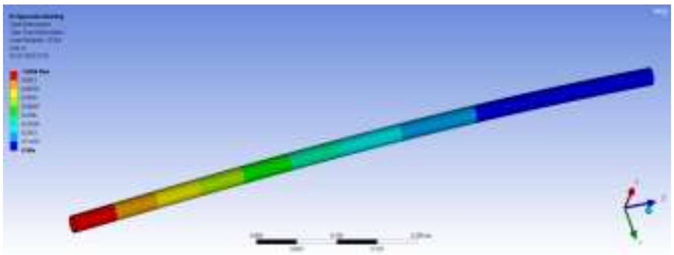


Fig 7: Critical buckling load for simple hollow pipe section.

Critical Buckling Load: Buckling of simple hollow section is shown in the fig 4. Critical buckling load is found to be $3.75X10^3$N

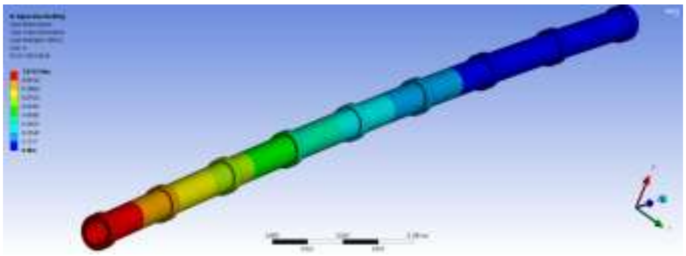


Fig 7: Critical buckling load for pipe section with ring buckle arrestor.

Critical Buckling Load: Buckling load of pipe section stiffened with ring buckle arrestor is shown in the fig 7. Critical buckling load is found to be $3.89X10^3$N.

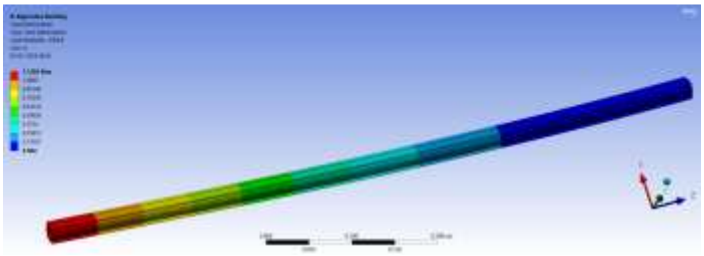


Fig 8: Critical buckling load for pipe section stiffened with rectangular pin buckle arrestor.

Critical Buckling Load: Buckling load of pipe section stiffened with rectangular pin buckle arrestor is shown in the fig 8. Critical buckling load is found to be $4.38X10^3$N.

2.2.3 Configuration 3

Pipeline of length 12m stiffened with Ring and Rectangular pin Buckle Arrestors.

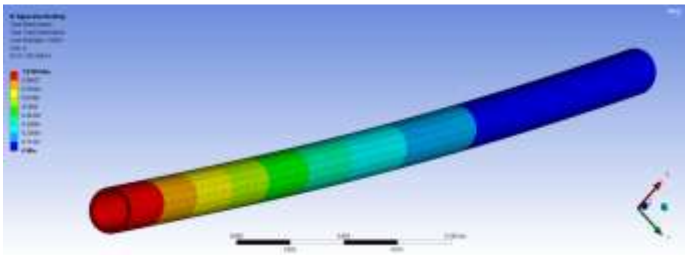


Fig 9: Critical buckling load for simple hollow pipe section.

Critical Buckling Load: Buckling of simple hollow section is shown in the fig 9. Critical buckling load is found to be 1.66X103N.

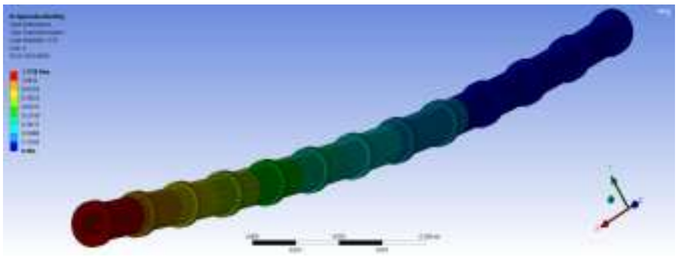


Fig 10: Critical buckling load for pipe section with ring buckle arrestor.

Critical Buckling Load: Buckling load of pipe section stiffened with ring buckle arrestor is shown in the fig 10. Critical buckling load is found to be $1.73X10^{3}$N.

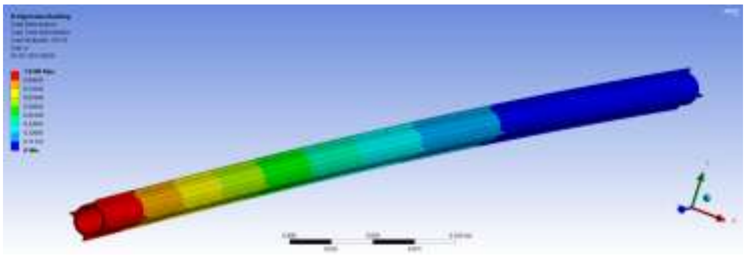


Fig 11: Critical buckling load for pipe section stiffened with rectangular pin buckle arrestor.

Critical Buckling Load: Buckling load of pipe section stiffened with rectangular pin buckle arrestor is shown in the fig 11. Critical buckling load is found to be $1.95X10^{3}$N.

3. CONCLUSIONS

This thesis focuses on buckling behaviour of offshore pipelines under the effect of axial force. The pipe model stiffened with different configuration of stiffness has been analyzed and the effect of these stiffeners on buckling of pipes is studied.

This thesis utilized finite element approach to analyze the buckle propagation of offshore pipelines. Eigen value buckling analysis is carried using finite element software called ANSYS. Pipe models stiffened with different configurations has been analyzed to obtain eigen value critical buckling load and deformation pattern. The computed eigen value critical buckling load helps in optimum design of offshore pipelines with stiffeners. Buckling load carrying capacity of offshore pipelines is increases, when the pipelines are strengthened with stiffeners. Results of eigen value buckling analysis is summarized below.

Type of buckle arrestors	**Crippling Load (N) for Length of pipe 4m**	**Crippling Load (N) for Length of pipe 8m**	**Crippling Load (N) for Length of pipe 12m**
Simple Hallow pipe section	15005	3754.8	1668.9
Pipe with ring buckle arrestor	15485	3894.2	1735
Pipe with rectangular pin buckle arrestor	17502	4389.8	1951.9

Table 2-Buckling load carrying capacity of stiffened pipe section with different lengths.

Provision of stiffeners contributes better strength against buckling of pipelines. The following conclusions can be made based on the results obtained from ANSYS.

- Finite element method is employed in the computation of Eigenvalue buckling load analysis and it is proved to be satisfactory. This analysis helped to optimize design against buckling.
- It is observed that model without stiffener has a low buckling load carrying capacity.
- Buckling load carrying capacity of pipelines increases with the implementation of buckle arrestors.

Type of buckle arrestors	**Length of pipe 4m**	**Length of pipe 8m**	**Length of pipe 12m**
Pipe with ring buckle arrestor	3.19%	3.71%	3.96%
Pipe with rectangular pin buckle arrestor	16.64%	16.91%	16.95%

Table 3: Percentage increase in Buckling load carrying capacity of stiffened pipe section with respect to simple hollow pipe section

- Buckling is minimized with proper selection of stiffener/buckle arrestor. From table 3 it can be concluded that, pipeline stiffened with rectangular pin buckle arrestor increases buckling load carrying capacity thereby reducing buckling of pipeline.

- From the results obtained it can be concluded that, pipe stiffened with rectangular pin buckle arrestor has better buckling load carrying capacity than ring buckle arrestor.

- Pipeline stiffened with ring buckle arrestor can increase buckling load carrying capacity by average 3% (as per table 3), hence it is not recommended for pipelines subjected more buckling.

REFERENCES

1. Daniel H. Johnson, Andrea P. Assanelli and Eduardo N. Dvorkin “Collapse arrestors for S. Kyriakides, T.-D. Park & T.A. Netto “On the design of integral buckle arrestors for offshore pipelines” Research Center for Mechanics of Solids, Structures and Materials, The University of Texas at Austin, WRW I IO, Austin, TX 78712, USA
2. Rita G. Toscano, Luciano O. Mantovano, Pablo M. Amenta, Roberto F. Charreaudeepwater pipelines Cross-over mechanisms” Center for Industrial Research, TENARIS Dr. Jorge A. Simini 250, Campana 2804, and Argentina.
3. T.A. Netto & S.F. Estefen “Buckle Arrestors for Deepwater Pipelines” COPPE-Federal University of Rio de Jsnerio, P.O.Box 68508, 21945/970 Rio de Janerio, Brazil.
4. Jason Sun and Paul Jukes “Finite Element Analysis Of Clamp-On Buckle Arrestor For Pipe-In-Pipe Flowlines By Reel-Lay Installation” Proceedings of the ASME 27th International Conference on Offshore Mechanics and Arctic Engineering OMAE2008 June 15-20, 2008, Estoril, Portugal
5. H. Showkati1 and R. Shahandeh “Experiments on the Buckling Behaviour of Ring-Stiffened Pipelines under Hydrostatic Pressure” Journal of Engineering Mechanics © Asce / April 2010.
6. Stelios Kyriakides “Efficiency Limits for Slip-on Type Buckle Arrestors for Offshore Pipelines” Journal Of Engineering Mechanics Asce / January 2002.
7. J. G. A. Croll “Analysis of Buckle Propagation in Marine Pipelines” J. Construct Steel Research 5 (1985) 103-122
8. Kyriakides and C.D. Babcock “On the dynamics and the arrest of the propagating buckle in offshore pipelines” 11thAnnualOTCin Houston, Tex., April30·May3, 1979
9. SteliosKyriakidesand CharlesD. Babcock “The spiral arrestor– anew bucklearrestor designfor offshore pipelines” 12thAnnual OTC in Houston, Tex., May5·8,1980.
10. Rita G. Toscano, Luciano Mantovano and Eduardo N. Dvorkin “On the numerical calculation of collapse and collapse propagation pressure of steel deep-water pipelines under external pressure and bending: Experimental verification of the finite element results” Centre for Industrial Research TENARIS GROUP, Dr. Simini 250, 2804 Campana, Argentina
11. Luciano O. Mantovano, Pablo Amenta, Roberto Charreau, Daniel Johnson, Andrea, Assanelli and Rita G. Toscano “Finite element modelling and experimental validation of buckle arrestors for deepwater pipelines” Centre for Industrial Research (CINI), Tenaris, Dr. Jorge A. Simini 250, B2804MHA, Campana, Argentina.
12. Carl G. Langne “Buckle Arrestors for Deepwater Pipelines” 1999 Offshore Technology Conference held in Houston, Texas, 3–6 May 199.
13. T.D.Park and S. Kayriakides “on the performance of integral buckle arrestors for offshore pipelines” Int. J. Mech. Sci. Vol. 39, No. 6, pp. 643 669, 1997.
14. Rita G. Toscano and Eduardo N. Dvorkin “Deepwater pipelines: reliability of finite element models inthe prediction of collapse and collapse propagation loads” Proceedings of IPC2006 6th International Pipeline Conference September 25-29, 2006, Calgary, Alberta, Canada.
15. Rita G. Toscano and Eduardo N. Dvorkin “Collapse and post-collapse behaviour of steel pipes” WCCM VFifth World Congress onComputational MechanicsJuly 7-12, 2002, Vienna, Austria.
16. Luciano O. Mantovano, Pablo Amenta, Roberto Charreau, Daniel Johnson, Andrea Assanelli and Rita G. Toscano “Finite Element Modeling And Experimental Validation Of Buckle Arrestors For Deepwater Pipelines” Mecánica Computacional Vol XXV, pp. 687-704 Alberto Cardona, Norberto Nigro, Victorio Sonzogni, Mario Storti. (Eds.) Santa Fe, Argentina, Noviembre 2006.